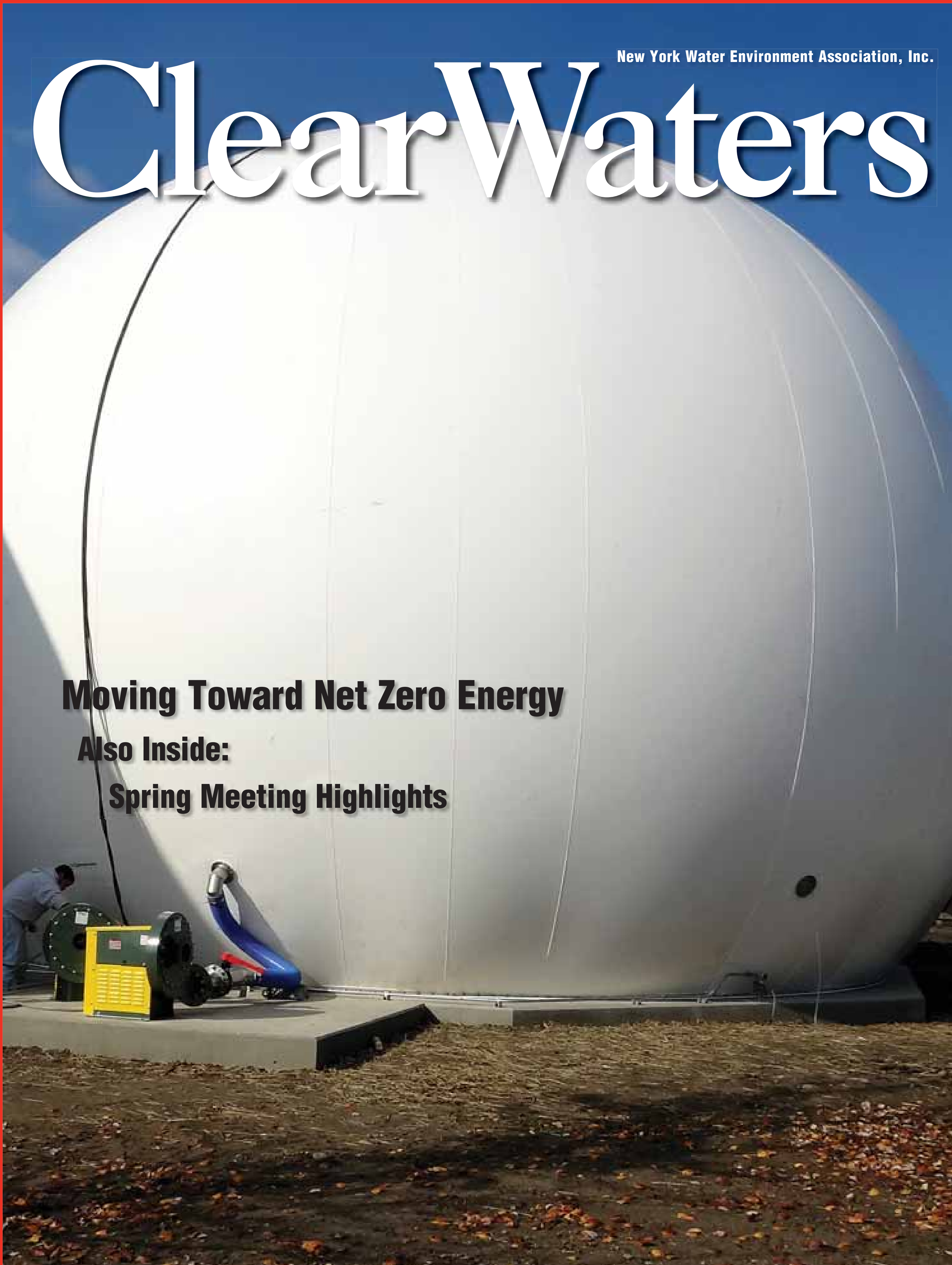
Summer 2013, Vol. 43, No. 2

New York Water Environment Association, Inc.

ClearWaters



Moving Toward Net Zero Energy

Also Inside:

Spring Meeting Highlights

Summer 2013, Vol. 43, No. 2

Clear Waters

New York Water Environment Association, Inc.

Cover Image: Photo by Dan Ramer, Ithaca Area Wastewater Treatment Facility, showing an Ecomembrane® gas holder cover exclusively marketed and sold by Ovivo USA, LLC and manufactured by Ecomembrane®

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Energy and Sustainability

This issue of *Clear Waters* is centered on energy, sustainability and funding. As facilities continue to stretch their operating and maintenance (O&M) budgets, the focus on sustainability and energy recovery is ever present. We hear the term "net zero" as a goal achieved when a wastewater treatment facility can create equal revenue from resource capture (i.e., cogeneration, biosolids reuse, etc.), bringing the bottom line revenue for expenses to zero.

I recently heard a new term "net positive." In watching this trend, the goal was first to harvest methane from anaerobic digesters to fire boilers for reduction in natural gas, oil and propane. Taking this a step further, some plants utilized methane gas to power an engine or microturbine for energy production to offset electrical and O&M costs. We have gone from offsetting the costs, to having the expectation of being net zero or net positive.

To reach these energy goals, the New York State Energy Research and Development Authority describes in its article many energy program funding opportunities. The New York State Environmental Facilities Corporation (NYSEFC) has provided billions of dollars in low cost loans and grants for water and sewer infrastructure projects across the state for the past 25 years. In addition, it has funded many green innovative programs and notes in its article the new State Revolving Fund's eligibility rules for available funds, especially for "shovel ready" projects.

Legislative and Regulatory Forum

In early May, a legislative and regulatory dialog session was held in Albany. This was very well attended with representation from the state assembly and senate staffs, Environmental Protection Agency, New York State Department of Environmental Conservation, NYSEFC, NYWEA and other organizations dedicated to protecting and enhancing New York's water environment. We heard remarks from Senator Mark Grisanti, NYS Senate Environmental Conservation Committee Chair, and Assemblyman Robert Sweeney, NYS Assembly Environmental Conservation Committee Chair.

Three main topics were covered. The first was water and wastewater infrastructure, its funding and job creation, moderated by Boris Rukovets with the Suffolk County DPW and NYWEA Government Affairs Committee Chair. Perhaps the most important issue we face today is aging infrastructure without a mechanism to provide sufficient funding for upgrade and repair. This is also while having to meet ever changing and more stringent effluent quality requirements. In grading our nation's drinking water and wastewater infrastructure, the American Society of Civil Engineers gave it a "D." This is a very real and, potentially, a catastrophic problem if ways to fund and upgrade our facilities are not found. It appears in the foreseeable future that federal funding will fall very short, so facilities are looking at other creative ways to achieve improvements. One way is becoming net positive or, at a minimum, net zero, allowing sewer rate revenue to fund upgrades rather than O&M. Another avenue is EPCs where a municipality works with an energy performance contractor who facilitates funding for upgrades based on energy and O&M savings.

The second topic was nutrient management, moderated by Bill McMillin with CH2M HILL and NYWEA Nutrient Task Force Chair. Nutrient pollution is a complicated topic, where the real goal is to find the balance in preventing an over abundance of nutrients in waterways. Nutrient pollution is the leading cause of water quality impairment in the US and worldwide.

The third topic was stormwater management and green infrastructure, moderated by Bob Kukenberger of CDM Smith and NYWEA's Past President. This is a very relevant movement and Onondaga County has been a national leader in transitioning from gray to green. A model for all municipalities, the county has posted its projects' plans, drawings and specifications on the web. The New York City Department of Environmental Protection must also be recognized for its leadership in creating an extremely effective and comprehensive stormwater management and green infrastructure program.

WEFMAX Conference 2013

Many of us attended WEFMAX in Niagara Falls, Ontario, held in May. Sponsored by the Water Environment Federation, WEFMAX originated as a platform for the different state Water Environment Associations (WEAs) that also are WEF member associations (MAs) to come together to share ideas. This has been very effective in promoting informational exchange among the MAs. In addition to me, NYWEA was represented by: Mike Garland with the Monroe County Department of Environmental Services and NYWEA Vice President; Joe Fiegl with the Erie County Department of Environmental Protection and NYWEA Vice President–Elect; Bruce Munn with GHD and our senior WEF House of Delegates Representative; Tony Della Valle with Arcadis and a representative on the WEF House of Delegates; and, Patricia Cerro-Reehil, NYWEA Executive Director. Steve Fangmann, our President–Elect, attended the WEFMAX in Providence, RI.

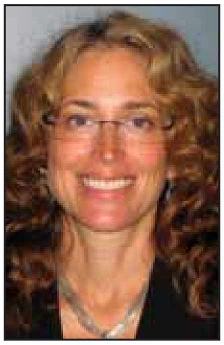
Attendees were specifically interested in hearing about our Utility Executive Roundtable (now the Utility Executive Committee). We explained that the roundtable was born from the Utility Membership Program. It is interesting to note that of the 90 utility memberships WEF has across the country, 30 of them are here in New York State. The roundtable started as a forum for chief operators, general managers and utility executives only. This committee is where members can talk in a "pure" environment among themselves about common issues including regulations, staffing, training, and more. The recently created Utility Executive Committee is chaired by Dave Comerford who is with the Buffalo Sewer Authority.

Meeting the Future

It is a unique time – shifting from sewage treatment plants to Waste Resource Utilities and moving from energy users to net zero or even net positive resources. Our wastewater treatment plants represent the future with sustainability.

As I move further into my year of presidency, I continue to learn more and more and deepen my appreciation for NYWEA and its members. In many ways we have been and continue to be a leader of other WEA organizations. It is this foresight that keeps NYWEA relevant, progressive and truly an environmentally conscious organization.

Mark Koester



Innovation Multiplied

Sharing new ideas, programs and perspectives from NYWEA's members is one way in which this organization grows and fulfills its purpose. This issue covers the topic of energy, showcasing innovations that might prompt similar action or inspire change from the status quo at your utility. In these challenging financial times, ingenuity, hard work and support from elected leaders can all result in better performance and cost savings at many utilities.

New Water Policy

As we address new ideas and programs, recently, Carter Strickland, commissioner of the New York City Department of Environmental Protection and member of the NYWEA Utility Executives Committee, put forth the idea that the time is right for a new NYS Pure Waters Program. For some NYWEA Life Members, like Bob Hennigan, Nick Bartilucci and Warren Schlickenreider, it may be *déjà vu,* but it is an opportunity to repeat another historic milestone. It was 1965 when New York State undertook a major comprehensive water pollution control program, called the Pure Waters Program, to protect its waters. Several states and the federal government followed New York's action. The 1966 Water Pollution Control Act (later the Clean Water Act) included many of the provisions pioneered by New York's program. The Pure Waters Program was then subsumed by the national Clean Water Act. New York had led the way for pollution abatement by setting the stage for enactment of this federal legislation. We hope history will be repeated by putting New York in the lead once again to modernize the Clean Water Act.

The NYWEA Utility Executives Committee developed a white paper on this topic, unanimously approved by the Board of Directors, which will help begin the dialogue in creating a new state Pure Waters Program. As this program develops, we will keep the membership apprised. The white paper, titled "A *New* NYS Pure Waters Program," is posted at www.nywea.org.

Spring Technical Conference

The NYWEA Spring Technical Conference was held in Syracuse, NY this year *(see photo highlights on pages 6–7).* The Program Committee coordinated 11 technical sessions during the three-day meeting that covered relevant topics, including asset management, green infrastructure, wet weather issues (CSOs and SSOs), and an entire session devoted to hydraulic fracturing. The meeting was well attended with 329 participants. A unique highlight was the Build-a-Bike event, where 4th and 5th graders from the Dr. Martin Luther King, Jr., Elementary School came to learn what happens to water after it is "used." While Dick Pope taught the children about wastewater, many of our members worked furiously to assemble 40 bikes shipped in by Huffy® that had been sponsored by members. These children received a big surprise at the end of the day when they all were presented the new bicycles. The event generated plenty of good energy, combining the missions of the Public Outreach and Humanitarian Assistance committees. Many thanks to President Mark Koester and Matt Marko for their passion in turning this idea into reality. Two local stations covered the conference – a TV station for the Build-a-Bike event, and a radio station for the hydraulic fracturing presentations.

The meeting also had a nice blend of technical and social events with offsite meals at the Erie Canal Museum (a real treasure for history buffs) and the Gateway Building at the SUNY College of Environmental Science and Forestry, where the Operations Challenge awards were presented. This year's winning teams were the Metropolitan Chapter's North River Harlem Pump Trotters, and the Long Island Chapter's Brown Tide. Congratulations to the winners and our hats off to all of the teams, judges and coordinators for their hard work to make the Challenge run without a hitch!

Maureen Kozol, NYWEA's information technology specialist, implemented a useful smart phone app for the meeting called "Guidebook," that helped members view the technical program as well as see any real time meeting announcements. The feedback received about it was generally positive, so we hope to offer the app at future conferences.

Many thanks to Dave Barnes, chair of the Spring Meeting Conference Management Committee, and to the leaders and members of the Program Committee who helped develop such a comprehensive technical program, and to all of the volunteers who helped to make this meeting a success. We look forward to next year's spring meeting on Long Island! Have an enjoyable summer!

Patricia Cerro-Reehil
pcr@nywea.org

How Would You Like to Be President in 2017?

If you are interested in a long-term, career enriching opportunity, please consider applying for this important position.

Being an officer is a rewarding experience, but it is also a commitment of five years (Vice President–Elect, Vice President, President–Elect, President, Immediate Past President). When reviewing applicants, the Nominating Committee will take the following items into consideration (no one is expected to have all of these items in their resumé):

- Leadership skills
- Vision and managerial skills
- Active and viable state committee chair
- Active and viable state committee involvement
- Continuous membership tenure greater than 7 years
- Chapter endorsement (in writing)
- Active member of Chapter Executive Board
- NYWEA award recipient
- Chapter representative
- Chapter officer
- Regular attendance at state meetings
- WEF Board of Directors service

"Serving the water environment industry as an officer of NYWEA was the most rewarding activity of my career. I looked forward to the interaction with other officers and directors, as well as the general membership both professionally and socially. From an educational point of view, my role with NYWEA kept me current with new trends, regulations and technology. I couldn't think of a more beneficial way to spend my limited volunteer time."–Robert Kukenberger, Past President

Please submit an electronic resumé with a cover letter that highlights any of the areas above to:

Patricia Cerro-Reehil, Executive Director, NYWEA, 525 Plum Street, Suite 102, Syracuse, NY 13204

Phone 315-422-7811 • **Fax** 315-422-3851 • **Email** pcr@nywea.org. ***Nomination deadline is August 2, 2013. All members are eligible to apply!***

Syracuse Sheraton University Hotel

Highlights of Spring Technical Conference and Exhibition

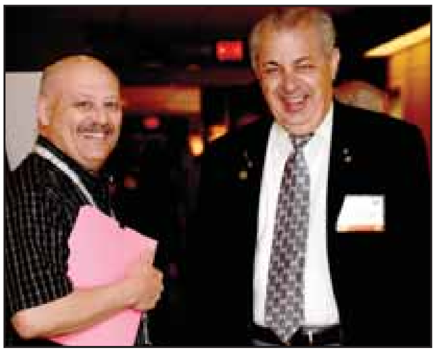
June 3–5, 2013

Dave Boshart, chair of the Central Chapter, welcomes attendees of the Spring Meeting.

Above: Onondaga County Executive Joanie Mahoney talks about the Save the Rain program.

Above: Kirk Rowland gives out the Golden Manhole Awards.

