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The Power of High-Strength H2O

The future of wastewater treatment is being designed in Pennsylvania, where the Milton Regional Sewer Authority's plant plans to upgrade its antiquated aerobic water treatment process. The technologies penciled into this design of tomorrow aren't new, but the designers are billing it as the world's first wastewater-to-energy project.

by Ron Kotrba

Scores of U.S. water treatment plants were designed decades ago in an environment of cheap and abundant energy, when regulations left uncapped the discharge of certain chemical and biological contents into the nation's water systems. Now, energy costs are high and conventional sources of power are questionable at best; and years spent mismanaging what flows into American rivers has left our estuaries in a state of disrepair. A progressive regional water authority, an engineering firm and a food-processing giant are working on an energy-independent, responsible model with the potential to revolutionize water treatment. "The end goal for this project is to create a wastewater treatment facility where net energy consumption is zero—a truly green wastewater complex," says Chris Graf, project engineer with Herbert, Rowland & Grubic Inc. (HRG), the engineering firm designing a 180-degree upgrade for the Milton Regional Sewer Authority's treatment complex in Milton, Penn. The project, dubbed Ww2E, or wastewater-to-energy, will turn high-strength influent streams into energy and money.

Driving the change are a major reduction in operational and maintenance costs, and the Chesapeake Bay Tributary Strategy (CBTS), a multi-state effort in partnership with the U.S. EPA to reduce nitrogen and phosphorus loading in the bay. "The Chesapeake Bay Tributary Strategy puts the onus on treatment plants throughout the Susquehanna River Basin to treat for total nitrogen and phosphorus effluent, whereas before we were only required to treat for total solids and biological oxygen demand (BOD)," Graf says. BOD is a means to determine the quality of treated discharge, and measures how much oxygen the microbes need to break down organic waste being dumped into water supplies—the lower the BOD, the cleaner the discharge.

Milton's original wastewater treatment plant was built in 1955. Initially the incoming sewage received only primary treatment or physical clarification—the use of large settling tanks in which solids were separated gravimetrically—followed by disinfection prior to its release into the west branch of the Susquehanna River. Through anaerobic digestion the remaining sludge was broken down further and was used as fertilizer. No energy was ever captured in that process. In the mid-70s, the facility was upgraded to meet more stringent codes and simultaneously handle a new industrial wastewater stream from a nearby food processing facility now owned by ConAgra Foods Inc. The improvements, done in partnership with ConAgra, allowed for secondary, or biological, treatment. The two influent streams would undergo separate primary clarifications before merging in aeration tanks, where oxygen stimulates microbial cell growth for faster degradation of the organic solids left after primary conditioning. In 1995, the plant was re-rated from 2.6 million gallons per day (MMgd) to 3.42 MMgd, and organic loading from 16,762 pounds per day (lb/day) to 18,759 lb/day, Graf says. Since 1995, ConAgra has increased its production leading to organic overload in the aeration tanks, he says. The need for an upgrade was evident.

Today, up to 70 percent of the Milton treatment plant's influent comes from ConAgra, which screens its own waste including sub par noodles from its Chef Boyardee line, for example, and adjusts for pH, after which the food processor conducts its own primary treatment to the liquid waste. The water is then pumped over to the treatment plant. ConAgra's screened solids are hauled off by whichever means is the cheapest. The Chef Boyardee liquid waste stream currently receiving treatment from the wastewater facility is nutrient deficient, so urea and monosodium phosphate must be added to spur microbiological growth and quicken organic degradation, according to Milton Regional Sewer Authority Superintendent George Myers. "A large portion of the bugs' cellular structure is made up of nitrogen and phosphorus, so as they eat, they split, multiply and divide, and they utilize the excess nitrogen and phosphorus that comes in from the domestic side," he tells *Biomass Magazine*. "We're still short, so we have to add nitrogen and phosphorus to maintain a healthy biomass," which has led to high levels of those nutrients in its effluent stream. "Right now we're already meeting any limits we plan to receive in our discharge permit," Myers says. Under the CBTS, wastewater treatment plants will be limited as to how much total nitrogen and phosphorus they can release into local waters. The addition of urea and monosodium phosphate comes with an annual cost of $40,000 to the utility's rate payers, and dumping all the sludge produced in the aerobic treatment process costs 10 times that much. In 2006, the Milton Regional Sewer Authority footed a $400,000 landfill bill. "We're our local landfill's second-largest customer in terms of tonnage, and we'd like to let somebody else take that recognition," Myers says. If operations were to remain status quo, another projected cost increase would probably come in 2009 or 2010, when the state of Pennsylvania is expected to deregulate the power industry. These costly reasons prompted the sewer authority to begin investigating unconventional ways to conduct its business.