Above right: Bob Kukenberger receives his outgoing WEF Board Service Award from NYWEA President Mark Koester.



Left: Anthony DellaValle and Fotios Papamichael

Right: Ethan Bodnaruk receives his NG Kaul Scholarship certificate from NYWEA President Mark Koester.

Operations Challenge

Above: John Fortin announces the winners of the Operations Challenge awards.

Right: Billy Grandner stands ready to hand out the Operations Challenge awards.

Sandy Lizlovs cleaning up the lab event

Operations Challenge onlookers

Left: Operations Challenge sludge contest

Bob Wither coordinates the questions to operators.

Team members of the 26th Ward from NYCDEP

Right: Team members of the Long Island Brown Tide

Mark Greene, left, and Ken Knutsen building bikes.

Dave Comerford and Mike Garland

Ken Skibinski and President Mark Koester

Long time member, Warren Schlickenreider, celebrates his birthday at the meeting.

Seth, Leilani and Lauren Livermore

The CH2M HILL team helped in the overall coordination of the Build-A-Bike event where 40 local children were given bikes.

Build-A-Bike Great Success and a Big Surprise for Kids!

Chris Eighmey of CH2M HILL builds some fun.

Professor Robert Sharp from Manhattan College adds a wheel.

Above and right: After learning about what happens to "used" water and given totes with a message, children from Dr. King Elementary School were presented with new bicycles built on NYWEA teamwork.

Maria Duran and Ann Kupferschmid

Photos by Ken Skibinski and Patricia Cerro-Reehil

Water Views | Summer 2013

Moving Toward Net Zero Energy

Our nation's water and wastewater systems account for 12.6 percent of the country's energy use each year. This is equivalent to the amount of energy 40 million Americans use in a year. And we all know that energy costs are increasing. How can the water industry reduce its energy use and costs? The answer is through greater efficiency.

When people use less water, there is less wastewater to treat. So water conservation saves water and energy. In some instances, the link is obvious. In New York City, water use has been reduced by 300 million gallons per day through the use of low flow toilets. This water conservation measure also reduces wastewater and the energy needed to treat it. Such water conservation efforts could reduce the need, not just for additional water and wastewater treatment capacity, but for additional power plants as well.

On a related front, a number of wastewater facilities are also increasing efficiencies by producing their own power. Anaerobic digesters, biogas and cogeneration are all examples of using waste products to produce energy. The City of Jamestown uses gas from their anaerobic digesters to power two generators. The waste heat from the generators is then used to heat the anaerobic digesters. As wastewater facilities replace older equipment, the use of newer, more efficient technologies and systems can be expected to increase.

There are grant programs that support efforts by wastewater facilities to use less power for wastewater treatment. New York State Energy Research and Development Authority's (NYSERDA) FlexTech Program identified opportunities for improved operating efficiency and energy conservation. This program provided funding for upgrades to the Gloversville-Johnstown Wastewater Treatment Plant in support of its move toward independence from the power grid. The program also worked with the City of North Tonawanda to identify, evaluate and determine energy savings through process wastewater, heating and ventilation modifications.

The Environmental Facilities Corporation (NYSEFC), which provides low interest loans for wastewater treatment improvements, works with NYSERDA on FlexTech reports to encourage water efficiencies. Also, the NYSEFC's Green Innovation Grant Program supports stormwater projects that will decrease the volume of stormwater entering sewer systems.

As these examples show, New York is becoming more energy efficient. I commend NYWEA for its efforts, including its hosting of the Energy Specialty Conference in November, to focus attention on new technologies, processes and resources that will support the sustainability of New York's water and wastewater management systems.

– James Tierney, Assistant Commissioner for Water Resources
NYS Department of Environmental Conservation

Focus on Safety | Summer 2013

Use Less, Make More – Safely!

Many companies and local governments are actively trying to reduce energy costs. This is especially important in wastewater treatment systems as they are energy intensive, with traditional systems using a disproportionate amount of energy. Reducing energy usage and cost usually is attacked on two fronts – alternative energy technologies and energy system efficiencies – or using less and making more by capturing energy from treated waste.

The days when the water treatment plant was a simple process and could be run by general personnel are becoming a memory. Technological improvements in the last 20 years alone require the operator to be not only a maintenance expert, but also an instrument and controls technician, electrician, chemist, pollution engineer and materials handler. The organization must be able to adequately address the safety concerns associated with these duties. The addition of alternative energy sources adds another layer of potential risk.

Enthralled by snazzy new technologies, some are blinded to the potential safety downsides. Wind turbines sound great, until the work environment is two hundred feet up, in a stiff breeze. Solid waste incineration is the future, until one confronts hidden chemicals, heavy equipment, noise, dust and incineration itself. Bio-digesters are a panacea, until one thinks of the methane, possible drowning hazard, ruptures and leaks. Replacing aging infrastructure with new innovations is great as long as the project is managed well, i.e., the workers are competent, hazards identified, work zones protected and heavy equipment respected.

The size of the project necessarily determines the safety response. My suggestion is to have a safety committee or coordinator oversee the safety aspects of any size project. This group/person must be included in the selection of contractors with formalized criteria. Insurance and workers' comp rates must be verified, safety training listed, drug test results recorded and safety programs reviewed. There will be overarching responsibility to make sure that hazards are identified and resolutions are in the project plan. Hazards can range from porta-potty locations to site inspections, and everything in between.

Often, because the sheer magnitude of proper safety management seems overwhelming, only a cursory effort is attempted. Nevertheless, the protection of workers is both a legal and moral obligation however complex it becomes in the evolving environment. Even while the adjustment from energy consumption to energy production at water treatment facilities may be steep, our efforts to remain safe at work must be steadfast.

– Eileen M. Reynolds, Certified Safety Professional
Owner, Coracle Safety Management

NYSERDA: Energy Program Funding Opportunities

by Silvia Marpicati

Wastewater treatment is intrinsically energy intensive due mainly to the needs of moving large volumes of water using pumps, and oxidizing organic material using aeration blowers. Moving toward net zero energy at a wastewater treatment plant (WWTP) requires reducing energy consumption; improving energy efficiency; and generating energy for onsite use. Identifying energy efficiency opportunities and implementing energy related projects can be overwhelming tasks. The New York State Energy Research and Development Authority (NYSERDA) can help municipal water and wastewater treatment facilities realize significant cost savings through various funding opportunities.

Where to Start – Energy Savings Ideas

The process of identifying and evaluating energy efficiency opportunities should initially focus on systems that consume large quantities of energy (i.e., large equipment that operates all or most of a 24-hour period). In wastewater treatment facilities, the greatest energy savings potential is typically found in aeration, pumping and solids management processes. As such, facilities should consider installing premium efficiency motors and variable frequency drives (VFDs), pumping system re-sizing, aeration system upgrades, and automated dissolved oxygen controls. To reduce peak demand, facilities should focus on large intermittent operations. Rather than allowing for concurrent operation of these systems, their operation should be staggered throughout the day.

Additional information, as well as helpful recommendations for energy efficiency at wastewater facilities, is included in the Water and Wastewater Energy Management Best Practices Handbook. This can be found at http://www.nyserda.ny.gov/water, under the "Tools and Materials" header.

Focusing on the processes that consume the most energy typically leads to the greatest savings; however, each treatment facility is unique. Therefore, a customized energy evaluation for each facility is recommended.

How to Pay for It – NYSERDA Assistance

Programs offered by NYSERDA are designed to help municipalities make sound energy decisions concerning the operation and maintenance of their water and wastewater treatment facilities. These include support for customized energy evaluations through the FlexTech Program; capital incentives for the installation of energy efficient equipment and processes through the Existing Facilities Program and Industrial Process Efficiency Program; and, technical assistance to evaluate and/or design energy efficient options through the New Construction Program. These programs are available to municipal facilities that pay the system benefits charge (SBC), typically facilities within the electric utility services areas of Central Hudson Gas and Electric, Con Edison, NYSEG, National Grid, Orange and Rockland and Rochester Gas and Electric.

A summary of currently available programs follows. More detailed information on each program can be found at: http://www.nyserda.ny.gov, under the "Funding Opportunities" tab.

Photo courtesy of Silvia Marpicati

Pumps typically consume large quantities of energy. Consider installing premium efficiency motors and variable frequency drives (VFDs), or re-sizing the pumping system.

Energy Efficiency Programs

FlexTech Program (Program Opportunity Notice [PON] 1746): The Flexible Technical Assistance (FlexTech) Program draws from NYSERDA's pre-qualified consultants to provide customized energy evaluations. Customer selected consultants may also be used to perform the evaluations. The agency will provide cost sharing of up to 50 percent of the study cost, but capped at 10 percent of a plant's annual energy costs. The FlexTech Program is typically for customers with annual electricity bills greater than $75,000 per year. Applications are accepted on a first come, first served basis through December 31, 2015, or until funds are fully committed, whichever comes first.

Existing Facilities Program (PON 1219): NYSERDA offers "pre-qualified incentives" through the Existing Facilities Program

In wastewater treatment facilities, the greatest energy savings potential is typically found in aeration system upgrades and automated dissolved oxygen controls.

to encourage the purchase and installation of energy efficient equipment. Incentives are available for pre-qualified equipment such as lighting, HVAC equipment, VFDs, chillers and interval meters for Demand/Response programs. Applying for incentives must occur within 90 days of the pre-qualified equipment installation. This "rebate" program is ideal for regular operation and maintenance (O&M) projects and small equipment replacement and upgrade projects. Applications are accepted on a first come, first served basis through December 31, 2015, or until funds are fully committed, whichever comes first.

Industrial Process Efficiency (IPE) Program (PON 2456): NYSERDA offers performance-based incentives to support projects that result in: verifiable savings of electric or natural gas use; enable participation in demand response; promote persistent and measurable operational-based energy savings; or promote industrial process efficiency. For example, for upstate New York facilities paying the SBC, the incentive for electric efficiency is $0.12 per kilowatt hour (kWh) and $15 per million British Thermal Unit (MMBtu). For downstate facilities paying the SBC, incentives are $0.16/kWh and $20/MMBtu, respectively. Projects must be large enough that they qualify for an incentive of at least $30,000. The IPE Program requires documentation showing estimated project savings and engineering analyses; and, for larger projects, requires measurement and verification. Applications are accepted on a first come, first served basis through December 31, 2015, or until funds are fully committed, whichever comes first.

New Construction Program (PON 1601): This program provides technical assistance to evaluate and/or design energy efficient options, as well as incentives to offset some of the incremental capital costs of purchasing and installing cost effective, electrical efficiency measures in new buildings and plants. Additional incentives and services are offered for buildings that achieve Leadership in Energy and Environmental Design (LEED®). Applications are accepted on a first come, first served basis through December 31, 2015, or until funds are fully committed, whichever comes first.

Energy Generation Programs: Thinking about generating power from your wastewater facility's anaerobic digestion process? The agency's Renewable Portfolio Standard's Customer-Sited Tier includes an ***Anaerobic Digester Gas-to-Electricity*** program. This offers funding to support the purchase, installation and operation of equipment that generates electricity from anaerobic digester gas (ADG). This program, as of this writing, is closed; however, a new PON is expected to open this spring. Please refer to the NYSERDA "Funding Opportunities" page for updates or to sign up to receive e-mails on new funding opportunities.

Two types of incentives are typically offered under this program: capacity incentives and performance incentives. Capacity incentives offset the total purchase and installation costs and are based on the installed capacity in kilowatts (kW) and the type of newly installed anaerobic digester and power generation equipment. Performance incentives are based on the verified electricity generated in kilowatt hours (kWh) over a 10-year period. There is a cap of $2 million in total incentives per project.

Toward Net Zero Energy Wastewater Treatment (PON 2722): This PON is expected to open this spring. Its objective is to solicit proposals for demonstration projects and feasibility studies that continue to support NYSERDA's efforts of moving New York State WWTPs toward zero net energy – that is, balancing energy demand with supply from onsite recoverable energy.

Other renewable power generation technologies (e.g., wind power and solar photovoltaic) are also eligible for funding through NYSERDA.

Solar Photovoltaic (PV) Program Financial Incentive (PON 2112): This provides cash incentives for new grid connected solar electric or PV systems installed by certified "eligible installers" that are 50 kW or less for commercial sites. Applications are accepted on a first come, first served basis through December 31, 2015, or until funds are fully committed, whichever comes first.

Onsite Wind Turbine Incentive Program (PON 2439): This offers incentives for new grid connected wind energy systems installed by eligible installers of up to a maximum of 2 MW (2,000 kW) per site, per customer. The NYSERDA incentive may not exceed 50 percent of the total installed cost of the system. The program will continue through December 31, 2015, or until funds are fully committed, whichever comes first.

More wind and PV opportunity information and certified installers can be found at: http://www.nyserda.ny.gov/renewable.

The NYSERDA programs described here are available to support facilities in reaching their energy improvement goals. Please check http://www.nyserda.ny.gov, or call the toll-free number **1-866-NYSERDA**, for the latest information on funding opportunities, applications and contact information.

Silvia Marpicati, PE, BCEE, is Senior Environmental Engineer for Malcolm Pirnie Inc., the Water Division of ARCADIS, located in Clifton Park, NY. She may be reached at: silvia.marpicati@arcadis-us.com.

NYS Environmental Facilities Corporation Recognized Nationally for Water Infrastructure Assistance

by Jon Sorensen

Water, water everywhere … but where is the financing available to collect, maintain and purify all that water? The effective answer is often the New York State Environmental Facilities Corporation (NYSEFC).

Since 1990, the NYSEFC has provided $15 billion in low cost loans and grants to more than 2,000 water and sewer infrastructure projects across New York State. The agency has also been helping municipalities, nonprofits and businesses to create sustainable stormwater projects with more than $90 million in grants through its Green Innovation Grant Program. While municipalities in some states have had to borrow on their own, the NYSEFC manages robust State Revolving Funds (SRFs), assisting the financing of municipal infrastructure projects at today's low rates.

"We applaud EFC for the establishment of such a strong financing program that reduces costs to municipalities while investing in projects across the state that put people to work upgrading our aging facilities and improving water quality," said Albert E. Caccese, executive director of Audubon New York. "It's exciting to see that the Environmental Facilities Corporation and the State of New York is a national model for advancing innovative, green solutions to our wastewater infrastructure crisis."

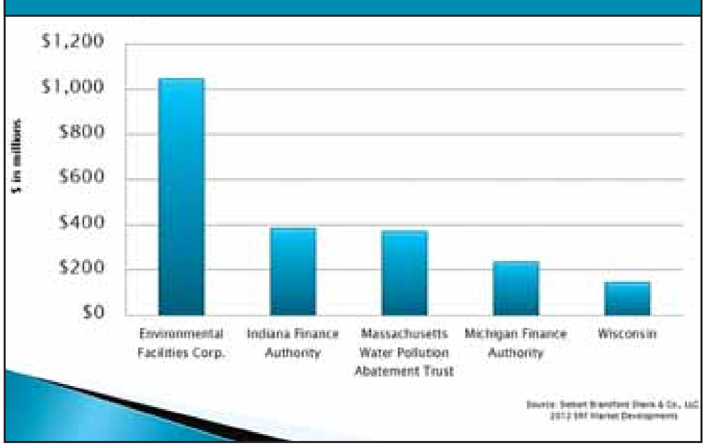
New SRF Eligibility Rules

The NYSEFC's active management of the SRFs led to changes this year in the rules governing eligibility for Clean Water Act project financing. Under the new readiness guidelines, New York State will be able to provide low interest and no interest financing to more municipalities ready to proceed than ever before.

"The EFC is currently loaning SRF money at record low rates and we want to use every dollar available for communities that are ready to put shovels in the ground and people to work," said NYSEFC President and CEO Matthew Driscoll. "This is a smarter way to utilize our funds by not committing them to proposed projects that may not go forward next year."

This year, the new rules allowed as many as 80 additional cities, towns and villages to take advantage of low cost financing for vital infrastructure projects. The premise of these changes was to get more projects started faster and create jobs more quickly.

State Revolving Fund: Top Five Issuers of 2012



"Too often in the past, Clean Water SRF funds were dedicated to infrastructure projects that scored high but ultimately were not ready to move forward," Driscoll said. "By imposing firm deadlines on the submission of engineering and other required documents, EFC was able to offer SRF money available to more communities with lower scores because they proved they were ready to begin work this year."

"The increased opportunity for communities to take advantage of the Clean Water State Revolving Fund will offer great environmental benefits and protection of New York's natural resources," noted Joe Martens, commissioner of the NYS Department of Environmental Conservation, which co-administers the CWSRF with the NYSEFC. "Best management practices for stormwater and wastewater treatment are vital to protect our waterways and environment."

Prudent Financial Management

The NYSEFC's vigorous administration of the Clean Water and Drinking Water SRFs can also been seen in New York State's issuance of water quality bonds. In 2012, New York issued over $1.05 billion in bonds – more than twice the amount issued by any other state. With those proceeds, the NYSEFC was able to refinance $1.4 billion of local infrastructure debt, saving more than $233 million for 73 cities, towns, villages and public authorities in New York.

"Through the sale of bonds, New York State is maximizing the capital available to improve or replace its aging infrastructure, helping to produce greater economic opportunity and create more jobs throughout the state," said Driscoll. "At NYSEFC, we are proud of our record in consistently and aggressively working to multiply and stretch available funding, especially at a time when resources are scarce and our state's needs are so great."

Along with $176 million in long term financing for 31 drinking water and wastewater projects, the NYSEFC helped municipalities and public authorities achieve more than $260 million in long term savings. These savings can potentially be used for future infrastructure projects, as well as existing maintenance and repairs, according to Driscoll. Stretching available capital is also accomplished through the agency's sound investment strategies, which annually produce hundreds of millions of dollars in additional SRF funds. Its success was cited in a 2011 report by the Environmental Financial Advisory Board of the US Environmental Protection Agency (USEPA).

New York's successful investment model, "…neatly served the stated purposes of the SRFs, which are to recycle dollars to support new projects expeditiously …," stated the financial advisory board in the report, "Current Status and Prospects for Enhancing SRF Sustainability." The report added: "This is a highly desirable outcome in that it extends the reach of finite SRF equity … This represents a 30.4 percent increased annual return on such equity when compared to the traditional reserve model."

In response to the report, the Center for American Progress wrote:

continued on page 15

continued from page 13


Monica Blount, NYSEFC

Much like San Antonio's famous Riverwalk, NYSEFC and its Green Innovation Grant Program have helped the City of Yonkers unearth a large portion of the Saw Mill River, transforming a deteriorated urban plaza into a revitalized public space. Last year, Yonkers won a second GIGP grant to help bring even more of the river back into the daylight.

"The funding model and investment strategy innovations pioneered by [NYSEFC in] New York … provide a roadmap for the country as it faces a critical and growing safe drinking water and wastewater infrastructure funding gap. Unless states harness these gains and strive for continued innovations to better put these funds to work today, we won't be able to meet our infrastructure needs tomorrow."

The NYSEFC manages the largest State Revolving Funds for Clean Water and Drinking Water projects in the nation with $13 billion in assets. Its tax-exempt bonds are rated triple-A or double-A (depending on the program), enabling the agency to offer much lower interest rates than if local governments sold their own bonds.

Funding Eco-Friendly Projects

Through the Clean Water SRF, the state has also created a program to fund the planning and installation of eco-friendly projects to manage stormwater runoff. More than 100 green projects – ranging from rain-absorbing garden roofs to the unearthing of the Saw Mill River in downtown Yonkers – have been selected for more than $90 million in funding through the Green Innovation Grant Program (GIGP) since 2010.

"Since 2009, the NYSEFC has led the way in funding green infrastructure projects that restore and protect the state's waters while building better communities. This leadership continues to set the pace for the region, and the nation, in investing in our future," said Jeffrey Odefey, director of Stormwater Programs for the American Rivers organization.

The GIGP program was awarded a 2012 Environmental Quality Award from USEPA Region 2, as well as its national Pisces Award in 2010. The GIGP is now among the funding opportunities that comprise Governor Andrew Cuomo's Regional Economic Development initiative. The next round of funding is expected to be announced this June.

Community Assistance Program

Through its Community Assistance Program, the NYSEFC also helps smaller communities in organizing and completing water and wastewater projects for State Revolving Fund (SRF) financing. The program covers two related aspects of a typical infrastructure project: project development services and funding coordination. The goal is to provide guidance and insight to community leaders to complete infrastructure projects – both Clean Water and Drinking Water – as effectively and efficiently as possible.

Work begins to organize the project by identifying the work tasks, scheduling the sequencing of work, and identifying the expertise needed to complete the project. These services are always tailored to meet the needs and circumstances of a particular project. The second area of assistance is guidance provided by the funding coordinator. The funding coordinator assists communities with the identification of applicable loan and grant funding programs offered by state and federal agencies through the NYS Water and Sewer Infrastructure Co-funding Initiative. Once the community's funding package is established, the funding coordinator continues to work with municipal officials, serving to manage communications between the community and funding agencies, to see that required submittals flow as efficiently as possible and that agency requirements are satisfied.

The NYSEFC recognizes that such water infrastructure projects will likely be some of the largest, most complicated and costly undertaken by a small community. The agency's experience and close involvement with the project assists in maintaining open communication among community leaders, retained professionals, regulatory agencies and the general public. The aim is to keep the project moving forward, eliminate duplication of work, meet funding agency schedules, and complete the project to serve its intended purpose. The Community Assistance staff also provides onsite assistance to the state's Regional Economic Development Councils.

Critical Support

"In New York State, we recognize that water quality infrastructure is the backbone of any community," Driscoll said. "It not only has a direct impact on retaining people and commerce, but in growing our economies as well. That is why this year New York expects to provide financial assistance up to $1.3 billion dollars in infrastructure projects, addressing critical public health concerns while protecting the environment for future generations."

For more information, contact the NYSEFC at 518-402-6924/www.efc.ny.gov.

Jon Sorensen is Director of Public Information for the NYS Environmental Facilities Corporation, and can be reached at Jon.Sorensen@efc.ny.gov.

Transforming Wastewater Operations into Resource Recovery: NYCDEP's Strategies for Energy Neutral Operations

by Anthony Fiore

Significant energy is required to deliver sufficient quantities of potable water and to collect and treat wastewater. Between three and four percent of total US electricity demand is used for these purposes.[1] For municipalities, the water and wastewater sector may make up as much as 35 percent of their energy consumption.[2] Fortunately, this sector also has a lot of opportunities to reduce energy needs. The challenge is the integration of energy initiatives with state of good repair programs.

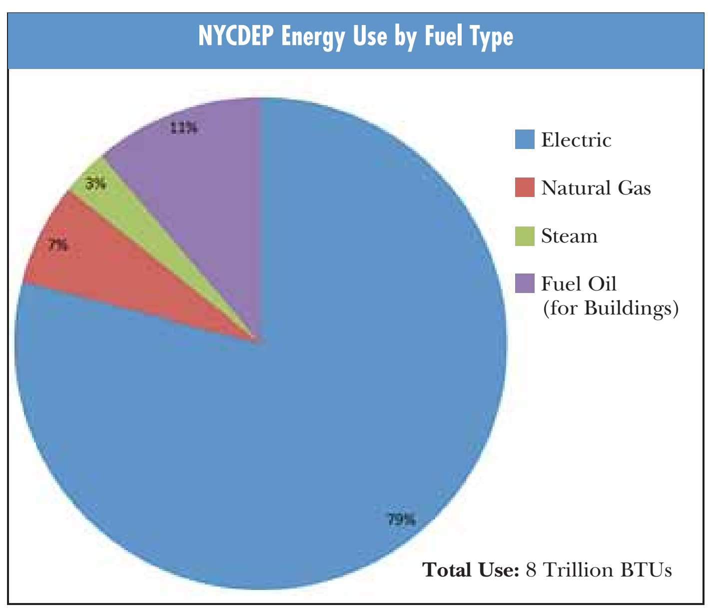
The greatest risks to achieving substantial energy conservation, efficiencies and production are the scarcity of capital dollars, a preference for the utilization of tried and true technology, and the long payback periods for energy projects. Water and wastewater utility operators are responsible for achieving water quality standards and, therefore, protecting the public health and the environment. As such, water and wastewater utilities tend to be cautious about changes in their processes. Regulators will need to be open minded to changes and work with utility managers to facilitate these initiatives. In evaluating energy efficiency, conservation, generation and supply initiatives, it is important to take the long view. Energy efficiency, conservation, generation, and supply initiatives may be superseded for more immediate needs. However, many assets have long life expectancies so it is important to evaluate investments considering the impact of new treatment requirements, air quality standards and energy prices.

NYCDEP – By the Numbers

The New York City Department of Environmental Protection (NYCDEP) is taking a long range view of how it makes investments and how best to promote energy efficiency. The NYCDEP's mission is to protect public health and the environment by supplying clean drinking water, collecting and treating wastewater, and reducing air, noise and hazardous substances pollution. The water supply system is an engineering marvel with a watershed that extends more than 125 miles from the city and stretches over 2,000 square miles. The system is divided among the Croton, Catskill and Delaware watersheds and is comprised of 19 reservoirs, three controlled lakes, over 7,000 miles each of water mains and sewers, and 14 wastewater treatment plants (WWTPs) ranging in size from 40 to 310 million gallons per day of dry weather flow. Approximately one billion gallons per day of water is supplied almost entirely by gravity to half the state's population including 8.3 million people in the city along with residents of Orange, Ulster, Westchester and Putnam counties. In addition, on average, approximately 1.3 million gallons of wastewater is collected and treated.

Energy Intensive Processes

Even with the majority of the system being designed to operate by gravity, it still requires about eight trillion British Thermal Units (BTUs) per year, or the equivalent of powering approximately 91,000 households (more than double the number of households in Albany) to operate the system. For New York City, the water and wastewater systems make up approximately 16 percent of the total municipal energy consumed. Eighty-eight percent of this energy is consumed by the wastewater treatment process. All this energy use costs the agency about $100 million dollars per year – about 10 percent of the operating budget.



As a result of this energy use, NYCDEP's carbon footprint is the second largest in the municipal inventory, second only to the aggregate municipal building stock. The overwhelming majority of the agency's greenhouse gas emissions (87 percent) are associated with the wastewater treatment process. Electricity used for aeration and pumping along with the release of methane as a result of anaerobic digestion accounts for about two-thirds of these emissions.

A Changing Landscape

The future holds increased environmental regulations requiring enhanced water treatment, reduced runoff in terms of combined sewer overflows, and increased nitrogen removal – all energy intensive processes. For example, the Croton Filtration Plant and Catskill-Delaware Water Ultraviolet Disinfection Facility will be coming on line over the next two years to meet new water quality standards and may increase the electricity consumption by as much as 25 percent. The NYCDEP has built four water detention facilities with a total capacity of over 100 million gallons to prevent combined sewer overflows. This water is detained during storms and then must be pumped to the wastewater treatment plants rather than relying on gravity. The department is implementing a green infrastructure program in conjunction with traditional grey infrastructure to reduce combined sewer overflows by 1.5 billion gallons per year by 2030. The green infrastructure program is expected to divert about 900 million gallons per year from the treatment plants, saving on energy required for pumping.

The western Long Island Sound and portions of Jamaica Bay have been identified as waters affected by high nitrogen loads and poor circulation. As a result, seven WWTPs are implementing step-feed biological nitrogen removal (BNR). This requires more energy in a number of respects, the most significant perhaps being increased oxygen demand in secondary treatment. While many

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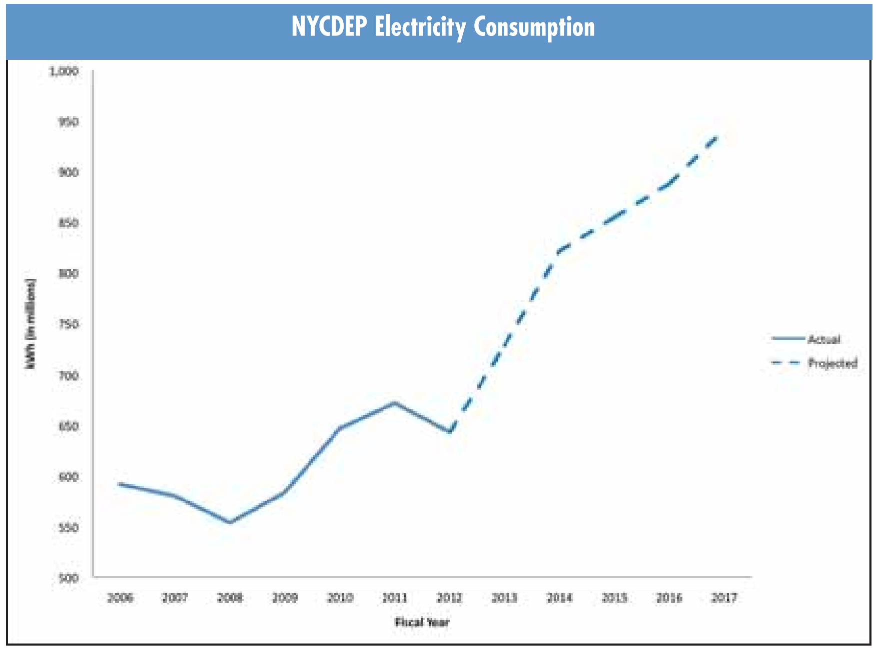

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energy efficiency measures are being explored, including other ways to denitrify (e.g., anaerobic ammonium oxidation), a business-as-usual scenario (i.e., meeting new regulatory requirements without any mitigation) results in a 46 percent increase in electricity consumption through 2017. While energy needs are increasing, the capacity of the energy generation, transmission and distribution systems are facing constraints and having a direct effect on the reliability of the system and the cost to operate it.

With respect to reliability, NYCDEP is seeing an increase in the frequency of distribution system interruptions such as voltage reductions and feeder outages. Consequences of this include the provision of temporary portable generation equipment, repair of failed equipment, and correction of process upsets. In-city power plants are reaching the end of their useful life. The practicality of siting new generation within the city is not favorable and importing energy from farther distances may result in increased reliability concerns (e.g., increased chance of supply interruptions due to storms).While energy prices for the department have been relatively low and stable, there are structural changes occurring in the way customers (including NYCDEP) are being charged. Electricity charges are now being determined not only for how much is being used, but when and how it is used. Tariffs now reflect the type of service provided (i.e., low-tension vs. high-tension), seasonal uses (i.e., winter vs. summer), time-of-day use (i.e., off-peak vs. on-peak), and the type of equipment being powered (i.e., reactive power requirements). These all contribute to increased costs for the agency.

Efforts at introducing climate change regulations on the federal level have been slow to take hold, but there have been some individual state efforts and regional collaborations (e.g. Regional Greenhouse Gas Initiative, Midwestern Greenhouse Gas Accord, and Western Climate Initiative) aimed at initiating policies that move their jurisdictions toward a low carbon economy. Despite the sluggishness of national carbon policy taking hold, trends are in this direction and it is hard to argue that society will never turn current climate science into policy. Reasonable risk management suggests that material climate policy is likely during the useful life of new water, wastewater and energy infrastructure. Whether this manifests itself as cap-and-trade, a carbon tax or something entirely different, the end result is likely increased costs for traditional generation and end-users.