An Epic Upgrade

The Milton Regional Sewer Authority in partnership with Bucknell University, ConAgra and technology provider the ADI Group, carried out a pilot testing program from 2002 through 2003 to evaluate a process using ConAgra's high-strength solid waste stream for combined heat and power (CHP) generation. "We found the ConAgra Food waste extremely amendable to the low-load anaerobic treatment process," Myers says, adding that the methane concentration in the resulting biogas ranged from 75 percent to 82 percent. "That's pretty darn good." This relatively pure stream of methane would require less scrubbing before use in an electrical generation system.

HRG's design calls for the addition of anaerobic digestion of the high-strength wastewater and biosolids, which would require much less energy than aerobic treatment alone. The new anaerobic design would need only 100 horsepower compared with the 800 horsepower currently required to power the process. "The bang for the buck there is that those bacteria aren't using the strength of the wastewater to create cellular mass—they're using it to strip the oxygen bonds and use a little bit of the nitrogen and phosphorus for cellular reproduction and synthesis," Graf says. "But that's only about a tenth of what the aerobic bugs do. So we'll see a 90 percent reduction in sludge compared with the aerobic process." The separated liquid wastewater will go through a nutrient removal process, followed by secondary and tertiary treatments before final discharge. Any biosolids recovered are rerouted back to the anaerobic digester. Solids remaining after exhaustive anaerobic digestion—volumes of which would be significantly reduced compared with those produced aerobically—would be dried using waste heat recovered from electrical power generation fueled by the biogas made in-house. The dried product will be considered a Class A biosolid, and could demand $5 a ton. "Hey, even if I have to give it away that's a $400,000 a year savings," Myers says.

One of the key areas of investigation was to determine how much biogas would be produced per pound of chemical oxygen demand (COD) removed. "It was about 6 cubic feet per pound of COD we removed—that's the methane production," Graf says. "Right now we're looking at burning the biogas in two 600-kilowatt internal combustion-powered gensets—Jenbacher, Caterpillar or another brand—which would give us the ability to turn down our production to about 25 percent of capacity, so we could go anywhere from 300 kilowatts to 1.2 megawatts." HRG's final design will in all likelihood include internal combustion CHP systems, necessitating the rigorous scrubbing of hydrogen sulfide. "That stuff will eat up an engine real quick," Graf says.

The new design includes partitioned aerobic/anaerobic treatment tanks. "Nitrogen will come in, especially out of the anaerobic process as ammonia, and we'll add air to that ammonia to create nitrate, or NO_3, and that gets recycled back to an area that has no oxygen, where the oxygen is stripped from the NO_2 (nitrogen dioxide) and NO_3 and is used in the respiration process of the anaerobic microbe cells," Graf says. "Nitrogen gas is then formed and goes to the atmosphere—that's what completes the nitrogen removal process. " Phosphorus may be treated with ferric chemicals.

The submission of HRG's final design and the subsequent project bidding process are expected to occur in late 2008, with ground-breaking targeted for the 2009 construction season. The projected cost is $32 million. "If we can eliminate a million dollars in [operational and maintenance] costs per year, that's a million dollars we can apply toward debt service which will buy a decent chunk of the project," Graf says. "We're hoping the remainder of the cost will be paid with grant funding wherever we can get it." Through its renewable energy production, the equivalent of 12,450 tons in carbon dioxide emissions will be averted and approximately a megawatt's worth of renewable energy credits will be generated, says HRG Vice President E. Charles Wunz. The projected financial savings of this cutting-edge design doesn't even take into account potential revenue gained from the sale of carbon credits on the Chicago Climate Exchange. "I heard carbon credits in New Jersey were recently trading as high as $600 each," Wunz says.

Without the collocated ConAgra facility this project probably wouldn't have materialized in Milton. The ConAgra plant is the source of the high-strength wastewater, and thus the excess energy production capacity expected out of Ww2E. Some of that extra electricity may be sold back to ConAgra. "This treatment plant will have a 4.5 MMgd wastewater flow, but the strength coming into it will be equivalent to that of a 44.5 MMgd plant once we're done with it," Graf tells *Biomass Magazine*. "What does that mean? I think the project will demonstrate to our industry what can be done with high-strength wastewater. When considering energy efficiency we need to be looking at all processes. We as a society need to view wastewater as a beneficial resource rather than a problematic issue that has to be dealt with." The widespread acceptance of this model could alleviate industrial facilities that are positioned near water treatment complexes from having to manage their own wastewater while simultaneously giving towns such as Milton a beneficial resource to make its own energy.

The only anxiety expressed over the project has nothing to do with the implementation of this design in Milton but rather the resistance of broader incorporation by a mulish industry unwilling to change its present course. “My only concern is one of a global nature really for wastewater treatment in general,” Wunz says. “There’s a huge installed base of active sludge treatment plants—a very energy inefficient method of wastewater treatment. The wastewater treatment industry is run by a huge number of engineers experienced in this inefficient technology, so my fear is that the true value of its approach will not be recognized.” Once Ww2E’s concept is proven, its designers believe it may serve as a poster child for the future direction of wastewater, but Myers says, “We need to build the rocket ship before we figure out what we’re going to do on the moon.”

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