Central Role of New Office of Energy

To meet these challenges, NYCDEP recently established an Office of Energy responsible for setting the strategic energy and carbon goals for the agency, the development of metrics and quality assurance programs for tracking consumption and energy costs, and the management of the capital priorities for energy projects. The water and wastewater industry is facing a paradigm shift from thinking about treating wastewater to recovering resources inherent in the influent stream. The department is defining its long-term goals with this in mind, while setting near-term (increased energy efficiency and renewable energy supplies) and mid-term goals (energy neutral operations) that put it on the path to meeting its long range aspirations. This requires that NYCDEP develops useful metrics to measure progress and to shine a bright light on any headway made so that energy management becomes a part of everyone's thought processes and practices in everyday operations. The agency's capital plan must integrate projects that allow it to achieve near-term, mid-term and long-term energy objectives.

As a first step to this, energy audits of the city's 14 WWTPs have been completed and recommendations are being analyzed to determine what is feasible to implement, what the projected costs are, and what the returns will be in terms of both energy savings and avoidance of greenhouse gas (GHG) emissions. Initiatives will then be prioritized and an implementation schedule developed.

Integrating Distributed Generation and Renewables

In addition to being a large consumer of energy, NYCDEP has the opportunity to become a significant producer of clean energy in New York State. Within the city, it owns and operates facilities each with a favorable footprint for developing renewable energy sources, such as solar photovoltaic cells, wind turbines and biogas for power generation. Further upstate, reservoirs in the Croton, Catskill and Delaware watersheds offer the prospect of harnessing clean, safe and environmentally-friendly hydroelectric power.

Image courtesy of NYCDEP

Spillway on New York City Reservoir representing the energy recovery opportunities in the water transmission system.

A risk-based approach to thinking about energy futures suggests a much greater role for cogeneration and integration of renewables. This will provide for a diversified supply portfolio, control of energy expenditures, and an added level of reliability as fuel supply disruptions will not require the startup of emergency power systems and will not be affected by transportation interruptions (vehicular and marine) as seen during Hurricane Sandy. This approach increases the flexibility of operations; eliminates the need to power down equipment during times of utility capacity constraints; and improves energy efficiency through the capture of waste heat, reduction of greenhouse gas emissions through offsets of purchased power, elimination of transmission line losses, and the use of cleaner fuels.

The NYCDEP is uniquely situated to develop distributed generation using renewables and has been doing so for some time. In fact, during the Northeast blackout of 2003, the Owls Head WWTP never realized that there was a loss of utility power as they were generating all of their energy needs (electric and heat) using anaerobic digester gas (ADG) in compression ignited, internal combustion engines. These engines have been in operation for over 25 years and there is a capital project in place to change their control to increase the amount of ADG they can use and improve emissions beyond local requirements. Similarly, the Coney Island WWTP has four 1,600 kilowatt turbo-charged, compression-ignited engine generators that produce in excess of 80 percent of the plant's electric demands and utilizes all of the ADG produced. Recovery of heat from the engines is used for sludge heating, service water and heating, ventilation and air conditioning needs.

Another combined heat and power project is in design at the North River WWTP. There, 10 compression-ignited, direct-drive engines will be replaced by five spark-ignited, gas driven combination engine generators. The engines will have a working capacity of approximately 10.5 megawatts and will be capable of supplying all base electrical and heating demands as well as all emergency power supply requirements. This project will practically eliminate the need for fuel oil and reduce the plant's carbon footprint by about 30 percent. Finally, we will be investigating the feasibility of installing similar technology at the city's second largest WWTP – Wards Island.

In addition to the cogeneration projects, NYCDEP has used its ADG in fuel cells and is in the midst of a public-private partnership with National Grid to clean ADG from the Newtown Creek WWTP to pipeline quality and inject it into the local distribution system. On average, the plant can only use about 30 percent of its ADG. This project will make certain all of the ADG will be used beneficially and provide enough heat for 2,500 homes or enough annual fuel for 166 city buses.

The NYCDEP is looking beyond the use of ADG for the generation of power and will install a 1.26 megawatt photovoltaic cell system atop the Port Richmond WWTP. Two hydroelectric facilities located on water supply tunnels that transfer water from one reservoir to another are currently in operation supplying more than 115 gigawatt-hours or clean energy per year. A license application and two permits were submitted to the federal Energy Regulatory Commission for three additional hydroelectric facilities with a total potential capacity of approximately 16 megawatts, or enough clean energy to power over 5,000 homes each year.

These North River WWTP direct-drive engines will soon be replaced by engine generators to achieve higher fuel efficiency and a reduced carbon footprint. *Image courtesy of NYCDEP*

Solids Handling: Higher Level of Importance

Much of contemporary thinking has viewed ADG as a free fuel and, as such, little investment has been made in optimizing its production. In the future, the energy inherent in the solids handling process will be viewed as a valuable commodity. Biogas will become a primary fuel for heating, power and transportation. Key to this

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is the ability to improve solids handling and subsequent biogas production. To do this, there must be a shift in thinking such that solids handling is put on the same level as liquid stream treatment. Synergies between solids inherent in wastewater and other sources will be required. Namely, the organic waste contained in municipal solid waste and industrial processes (e.g., breweries) will be needed to supplement wastewater sludge.

The NYCDEP has begun a small scale project in cooperation with the New York City Department of Sanitation, the Department of Education and the firm, Waste Management, to remove organic waste from schools, divert it from landfills, process it into an engineered food waste and introduce it into the Newtown Creek anaerobic digesters to increase gas production for beneficial use.

New Ways to Conduct Old Business

Bolder changes in our wastewater treatment process will also need to take place in order to meet the mid-term goal of energy neutral operations. Secondary treatment is the most energy demanding component of wastewater treatment and accounts for approximately 50 percent of the electricity at the WWTPs. Sidestream treatment of high carbon and nitrogen loads has the greatest opportunity to reduce energy consumption. For example, the department is piloting the denitrification of wastewater at the 26th Ward WWTP through an anaerobic ammonium oxidation process. This process is expected to reduce aeration demands by 60 percent, reduce methanol usage by 2,000 tons a year, and eliminate 5,700 pounds of carbon dioxide emissions a year – saving the NYCDEP about 2.2 million dollars annually.

In addition, the use of algae to filter nutrients is currently

Image courtesy of NYCDEP

An algal turf scrubber was constructed at the Rockaway WWTP to test its efficiency at filtering out nutrients and potential for conversion of the algae to biofuel.

being tested at the Rockaway WWTP. Periodic harvesting of algae removes nutrients and pollutants from the system while stimulating continued algal growth and enhancing uptake efficiencies. The harvested algae can then be harnessed to produce biodiesel.

Planning for the Future

Since water and wastewater facilities generally have long life expectancies, today's investments must not only consider the current environment, but what conditions will look like 20 and 50 years from now. It is known that the population will increase over time, detection limits for water quality contaminants will improve, and the understanding of public health and environmental impacts will evolve. This will likely require more energy intensive treatment processes. In light of this, smart investments with energy must be a key component. Opportunities to meet this challenge include demand-side reductions, increased onsite energy generation, integration of renewable energy, and research, development and implementation of low energy intensity process technologies. The NYCDEP is taking steps on all fronts to meet this challenge by shifting its operations toward energy neutrality and from wastewater operators to resource recovery managers. Energy conservation measures identified through energy audits will curb the demand: optimization of the solids handling process will provide increased gas production for beneficial use; the integration of photovoltaic and hydroelectric power will move the city toward cleaner fuel supplies; and implementation of alternative process techniques, such as anaerobic ammonium oxidation, will allow it to meet stricter environmental requirements with the same or less energy. Rather than following a business-as-usual path, the NYCDEP's current capital plan includes projects that will bring it to within 10 percent of its 2006 baseline GHG emissions. This is an exciting time for the industry as it thinks more in terms of energy efficiency, carbon reductions and resource recovery. This is an opportunity to help direct changes that will improve not only systems, but also the environment and health of everyone involved.

Anthony Fiore is the Director of the Office of Energy in the NYC Department of Environmental Protection. He can be reached at afiore@dep.nyc.gov.

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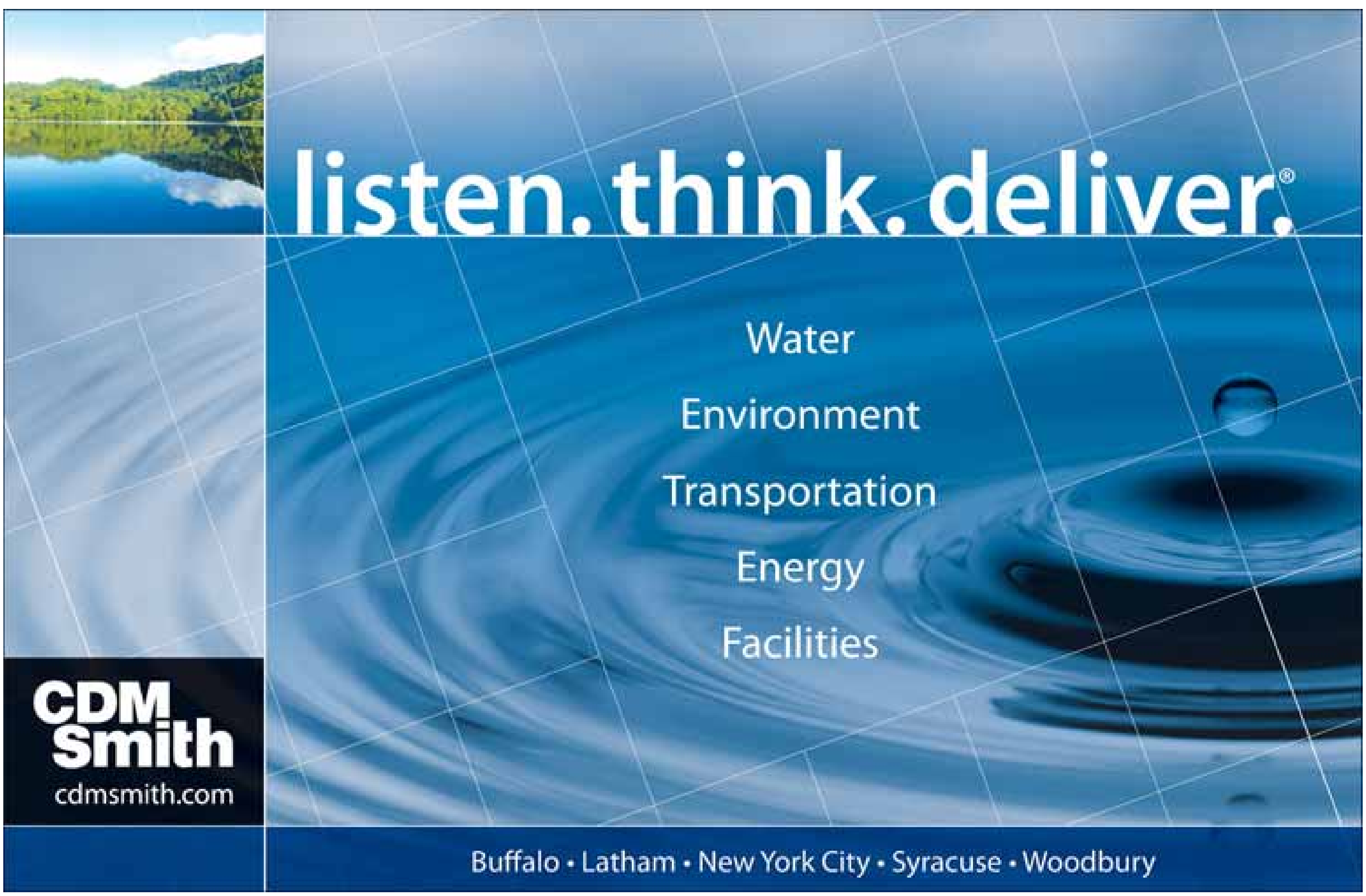

Tapping into Hydrokinetic Technologies for Clean Energy

by Frank Zammataro

The relationship between water and energy has particular meaning to wastewater operators and is fundamental to what is known as the "water-energy nexus." According to the US Environmental Protection Agency, the United States alone has over 410 billion gallons of treated water flowing through pipes every day, a major amount of which becomes wastewater. Approximately 175 billion gallons per day are used by electric power facilities, such as coal and nuclear plants; 150 billion gallons meet agricultural irrigation needs; 40 billion gallons are used in commercial industries, such as pharmaceutical, food and beverage producers; and 50 billion gallons go toward human consumption. In other words, water is necessary for all forms of energy and refining processes, including power plants and manufacturers of everything from silicon chips to beer. As the US economy continues to develop, these industries will grow in size and thereby consume ever greater amounts of water and energy. In fact, according to the USEPA, today approximately four percent of the nation's total energy consumption (up to 20 percent in California) is associated with the distribution and treatment of water.

While there is no clear consensus for addressing this challenge, one thing remains clear – generating energy requires large amounts of water, and providing clean, pressurized water requires large amounts of energy. In the future, a greater demand for energy will increase the demand for water and, in turn, the demand for more water will require more energy.

Energy Recovery is Crucial

The water-energy nexus, when considered with future population and industrial growth, creates the need for new and novel approaches that can take advantage of flowing water while reducing the carbon footprint of water operations. Water and energy systems need to be planned together in order to ensure that operators are as energy efficient and sustainable as possible. Future water or wastewater infrastructure projects should require energy recovery consideration at the drawing board. With over 22,000 wastewater facilities in the US, in addition to the many power and industrial plant waste systems, there must be consideration for new approaches in energy recovery.

Rentricity, Inc. identified the most applicable energy recovery technologies for wastewater outfalls and channels in a recent NYSERDA-funded project (PON 2202: Energy Recovery Wastewater Design.)

Rentricity's review of wastewater infrastructure included open concrete conduit and channel dimensions, water flow rate and velocity, as well as electrical interface equipment. Both outfall weirs and secondary treatment channels ***(Figures 1 and 2)*** were identified as the best locations for energy recovery to be captured, offering on average approximately 12 feet of hydraulic head and four cubic feet per second of flow, respectively.

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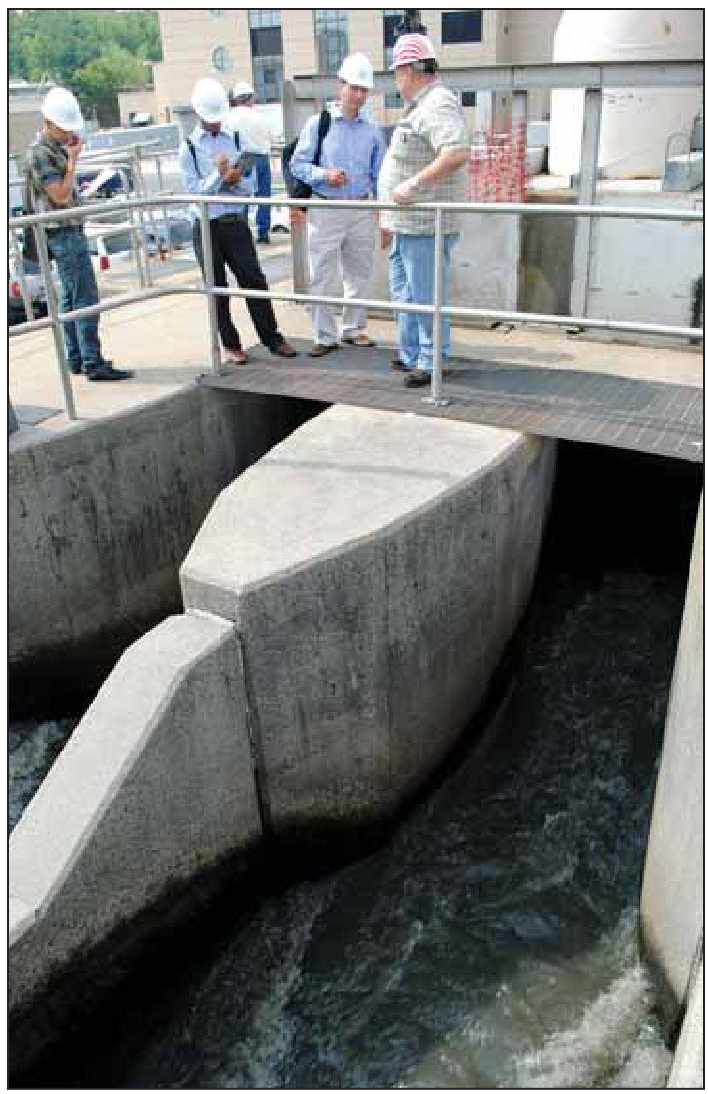
Courtesy of Rentricity

Figure 1. Example of an outfall, an efficient location in which to employ energy recovery technology.



Courtesy of Rentricity

Figure 2. Example of a concrete secondary treatment channel where a hydrokinetic system can be installed.

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Project Technologies

Rentricity chose equipment that would best optimize the available energy potential; however, several integration design challenges exist, including concentrating the water flow and alterations to the concrete bunkers. The most significant challenge when addressing wastewater channels and outfalls is the invasiveness of the energy recovery systems. This often requires adjustable height racking systems to easily adjust the turbines for changes in flow and to ensure maximum energy recovery efficiency.

For the outflows technology, Rentricity selected the Hydrovolts industrial waterfall cross-flow turbine. For the channels, the company chose the Natel impulse hydropower turbine, called the hydroEngine.™

Courtesy of Rentricity

Figure 3. A rendering of the Hydrovolts turbine engine.

Outflows Technology: In the Hydrovolts cross-flow turbine, water moves through a turbine across blades and the rotational motion of a runner, then through a speed increaser which drives a permanent magnet generator to create variable frequency. It is best utilized in applications with low head and high flow, such as the outfall weirs. Self-contained units, these can be quickly installed, require low maintenance, and continuously generate electricity as long as water is flowing. Each unit can produce between 1.5 and 30 kilowatts. The average turbine efficiency for the system is about 70 percent, and it has a full installation cost of between $4,000 to $6,000 per kW. This system was selected as the technology of choice because it has an acceptable payback – between five to seven years – and can be easily installed at wastewater sites. Rentricity also preferred these turbine units because they are rugged with few components.

The turbine unit is shown in the rendering ***Figure 3*** and the photos ***(Figures 4 and 5)*** represent how this system looks being installed in plant outfalls. As depicted in Figure 3, gating would be installed to concentrate the flow into the penstock (conduit) through the turbine.

Channels Technology: The hydroEngine™ is optimized for large flow rates, not high pressures, where the available head ranges between five and 20 feet. It is well suited for channels where it

Courtesy of Hydrovolts

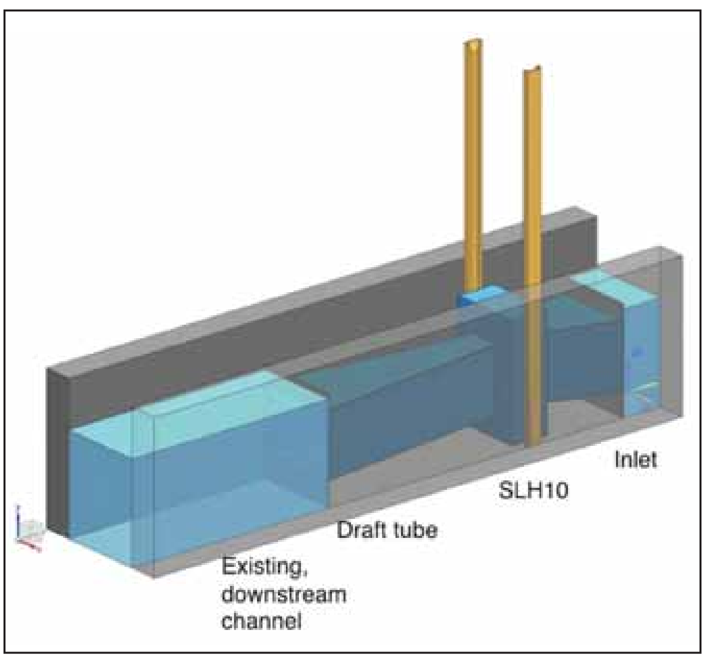
Figure 4. The cross-flow turbine engine being lifted into place

Courtesy of Hydrovolts

Figure 5. Shown in operation, the turbine generates electricity through the outflow.

Courtesy of Natel

Figure 6. The hydroEngine™ small turbine system ready to be installed.



Courtesy of Rentricity

Figure 7. Diagram of the SLH10 system within an open concrete channel

utilizes the rate of volumetric flow. It is a two-stage, axial-flow, fully flooded impulse machine with uniform cross section and velocity ratios. Each turbine has adjustable guide vanes, which optimize the unit's performance as flow varies, and is cavitation free. Similar to the outfalls machine, this system requires minimal maintenance, has a low associated installation cost and is able to generate electricity across a wide range of flows. The smallest turbine (the SLH10) can produce between 10 and 50 kW. The average turbine efficiency for the system is approximately 80 percent, and the full installation cost is between $2,000 and $4,000 per kW. Rentricity selected the SLH system ***(Figure 6)*** for its high quality and applicability to wastewater channels. ***Figure 7*** depicts how the SLH system would be integrated into an open concrete channel.

Noting these two project examples, wastewater operators can benefit significantly from exploring the use of emerging hydrokinetic technologies for existing and new wastewater infrastructure. Future increases in energy costs and increases in water usage will create a nexus that will eventually trickle down to every wastewater operation in the nation.

Frank Zammataro (frankz@rentricity.com) is founder and CEO of Rentricity, Inc., based in New York, New York. Rentricity is a renewable energy company that develops in-pipe hydropower solutions that generate clean electricity from excess pressure in water pipes. Rentricity's systems have applications in water, wastewater and industrial process piping systems. For more information, visit www.rentricity.com, or write to info@rentricity.com.

Sludge Co-Thickening and Biogas Cogeneration in the Electric City

by Vincent Apa

Electricity and the Light Bulb

In 1879, Thomas Edison produced a reliable, long-lasting source of light using lower current electricity, a small carbonized filament, and an improved vacuum inside the globe. The idea of electric lighting was not new, as others had already developed forms of electric lighting. However, until Edison's invention, nothing had been developed that was remotely practical for home use. His eventual achievement went beyond developing not just an incandescent electric light, but also an electric lighting system that contained all the elements necessary to make the incandescent light practical, safe and economical. After one and a half years of work, success was achieved when an incandescent lamp with a filament of carbonized sewing thread burned for 13 and a half hours.

Electric City and Cogeneration from Renewable Resource

Electricity has always been a vital part of the economy in the City of Schenectady. In 1887, Thomas Edison moved his Edison Machine Works to Schenectady and in 1892 it became the headquarters of the General Electric Company. Fast forwarding over a century, the "Electric City" began investigating cogeneration options at the Water Pollution Control Plant (WPCP) in 2006. An Energy Advisory Board was created in May 2007 just after the US Mayors' Climate Protection Agreement was signed pledging to reduce the city's carbon footprint seven percent by 2012.

The city hired CDM Smith in late 2007 to independently evaluate viable options for beneficial use of biogas produced from the WPCP based on various proposals received. The primary objective of the work was to identify a plan that would provide the most cost effective use of biogas. A more detailed study, completed in 2009, focused on sludge thickening, digester upgrades, improved biogas production and cogeneration. The design for this was completed in early 2010, and construction was started in March 2010 and completed in January 2012.

Plant History

The plant was initially built in the early 1900s and included primary settling tanks. The facility has been upgraded over the years with major projects that included:

- Anaerobic digesters, Screen Building, grit detritor, Auxiliary Sludge Disposal Building and Digester Control Building (1950s)
- Secondary treatment upgrades (e.g., aeration tanks, secondary clarifiers, chlorine contact tanks), Main Sludge Disposal Building (1970s)
- In-vessel sludge composting system (1987)
- Liquid chlorine disinfection system and diffusers (1995)
- Centrifuge dewatering (1996)
- Diffused aeration system and blowers (1996)
- New mechanical bar screens (2003)
- Peripheral (Stamford) baffles in four secondary clarifiers (2006)
- Digester cleaning and mixing upgrades (2007)
- New gravity belt thickeners (GBTs) for co-thickening primary sludge (PS) and waste activated sludge (WAS) (2011)
- Anaerobic digester cover replacement, biogas dampening/storage, biogas conditioning and cogeneration (2010 to 2012)

Current Unit Processes

The current major unit processes at the City of Schenectady WPCP include mechanical bar screens, grit removal, primary settling tanks, fine bubble diffused aeration, secondary clarifiers and liquid chlorine disinfection. Plant effluent usually flows by gravity but is pumped to the Mohawk River when the river levels are high. The PS and WAS are co-thickened in gravity belt thickeners (GBTs), anaerobically digested, dewatered by a centrifuge and hauled to an off-site landfill. An overview of the current unit processes is shown in ***Figure 1*** and an aerial view of the facility is shown in ***Figure 2***.

The plant has a permitted monthly average flow of 18.5 mgd. The treatment plant is also required to be capable of receiving a minimum of 27.75 mgd through the secondary treatment system during wet weather. Currently, the average day flow is 15 mgd with a peak day flow of 34 mgd. The influent biochemical oxygen demand (BOD) and total suspended solids (TSS) concentrations are 130 mg/L and 160 mg/L, respectively.

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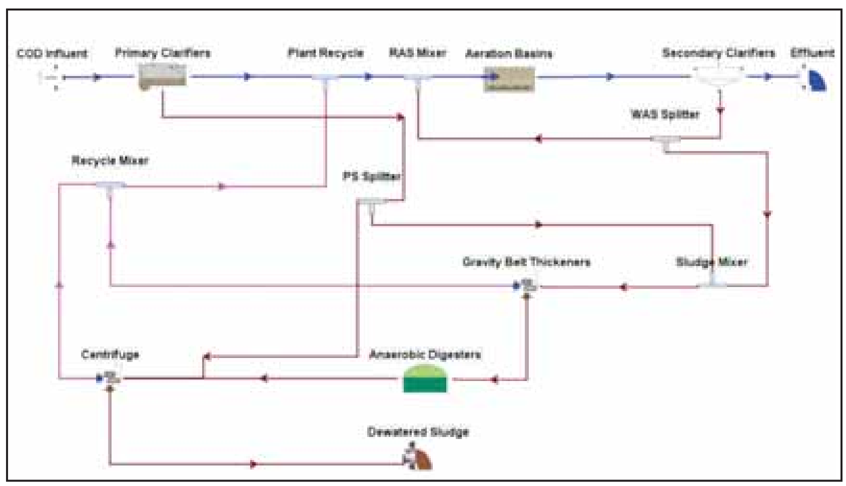

Graphic courtesy of Vincent Apa

Figure 1. The current process flow diagram at the Schenectady plant

Photo courtesy of Google Earth

Figure 2. Aerial view of Schenectady's Water Pollution Control Plant

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The composting facility was shut down at the end of July 2012 due to the rising price and availability of amendment (sawdust and wood chips), equipment failures and the associated energy cost for operating the facility. Without the compost system in operation, the odor control chemical scrubbers have also been shut down.

Historical Power Consumption

As part of the early evaluation, power demand and usage was analyzed. During the time period of December 30, 2006 to February 29, 2009, the city's total plant electricity cost was $57,000 per month or $684,000 annually. Of this total cost, the monthly demand charge was over 20 percent. The total cost of power ranged from $0.11/kWh to $0.19/kWh, with an average monthly total cost of $0.14/kWh. The average monthly usage was approximately 410,000 kWh.

The demand charge is assessed by the utility as the highest average kW measured in a 15-minute interval during the billing period. When the centrifuge was operational, the average demand was approximately 650 kW and the peak month was 750 kW.

Deficiencies Before This Project

Prior to the recent upgrades, the following deficiencies existed:

- Majority of PS was not digested
- Poor thickening of WAS in dissolved air floatation thickeners (DAFT)
- Lack of anaerobic digester capacity (thin sludge, low solids retention time)
- Very limited digester gas storage with floating covers (and not fully sealed tanks)
- Digester gas used by dual fuel boiler for process heating only
- Periodic digester foaming incidents

Key process parameters for the digesters prior to the upgrades are shown in ***Table 1***.

It is well documented that methanogens (bacteria that produce methane) grow slowly in the mesophilic temperature range. They require at least a 10-day SRT (solids retention time) to keep the acid formers in balance. When the SRT is <10 days, methanogens can be washed out. Although this plant was running above the washout SRT, it was lower than typical operation of similar facilities (15 to 20 days).

In addition, VSR (volatile solid reduction) and biogas production can drop when the SRT is less than 15 days. One of the objectives of these upgrades was to reduce the amount of PS bypassed around digestion and increase the SRT to improve digester gas production. Design standards recommend a 15 to 20 day maximum month SRT for process stability, achieving a Class B process to significantly reduce pathogens PSRP (process to further reduce pathogens) and optimal biogas production.

Based on the low VSR and quantity of PS being bypassed around digestion prior to the upgrades, the plant generated enough biogas to fuel a 100 kW reciprocating engine on average. As with any digester, the quantities of biogas produced and methane content are measures dependent on the feed substrate.

Community Based Goals

As part of the extensive project planning, the following goals were developed for the plant and neighboring community:

- Improving sludge thickening, digestion and biogas production
- Providing sufficient gas storage/dampening
- Upgrading aging infrastructure
- Using biogas to generate power and utilize waste heat
- Reducing sludge mass and solids handling costs
- Reducing odors by completely covering digesters
- Demonstrating technology for other plants

Like the incandescent light bulb, the City of Schenectady was looking for a cogeneration technology that was reliable, safe and economical for its staff and the community.

Geographic Location and Competition

Schenectady is geographically located almost in between two progressive wastewater treatment facilities, the Albany County Sewer District and the Johnstown-Gloversville Joint Wastewater Treatment Facility. Historically speaking, the City of Schenectady has not received the attention or funding support of its neighbors and executing large capital improvement projects has been challenging. This has been even more challenging for the Schenectady WPCP, a facility with a significant portion of its infrastructure constructed 50 to 100 years ago still in operation.

Design and Construction Overview

The fast track design was completed in four months and American Reinvestment and Recovery Act (ARRA) compliant documents were generated to meet funding requirements.

Unique cost saving design features included:

- Creation of a wet well in each existing concrete DAFT tank
- Submersible nozzle and chopper pump for blending PS and WAS in each wet well
- Installation of GBTs with new I-beams on top of DAFT tanks to co-thicken PS and WAS
- Polymer blending systems to dilute mannich polymer in neat form (no manual dilution required like existing system)

New plunger pumps and variable frequency drives for pumping PS were provided. In addition, a programmable logic controller (PLC) was installed for sequencing the associated motor operated valves and pumps on timed intervals. This provides a consistent ratio of

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Table 1. Anaerobic Digester Process Parameters Prior to Upgrades

Parameter	Unit	Average Day	Maximum Month	Maximum Day
Digester Feed Total Solids	%	3.0		
Digester Feed Volatile Solids	%	79		
Volatile Solids Loading Rate	lb/day*ft3	0.09	0.12	
Solids Retention Time (SRT)	day	15.7	12.0	
Digested Sludge Total Solids Concentration	%	2.2		
Volatile Solid Reduction (VSR)	%	38		
Dewatered Cake Total Solids	%	25		
Biogas production	scf/day	46,856		99,028
Primary sludge bypassed around digestion (mass)	%	70		

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PS and WAS sent to GBTs. The existing primary settling tanks were converted from Imhoff tanks many years ago. They have small sludge hoppers that require short pumping durations to limit the amount of water directed to the pump, but frequent pumping to prevent too much compaction.

Rotary lobe pumps were installed to send combined sludge from each wet well up to the operating GBT. Thickened sludge drops into a small common hopper (3,000 gallons). From the hopper, larger progressing cavity (PC) pumps were installed to deliver up to eight percent thickened sludge to digesters. The new PC pumps were designed with 25 hp motors, as compared to 10 hp on the existing pumps. Sludge is pumped over 600 feet and more torque was needed to move the fluid. This is important especially when pumping is not continuous like at this plant.

The earthen-bermed digesters were originally configured in the 1950s as two trains of primary and secondary digesters (four digester tanks total). All of the concrete tanks are 65 feet in diameter and have a 20 foot straight side wall height plus a 6 foot deep cone bottom. The current configuration includes two heated and mixed digesters, with an unmixed and unheated tank used as a secondary digester. Digested sludge is stored in the secondary digester prior to being pumped to the centrifuge for dewatering.

Fixed steel covers were installed on top of the two active digesters to fully seal them and reduce potential odors. A flexible, dual membrane cover was installed on top of the secondary digester to collect residual biogas and store/dampen gas produced in the two active digesters. The dual membrane cover provides approximately 47,000 cubic feet (cf) of biogas stored when fully inflated. Another 30,000 cf of biogas storage is provided by the freeboard – the distance between the operational sludge level in the digester and the top of the tank – where the dual membrane cover is anchored.

In addition, explosion proof motors were installed on various pumps in the Digester Control Building to comply with current code requirements. The digesters were upgraded from manual to automatic feeding by the addition of electric operated knife gate valves and controls programming. The controls maintain a constant level in the digesters. One digester is filled while the other is withdrawn from based on an adjustable flow set point. Currently, the plant feeds either of the two active digesters approximately 1,500 gallons every two hours at a flow rate of 70 to 80 gallons per minute (gpm).

A robust biogas treatment system was installed and included:

- Hydrogen sulfide removal vessels (2) with iron oxide based media
- Particulate/coalescing filter and positive displacement blowers (2)
- Dual core heat exchanger (1)
- Glycol chiller (1)
- Siloxane removal vessels (2) with polymorphous graphite media
- Particulate scrubber with polypropylene mesh (1)

This biogas treatment system was designed to reduce engine operation and maintenance (O&M) costs and increase engine component life. Highly corrosive sulfur compounds can condense out of the biogas and damage engine components (e.g., piston head, after-cooler and oil cooler). During combustion of biogas in an engine, silica and silicates are formed. They deposit on engine head cylinders and exhaust heat recovery equipment causing increase in wear of engine valves, cylinder walls and piston rings. Siloxanes can also reduce the life of engine oil and spark plugs.

A new 280 kW lean burn reciprocating engine was installed to run on biogas only and parallel the utility. It was designed to run at less than full load continuously. It should be noted that as the engine load is reduced, the heat rate of spark ignition engines increases and efficiency decreases. The efficiency at 50 percent load (minimum) is approximately eight percent less than full load efficiency.

The recovered hot water from the engine satisfies the heat demand for the digesters and is distributed to unit heaters in two buildings. In addition, a dual fuel boiler (biogas and natural gas) was installed to supplement the heat demand or operate when the engine is out of service. Waste biogas is sent to a new flare.

Many of the buildings and structures were built in the 1950s and were renovated for the installation of new equipment. New and energy efficient heating systems were installed, and repairs were made to roofs and building exteriors. The project focused on renovating aging infrastructure wherever possible rather than erecting new structures or buildings.

A new State Facility Air Permit application was submitted for approval to the regulatory agency. Extensive coordination was necessary with the utility for parallel operation of the engine generator.

Many new PLC panels were tied into a new alarm panel to give operators more control, monitoring capabilities, data trending and overall flexibility. The sequence of construction was also challenging while maintaining plant operations. The construction was done by three prime contractors in five existing buildings and one new building (Cogeneration). The gravity belt thickeners (GBTs) were installed one at a time, while the digesters were taken out of service simultaneously for safety reasons. The contractors were given four

Photo courtesy of Vincent Apa

Figure 3. Two gravity belt thickeners (GBTs) are installed in the Main Sludge Disposal Building.

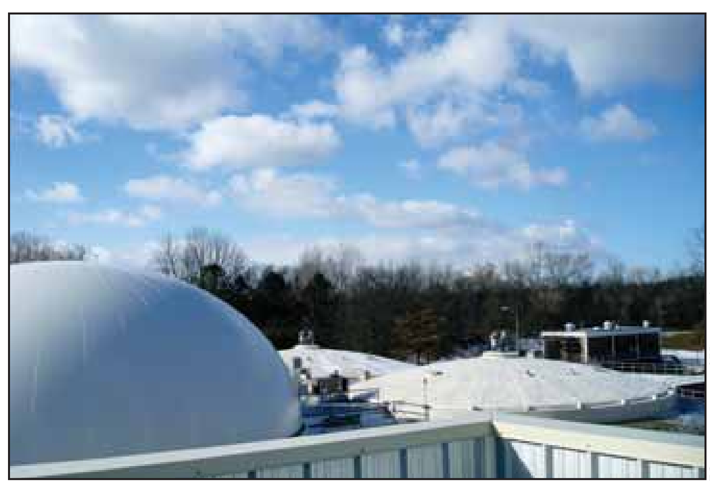

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Figure 4. Digester covers and flexible membrane gas holder (seen left) at the plant.

Photo courtesy of Vincent Apa

Figure 5. A biogas fueled reciprocating engine

months from when the owner had the digesters emptied to complete the work.

A few images of the upgrades are shown here. ***Figure 3*** shows the new GBTs, while ***Figure 4*** depicts the new digester covers and flexible membrane gas holder cover. ***Figure 5*** shows the biogas fueled reciprocating engine.

Results Since Upgrades

The digesters were successfully placed back into operation in August 2011.

Results from this time to January 2013 show the following:

- ~70 percent primary and 100 percent WAS co-thickened and digested
- GBTs have increased total solids fed to digesters from three to six percent
- Average SRT increased from 16 to 25 days
- Volatile solids reduction increased from 38 to 48 percent
- Biogas production increased from 47,000 to 96,000 scf/d
- Monthly power consumption decreased by 120,000 kWh ($33,100)
- Dewatering operation reduced from four to three days/week
- Centrifuge cake solids decreased from 25 to 23 percent

The engine has run at 180 to 200 kW on average since successful commissioning.

In early January 2013, the city changed how the centrifuge was operated and began running the machine approximately 14 hours a day, five days a week. This was done to potentially reduce labor costs and be able to send more primary sludge to digestion. Digester gas production has increased and the engine runs at an average output of 220 kW now.

Figure 6 shows digester alkalinity and volatile acid concentrations once the digesters were put back into service and operating in a stable fashion. Some of the dips in alkalinity in August 2012 may be due to the addition of small quantities of cheese whey which was accepted to increase revenue and boost biogas production.

The digested sludge pH is represented in ***Figure 7*** and shows stable operation for both active digesters.

The thickened sludge discharged from the GBT as fed to the digesters is shown in the ***Figure 8*** chart with total solids percentages.

The methane concentration in biogas was measured after the upgrades were completed. Methane typically has a heating value of 900 up to 1,000 BTU/scf. The conservative biogas lower heating value was calculated by multiplying measured methane content and a lower heating value of methane at 900 BTU/scf. These results are shown in ***Table 2***.

Graphic courtesy of Vincent Apa

Figure 6. Levels of alkalinity and volatile acids in digesters 1 and 2.

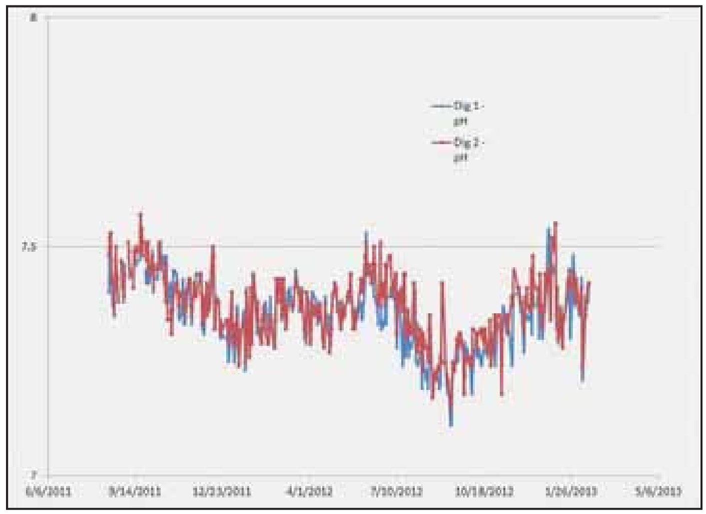

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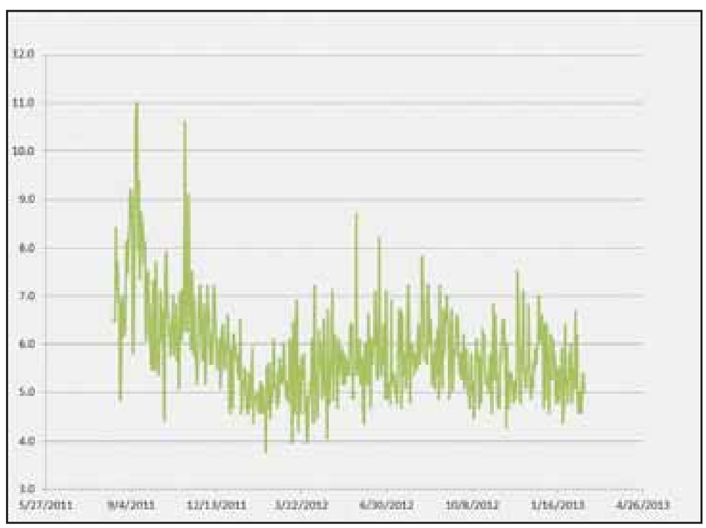
Figure 7. Digesters' sludge pH shows stability over time.



Graphic courtesy of Vincent Apa

Figure 8. Digesters feed total solids from the gravity belt thickeners as shown in this data chart.

Literature values for well operated digesters suggest that methane concentrations of biogas should be 60 to 70 percent by volume *(Water Environment Federation, 5th Edition, 2010)*. Based on the literature values, the methane concentrations from the plant and subsequent biogas heat value show the digesters are performing well and producing a high quality fuel for cogeneration.

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Table 2. Biogas Heat Value Results

Date	Methane Concentration(%)	Biogas Lower Heat Value (BTU/scf)
8/5/11	70.6	635
9/9/11	64.1	577
9/10/11	63.4	571
9/11/11	62.6	563
9/12/11	62.6	563
2/27/12	64.0	576
AVG	64.6	581

Taking Back Operations

The city entered into an Operations, Maintenance and Management Agreement with a private company in 1992. This was renewed on January 1, 2002 for a 10-year period. However, the service agreement between the private company and the city was not renewed on December 31, 2011 and the city took back these responsibilities. This decision has proven financially beneficial to the city. In 2012, it collected over $435,000 in revenue from septage, liquid sludge, some cheese whey and the sale of compost (minor amount).

Factors Discussed

The VSR for high rate mesophilic anaerobic digesters is typically 45 to 55 percent (*Water Environment Federation, 5th Edition, 2010*). The mass ratio of primary sludge to WAS that is thickened and digested is currently 0.6 at the plant. Although the VSR has increased 20 percent on average after the upgrades, this high ratio of WAS is more difficult to digest and may explain the VSR of less than 50 percent.

In addition to higher SRTs, the elimination of the holding tank to feed the digesters has resulted in more stable digester operation and minimal foaming. Volatile acid concentrations were measured during startup when the holding tank was still being utilized due to construction sequencing. Results showed volatile acid concentrations in the holding tank of 1,500 mg/L on average, as compared to less than 50 mg/L from the small thickened sludge hopper below the GBTs.

The city has chosen to bypass a small portion of primary sludge to maximize dewatering centrifuge cake solids and engine power production. If all primary sludge was sent to the digesters, the engine would run closer to full load, but cake solids would decrease from 23 percent to 19 percent based on full scale test results. This would result in additional sludge hauling and disposal costs. The current bypass of approximately 15 percent of the primary sludge around digestion to dewatering is deemed to be most cost effective.

The decision to install a robust biogas conditioning system is site and plant specific. If the biogas conditioning system were reduced in scope, engine oil changes would be more frequent. With a less robust system, oil changes could be required every 700 hours. However, engine oil changes have averaged every 1,300 hours. This can result in savings of $25,000 per year. For reference, the installed cost for this biogas conditioning system was approximately $235,000 more than the engine and switchgear.

Also, the predicted hydrogen sulfide and siloxane removal media life was three years and six months as estimated by the manufacturer, respectively. Air testing of the installed equipment shows the estimated media life should be well exceeded for the more expensive

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siloxane media and possibly hydrogen sulfide media as well.

Other benefits of this project are related to air emissions and demand shaving. The biogas is treated and has lower emissions from the engine generator as compared to the former boiler and flare systems which were demolished. This project is also reducing the peak demand periods, which should free up power during critical times.

Although there are many benefits to cogeneration, there are additional motor loads that need to be accounted. One specific example is that the biogas is boosted from an eight-inch water column to almost three psig (pounds per square inch, guage) at the engine inlet. A list of cogeneration related motor loads for this project includes:

- 25 hp hot water loop pump
- 5 hp flexible membrane cover blower
- 2 hp biogas gas compressor
- 14 kW chiller
- 1 hp waste heat dump radiator fan motor
- HVAC

Demonstration for Sustainability and Model for Others

It is estimated that almost 25 percent of the water resource recovery facilities (wastewater treatment plants) in New York State and over 80 percent of the dry tons of sludge produced per year are treated by anaerobic digestion *(NYSDEC, 2010)*. However, the number of facilities utilizing cogeneration from biogas remains low.

This project will serve as a technology transfer for many other wastewater treatment plants in the state. It is hopeful that the number of engine generator manufacturers grows and the cost of biogas conditioning is reduced to make more projects financially feasible.

The total cost of this project was almost $7 million. A $1 million grant was received from the New York State Energy Research and Development Authority (NYSERDA), where the facility is being used for data collection and as a showcase to transfer knowledge to others. Another $0.5 million grant was received from the Department of Energy.

Positive Conclusions

This project has met all goals established at the beginning. The O&M costs for the WPCP have been significantly reduced by producing power and heat from a biogas fueled engine. Sludge production has also decreased with improved digestion, and an increased ratio of sludge digested. This has resulted in further savings by running the sludge processing equipment fewer hours per week and having less material for final disposal.

The project has less than one year left of the demonstration and data transfer. Other facilities are expected to maximize use of their infrastructure in a similar fashion and make investments as necessary in the future based on the work done under this project.

The city has authorized the design for up to two new dewatering centrifuges and is planning for conversion of another out of service digester back into operation for treatment of future loads for this regional facility, including more high strength cheese whey. This will provide a total of three active digesters plus the secondary digester.

There are also potential plans for a new sludge dryer to further reduce overall costs if disposal costs significantly increase or merchant cake is readily available.

Even with the progress made on this project, the city continues to look for opportunities to decrease energy usage, increase revenue and upgrade aging infrastructure with a long term goal to get closer to becoming a net zero facility. An evaluation is to be performed on the aeration system to install a smaller blower and possibly more efficient diffusers as well to further reduce electricity consumption.

***Vincent Apa** is Principal Engineer in the Albany, New York office of CDM Smith and may be reached at apavl@cdmsmith.com.*

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Emergy Accounting for Assessing the Sustainability of Wastewater Management Systems

by Douglas Daley

Sustainability is one of many factors that are considered in the design, operation and maintenance of wastewater collection, conveyance and treatment systems. The decision about what metrics to use to determine system sustainability is challenging. This article introduces a method of analysis that is suitable for comparing sustainability of environmental systems that use very different resources, including materials of construction, energy, water and chemicals. ***Emergy analysis*** (a term meaning the total amount of solar energy used directly and indirectly to make a product or provide a service) has been used to determine the sustainability of systems that have human and environmental benefits and costs. Application of emergy analysis in wastewater systems has demonstrated that the expenditure of purchased resources such as electricity offsets the consumption of environmental resources that would result from discharge of untreated wastewater to the local environment. With increased interest in designing and operating wastewater treatment systems to meet "net zero" goals, emergy accounting is another tool to compare widely disparate treatment and conveyance processes.

Design for Sustainability

Sustainability needs to be considered from the onset of the planning and design process. The engineering profession explicitly states in both education requirements and rules of practice that designers address sustainability. Engineering students graduating from an ABET-accredited (Accreditation Board for Engineering and Technology, Inc.) program "must be able to design a system, component or process to meet desired needs within realistic constraints such as … sustainability (ABET 2013)." Through codes of ethics, engineers are "encouraged to adhere to the principles of sustainable development" *(National Society of Professional Engineers, 2013)* and to protect and improve the environment using "the principles of sustainable development so as to enhance the quality of life of the general public (American Society of Civil Engineers, 2013). In 2009, the ASCE (2013) defined sustainable development as the "process of applying natural, human and economic resources to enhance the safety, welfare and quality of life for all of society while maintaining the availability of the remaining natural resources."

The natural outcome of the design profession's use of sustainability as a design criterion was the inevitable demand for a means to assess the sustainability of alternative solutions. The US Green Building Council (USGBC) responded with the Leadership in Energy and Environmental Design (LEED®) program in 1998. The USGBC initially developed the rating system focused on new building construction, recognizing that reducing energy and water use demands in buildings could have immediate and long lasting benefits *(USGBC, 2007)*. One limitation to the application of a rating system to buildings is that certain elements of system design, operation and maintenance that are important locally may not be weighted accordingly, and the comparison of alternative methods that utilize radically different resources is challenging.

The Water Environment Federation (WEF) position on energy sustainability recognizes that wastewater treatment plants "produce clean water, recover nutrients… and can reduce the nation's dependence on fossil fuels *(WEF, 2012)*." As each of these outcomes implies, the use of centralized wastewater management systems is consistent with the principles of sustainable development. But, the degree to which the design, selection, organization and operation of unit processes produce a sustainable system demands the use of a comprehensive means of measuring progress towards a "more sustainable" future. Much of the consideration of sustainability for wastewater systems has been focused on improved energy efficiency. Other aspects, especially the use of local resources such as site selection, material utilization, recycling and recovery, and design innovation have been overshadowed.

Emergy Analysis Defined

Emergy is a relatively new concept that is defined as the sum of all available solar energy used up, both directly and indirectly, to make a service or product *(Odum and Odum, 1983)*. Emergy analysis accounts for the direct and indirect use of a resource, and is similar to economic analysis, where the economic cost (or benefit) of the product or service is the sum of all energy costs and benefits incurred, or otherwise embodied in the ultimate product or service. Where economic analysis uses a unit of monetary measure (e.g., dollars), emergy analysis uses a solar emjoule (sej) as its basic unit. **Transformity** (sej/j) is the emergy per unit of available energy (joules) and is a measure of the "quality" of the solar emergy through the chain of input/output processes. This approach is similar to a life cycle approach that considers the total inputs to a product. Essentially, the greater the transformity, the greater the amount of environmental activity is needed to produce the product *(Brown and Ulgiati, 1997)*.

Emergy analysis is a systematic approach to consider environmental and economic sustainability at a systems level. It allows one to determine at a point in time and space whether a system or process can be considered sustainable. Man-made processes and systems are known to grow and decline in ways that are similar to natural ecosystems, and all are connected by energy flow. Sustainability then is not necessarily a static or even steady-state condition, but may range across a spectrum from non-sustainable (using only stored nonrenewable energy or resources) to completely sustainable (using only renewable resources).

As with analysis of economic sustainability, the flow of energy in a system provides a useful means to determine its sustainability. Metrics used in emergy analysis such as "net yield," "renewability" and "environmental load" each determine the sustainability of a process or service. Traditional energy analysis, typically focusing on operational energy flows, is not well-suited to accounting for the various and different materials and services that comprise the system. In a similar fashion to life cycle accounting, emergy analysis considers the "embodied energy" that comprises each system component or process.

Emergy analysis uses a special emergy accounting network diagram ***(Figure 1)*** to describe the local renewable emergy inputs (R), local nonrenewable inputs (N) and purchased inputs from outside of the system boundary (F) that are needed to yield (Y) a product or service. A ground, or sink, term is used to express waste. As illustrated in ***Figure 1***, the network diagram uses symbols to describe the emergy flows. Emergy based indices ***(Table 1)*** are computed to indicate system performance measures such as emergy investment ratio (EIR), emergy yield ratio (EYR), environmental loading ratio (ELR), and index of sustainability (ESI).

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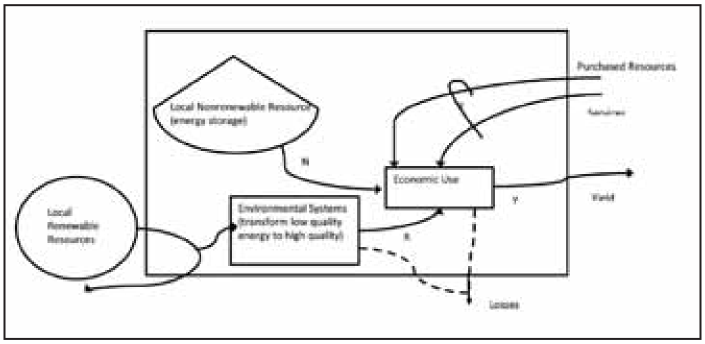

Brown and Ulgiati, 1997

Figure 1. Emergy Accounting Network Flow Diagram

As expected, if one strives to achieve sustainability, a system should be designed and operated to maximize the emergy yield ratio EYR (by reducing purchased emergy, or increasing emergy yield) and/ or to minimize the ELR (by increasing the use of renewable emergy resources or decreasing the use of purchased and nonrenewable emergy resources). High values of EYR (EYR>5) would have high economic benefit, as well as favorable competition against other resources. Low values of ELR (ELR<2) indicate either low environmental impact, or processes that have a large area in which to minimize the environmental impacts (e.g., large assimilation capacity). Finally, processes and systems with an ESI >5 are considered sustainable in the long-term, while 1<ESI<5 may have sustainable aspects over shorter periods. An ESI<1 is not considered sustainable in the long term; conversely, an ESI>10 may indicate that the system is underdeveloped and does not meet the sustainability definition of providing economic and environmental benefits.

Ecological engineering activities in the water environment, such as treatment wetlands and green infrastructure, emphasize the effective use of both renewable and nonrenewable emergy such that there is not only a net benefit to society, but environmental load is minimized. Brown and Ulgiati *(1997)* point out that the ESI is a function of three variables, not just two as the ratio might indicate. Thus, sustainability is not just predicated by a low requirement of feedbacks; a large input of emergy from outside the system may be sustainable as long as this creates an opportunity to exploit a very large amount of emergy from local renewable resources.

What distinguishes the emergy analysis from other types of sustainability assessments is findings such that wastewater inputs to a typical wastewater treatment facility represent the greatest emergy input due to wastewater's material, thermal, chemical and potential energy content. Oxygen consumption is the greatest renewable emergy contribution while construction materials and electricity dominate non-renewable external resources. Emergy analyses have found that the large amount of emergy in wastewater is balanced by the amount of resources used for treatment and the extensive ecosystem effects that would result from the discharge of untreated wastewater *(Bjorklund, Geber and Rydberg, 2001)*.

Case Studies

Emergy evaluations are used to determine environmental sustainability for systems that produce environmental and human benefits. Emergy analysis was able to quantify the increased environmental sustainability achieved at a municipal wastewater treatment plant when a reclaimed water reuse subsystem and aerobic sludge compost subsystem replaced potable water use and landfilling *(Zhang, Deng, Wu and Jiang, 2010)*. The advantage of using the emergy evaluation was that they were able to incorporate the emergy value of human health impacts from air pollutant emissions and the emergy value of the landfill resource into the analysis.

Three waste management systems (composting, landfilling and waste-to-energy) were evaluated using emergy analysis *(Marchettini, Ridolfi and Rustici, 2007)*. This study determined that composting (EYR=3.9) is better at recovering emergy (e.g., nutrients), but incineration is better at resource extraction, even if it is less efficient. As expected, landfill disposal (EYR=0.19) has a much greater resource use than either of the other two.

Table 1. Emergy-Based Indices

Emergy Based Index	Formula	Description
Emergy Investment Ratio **(EIR)**	= F/(N+R)	Ratio of purchased resources and services (from outside the system) to the nonrenewable and renewable emergy inputs inside the system boundary
Emergy Yield Ratio **(EYR)**	= Y/F	Ratio of emergy yield of output to emergy inputs from outside the system. Measure of the ability of the process to exploit local, rather than outside, resources
Environmental Loading Ratio **(ELR)**	= (F+N)/R	Ratio of purchased and nonrenewable emergy to the renewable emergy. A measure of ecosystem stress due to the production activity.
Emergy Sustainability Index **(ESI)**	= EYR/ELR	

Brown and Ulgiati,1997.

Table 2. Examples of transformity values used in emergy analysis of wastewater systems. Transformity is the amount of solar energy needed to produce one unit of resource.

Emergy Resource	Typical Examples for Wastewater Treatment Processes (units: J=joule, g=gram)	Transformity (sej/unit)
Renewable Emergy Inflow (R)	Sun (J)	1
	Wind (J)	1.47E+03
	Rain (chemical potential) (J)	1.79E+04
	Oxygen (g)	5.06E+07
Nonrenewable Emergy Inflow (N)	Wastewater (J)	3.73E+06
Purchased Emergy Inflow (F)	Treatment chemicals (g)	3.73E+08
	Human labor (J)	7.24E+06
	Electricity (J)	1.71E+05
	Water (g)	7.16E+06
	Concrete (g)	7.34E+08
	Copper (g)	6.80E+10

Brown and Ulgiati,1997; Bjorklund, Geber and Rydberg, 2001.

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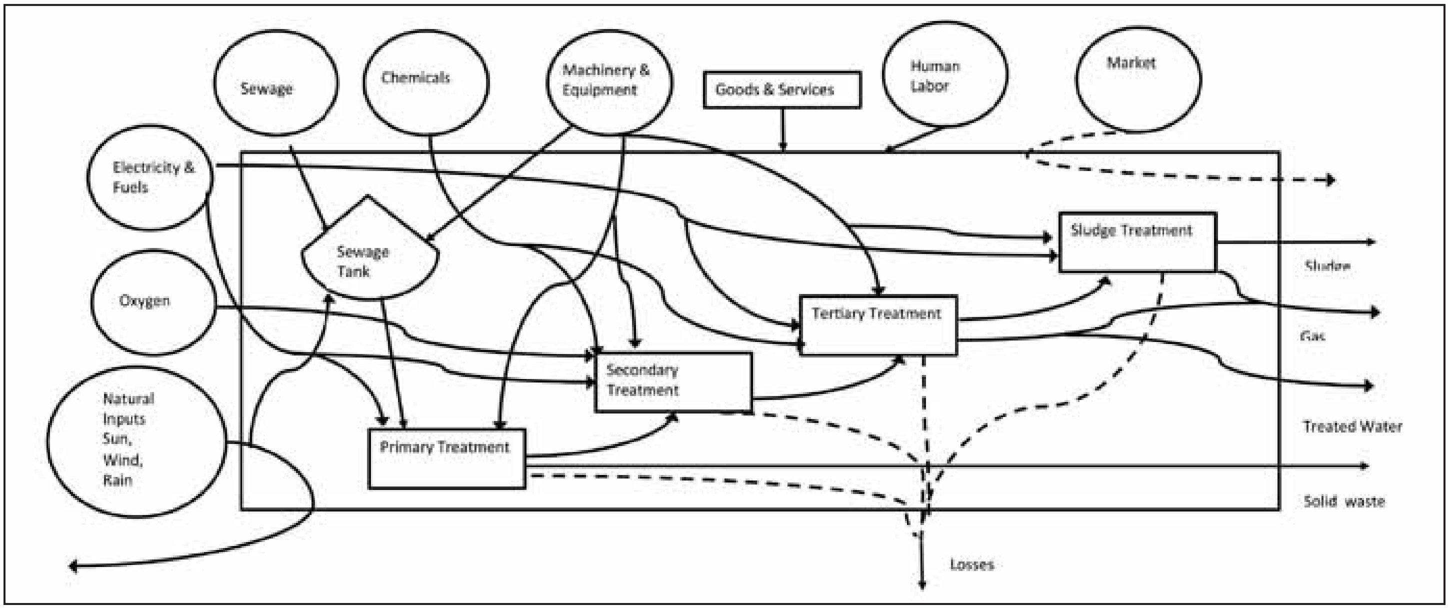

Figure 2. Schematic diagram of emergy resources and flows in a wastewater treatment plant

Emergy analysis was used to determine if the installation of a constructed treatment wetland at a small wastewater treatment plant would result in economic savings and environmental benefit. Water reuse, in particular, provides benefits to offset the use of high quality drinking water for process purposes. While water has high value associated with it as a natural capital, additional monetary and emergy value is added as it is conveyed, treated and stored.

Emergy analysis was used to compare two very different wastewater treatment systems in a cold climate, including one conventional activated sludge process and a second including sand filtration followed by a constructed wetland. Due to its use of solar, wind and rain (chemical) energy, the treatment plant with constructed wetland used much more local (free) renewable energy (R) than the conventional WWTP. Interestingly, the treatment plant wetland treatment system also used a slightly greater amount of purchased resources (F) from society. While the emergy yield ratio (EYR =1.0) was equal for the two systems, the Environmental Load Ratio for the WWTP (ELR = 4246) was an order of magnitude greater than for the treatment plant with wetland (ELR=193). Both systems had a very low ESI (ESI <1), although the wetland system was an order of magnitude greater.

Emergy Analysis for Sustainability Assessment

Emergy analysis accounts for resource inputs to the wastewater treatment system using their energy content as the basis for evaluation. Published transformity values are used to determine the amount of energy needed from the accumulated resources that support that resource. Emergy accounting allows comparison of widely disparate technologies. Labor-intensive activities requiring human work can be incorporated into emergy analysis by considering a person's metabolic energy use (i.e., the accumulated energy that it takes to support that person's role in the system). Emergy accounting can be used to compute metrics that indicate a system's resource use efficiency (yield ratio), its use of renewable or nonrenewable resources (emergy investment ratio), its environmental impact (environmental loading ratio), and its sustainability (emergy sustainability index). By accounting for all energy used, directly and indirectly in a system, these emergy-based indices provide designers, operators, managers and planners with a tool to assess the sustainability of complex systems in the water environment.

Douglas Daley, PE, is Associate Professor of Environmental Resources Engineering at the State University of New York College of Environmental Science and Forestry in Syracuse, NY. He may be reached at djdaley@esf.edu.

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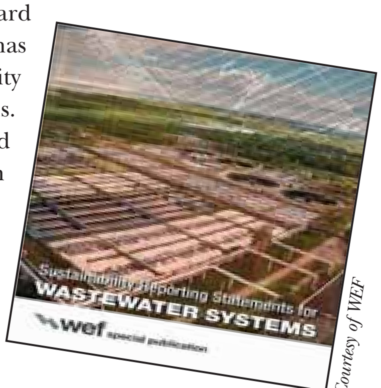
UNMATCHED RELIABILITY

Sustainability Reporting for Wastewater Utilities

by Angela M. Hintz

Wastewater utilities have provided a wide variety of services over the years including the collection and treatment of wastewater, industrial waste monitoring and pretreatment, and biosolids management. These services have been provided traditionally with a focus on reliable, low cost service delivery; however, the movement toward effective utility management has changed the focus to sustainability of wastewater utility operations. Utilities, regulatory agencies and the public are concentrating on the "triple bottom line" (TBL) or the economic, social and environmental impacts associated with wastewater operations. The public's increased interest in utility operations has resulted in a greater transparency within agencies.



Courtesy of WEF

The Water Environment Federation (WEF) released a 2012 special publication titled, *Sustainability Reporting Statements for Wastewater Systems,* which uses the TBL approach in reporting a number of factors. Regard for TBL measures of utility activities, whether operating protocols or capital project investments, increasingly is being embraced as a more appropriate decision-making framework than past methods.

The reporting framework for wastewater utilities is based on the Global Reporting Initiative's (GRI) (www.globalreporting.org) Sustainability Reporting Framework. The GRI was established in 1997 in Boston, Massachusetts and is now headquartered in Amsterdam in the Netherlands. Over the years, it has developed the reporting framework and associated resources for companies and other organizations to document sustainability performance on a regular basis, in a manner similar to that used for financial statements. The framework is based on definable metrics that can be documented and reviewed on a year-to-year basis, or on another more relevant review cycle, to assess improvement and identify areas of improvement.

Framework for Sustainability Reporting

Like the GRI framework, the recommended framework for reporting wastewater operations sustainability uses three separate distinctions of reporting: primary metrics, secondary metrics and supplemental information. These metrics are compiled under four major headings and are in addition to general information about the utility, such as numbers of users, total area served, etc. These main headings are: Environmental, Social, Economic and Technical.

Primary metrics, or indicators, are defined as those basic sustainability metrics applicable to all wastewater treatment utilities; while secondary metrics, or indicators, are site-specific and utilities can typically choose those indicators applicable to their facility. Primary and secondary indicators are shown in the table below. Supplemental information is other information that is available and that does not fit into one of the indicators, but is important for full understanding of the utility.

Each of the primary and the selected secondary indicators are

Above: Aeration systems provide significant opportunities for energy and cost savings, providing multiple sustainability benefits to municipalities.

Left: Anaerobic digesters provide a way for wastewater treatment plants to become more sustainable by producing biogas used to offset energy use in other parts of the plant.

Photos courtesy of ARCADIS

	Primary Metrics or Indicators	Secondary Metrics or Indicators
Environmental	Total effluent discharge flow Compliance with permit requirements Concentration of key constituents for compliance Overflows or spills of any type Greenhouse gas emissions – Scope 1 (direct) and Scope 2 (energy use) only Other air emissions Total solids waste by type Direct and indirect energy consumption Potable water use Nutrient recovery Water provided for reuse Beneficial use of biosolids Renewable energy use O&M materials used Protection of habitat and wildlife	Concentration of other constituents not covered in the primary indicators Greenhouse gas emissions – Scope 3 (other) only Emission of ozone-depleting substances More detailed energy use detailed by process Non-potable water use (internal recycle) On-site energy generation Biogas used Construction and recycled materials used Restoration of habitats
Social	Customer satisfaction Noise, odor, traffic, visual effects (complaints) Workforce composition Health and safety statistics Nondiscrimination practices Employee recruitment and retention Diversity and equal opportunity Staff training and education	Effectiveness of community engagement Sewer service interruptions Worker benefits Health and safety committees and agreements Performance reviews/career development
Economic	User rate affordability Life cycle cost analysis use Revenue, including internally generated revenue sources Debt service Bonding capacity Local purchasing and hiring	Return on equity External funding Enterprise fund operating position
Technical	Equipment availability Inflow and infiltration of % of total annual flows Design capacity utilization Area available for expansion	No. of overflow events Volume of overflows

chosen and data collected for each of the indicators. The status of each indicator is packaged into a report, which is then typically released on a yearly or bi-yearly basis. The report can be published in hard copy or more commonly, published on the website and shared with stakeholders, including system users, regulatory agencies, board members and utility staff.

Why Do Sustainability Reporting?

In addition to allowing greater transparency within wastewater utilities, there are other internal and external benefits to adopting sustainability reporting, including:

- Unifying utility staff, while improving internal governance
- Identifying, reinforcing and demonstrating progress towards achieving organizational goals and commitments in the social, environmental and economic arenas
- Documenting resource (i.e., chemicals, electric, natural gas, other fuels, etc.) and associated economic savings
- Publicizing a utility's work, enhancing the utility's reputation, and allowing the utility to lead by example
- Encouraging involvement of stakeholders
- Defining minimum level of service criteria

While not currently mandated, it is clear that sustainability reporting brings numerous benefits to utilities and their stake holders. The WEF guide (#P120002), referred to earlier, can encourage and assist utilities in implementing sustainability reporting. The guide discusses the basis of evaluation that is in line with reporting procedures used by other industries and offers a template for utilities to formally document and monitor performance of defined goals and objectives. Sustainability reporting also offers utilities an opportunity to achieve increased transparency with both public and private stakeholders.

Angela M. Hintz, PE, CEM, CEA, is Senior Environmental Engineer for ARCADIS in Buffalo, NY, and may be contacted at Angela.Hintz@arcadis-us.com.

NYWEA
LEADING THE WAY IN
WATER QUALITY MANAGEMENT

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Driving Water and Wastewater Utilities to More Sustainable Energy Management Energy

Reaching Energy Neutrality and Beyond: A Road Map for the Water Sector

WEF Energy Roadmap 1.0

Wastewater treatment plants are not waste disposal facilities but are water resource recovery facilities that produce clean water, recover nutrients (such as phosphorus and nitrogen), and have the potential to reduce the nation's dependence on fossil fuels through the production and use of renewable energy and the implementation of energy conservation.

– Water Environment Federation
2011 Renewable Energy Position Statement

Topic: Strategic Management

	Enable	Integrate	Optimize
STRATEGIC DIRECTION	**Set Goals** • Energy goals and key performance indicators are established for both conservation (see Energy Generation)	**Gather Support** • Utility incorporates energy goals and key performance indicators into strategic plan • Governing board establishes energy/sustainability committee	**Prioritize & Implement** • Energy management program initiatives are prioritized using tools such as: • Strategic business planning • Effective Utility Management (EUM) • Environmental Management Systems (EMS) • Energy generation is an integral part of utility's suite of services • Utility utilizes triple bottom line approach for sustainability project decision-making
FINANCIAL VIABILITY	**Identifying Funding Options** • Financial strategy developed to support energy audit and to fund resulting projects	**Budget for Success** • Lifecycle analysis used for decision-making on energy projects • Energy use is considered on all capital project design and in operating budgeting decisions and standard operating practices	**Invest in Future** • Utility's energy initiatives generate sufficient revenue to invest in other utility priorities/reduce upward pressure on rates • Energy arbitrage opportunities are leveraged
COLLABORATIVE PARTNERSHIPS	**Evaluate Opportunities** • Opportunities for collaboration on energy projects (e.g., Energy Services Company – ESCO, joint venture, public-public/private partnership) are analyzed • Diverse markets for energy products are identified	**Establish Connections** • Contracts with partners are in place and implemented to facilitate data exchange and planning with water, energy and gas utilities • Utility planning efforts are integrated with other agencies regarding multiple resources (e.g., water, stormwater, etc.)	**Leverage Resources** • Utility uses partnerships to maximize energy sales revenues and/or reduce demand (e.g., selling power or biogas to adjacent facility, working with a feedstock provider for co-digestion)
TOWARDS CARBON NEUTRALITY	**Plan Carbon Footprint Analysis** • Approach to carbon footprint analysis/GHG inventory is established	**Inventory GHG Emissions** • Carbon footprint/greenhouse gas (GHG) inventory is developed	**Recover Resources** • Additional resources are recovered or realized (e.g., carbon credits) as utility moves towards carbon neutrality • Comprehensive carbon footprint/GHG inventory is maintained, including fugitive emissions and embodied energy of major inputs (e.g. chemicals)

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WEF's Energy Roadmap is a series of steps to help wastewater utilities plan and implement a wastewater energy program. The road map is applicable whether plants choose simply to increase energy efficiency or to build a full-scale cogeneration system. Steps will be arranged under various topics, from technical needs to managerial aspects, and will be applicable to small, medium, and large facilities. The steps are arranged under six topics, three of which are included on these pages:

Strategic Management: High-level management policies and practices that lay the foundation for sustainable energy management

Organizational Culture: Implementation of an energy vision to create an organizational culture that values energy efficiency at all levels and supports an energy champion and cross-functional energy team

Communication and Outreach: Tools for effective two-way communication with key stakeholders around energy management

Demand Side Management: Methods to assess and reduce energy use and energy costs

Energy Generation: Tools for utilities to evaluate whether

Topic: Energy Generation

	Enable	Integrate	Optimize
STRATEGY	**Set Production Goal** • Measurable energy generation goal is established • Energy generation plan is coordinated with utility strategic plan • Energy Team understands regulatory and permit limitations (e.g., air emissions) with regard to generation	**Obtain Support** • Governing body approves capital budget for energy generation projects • Regulatory issues have been addressed and satisfactorily resolved	**Grow Program** • Infrastructure for energy generation is proactively maintained, renewed, and upgraded • Holistic evaluation methodologies (e.g., triple bottom line) are used to evaluate energy generation opportunities
ENERGY FROM WATER AND WASTEWATER	**Evaluate Integral Energy Sources** • Available energy resources are quantified, such as: • Biogas • Hydropower • Heat	**Implement Generation Systems** • Energy generation facilities are operating and producing power/heat for utility use • Electricity/heat • Fuel (natural gas, pellets, etc.)	**Optimize Production** • Energy production is optimized to maximize the value of generation (e.g., biogas storage to offset power purchases during "on-peak" hours)
SUPPLEMENTAL ENERGY SOURCES	**Identify Supplemental Energy Sources** • Available non-wastewater/water derived energy sources are quantified, including: • Co-digestion • Solar • Wind • Feedstock market evaluation is performed	**Implement Generation Systems** • Energy generation facilities are operating and producing power/heat or fuel • Quantity and quality of feedstock meets capacity	**Maximize Production** • Onsite electricity generation from all sources approaches or exceeds onsite electricity demand • High-strength organic waste (e.g., food, FOG, etc.) is integrated into feedstock supply to increase generation potential
RENEWABLE ENERGY CERTIFICATES (REC)	**Plan for RECs** • Staff gain understanding of State regulations for Renewable Portfolio Standard (RPS), as well as production and sales of RECs	**Utilize RECs** • Utility produces, sells and/or purchases RECs, as appropriate	**Maximize Value of RECs** • Sales and purchases of RECs are optimized to maximize value of resources, potentially using automation

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and how to increase onsite renewable energy production and/or investments

Innovating for the Future: Guidance for utilities of all sizes to leverage existing research, further in-house innovation and manage risk associated with these ventures

The progression towards the utility of the future is based on a process of continuous improvement. Not all facilities will become "power positive," nor should they expect to. The three levels of progression within each topic areas are defined as:

- **Enabling:** Planning process, including initiating first steps and launching program components
- **Integrating:** Implementation process, including establishing a framework to make widespread adoption within the utility successful
- **Optimizing:** Further enhancing and fine-tuning improvements and spreading them outside of the utility.

In addition to the six topics matrix which can be downloaded at: http://www.wef.org/AWK/pages_cs.aspx?id=568, WEF has just released a 140-page guidance document that includes nine case studies to assist users of the matrix. The document can be ordered through WEF's website at https://www.e-wef.org/Home/ProductDetails/tabid/192/Default.aspx?ProductId=20487783.

Topic: Innovating for the Future

	Enable	Integrate	Optimize
RESEARCH AND DEVELOPMENT	**Prepare for R&D** • Staff well versed in existing technologies • Opportunities are identified by survey of emerging technologies	**Perform R&D** • Utility budget includes R&D funding • Utility actively participates in water innovation partnerships (e.g., water innovation centers, research foundations, university partnerships, etc.)	**Expand R&D** • Site visits to facilities utilizing innovative technologies occur regularly • Completed trials and research projects provide the foundation for further advancement within the industry
RISK MANAGEMENT	**Identifying and Prioritize Risks** • Risk of innovation is identified • Strategy for risk mitigation is developed • Planning includes measures for climate change adaptation (e.g., extreme events)	**Mitigate Risks** • Risk is reduced through collaborative research and information sharing • Leadership group recognizes and rewards innovative approaches	**Leverage Innovation** • Organization can successfully trial and implement innovative projects and is adaptable to emerging opportunities • Patents are obtained to protect utility and water sector
ALTERNATIVE TECHNOLOGIES	**Evaluate Opportunities** • Technologies that reduce energy use or increase generation are identified	**Initiate Trials** • Advanced low-energy treatment technologies and energy production technologies are demonstrated	**Implement Full Scale Solution** • Lower energy consuming processes replace energy-intensive secondary treatment
ALTERNATIVE MANAGEMENT APPROACHES	**Identify Alternatives** • Decentralized treatment are considered • Planning is performed on a watershed basis	**Implement Alternatives** • Green infrastructure projects are implemented where appropriate • Enhanced regionalization (e.g., biosolids processing) has been considered and implemented where appropriate	**Expand Integration** • Alternative management approaches (e.g., decentralization, regionalization, etc.) are used, where appropriate, to maximize overall, region-wide benefit

In Memoriam

Arthur Gordon Wheler

The NYWEA membership, colleagues and friends are remembering the many important contributions to the water quality field made by Arthur Gordon Wheler, 92, of Syracuse, who died May 6. Along with Donald E. Stearns, he formed the consulting firm of Stearns and Wheler Environmental Engineers of Cazenovia in 1955, and he retired in 1989. He was one of the inaugural inductees into the NYWEA Hall of Fame, served NYWEA on the state board and was a Diplomat of the AAEE. He is survived by his wife, Barbara, of 61 years, their two children and their spouses, two grandchildren and their spouses, and a great-grandson.

Rosemary Donnellon

Rosemary Donnellon, 73, passed away April 29. She was the wife of John J. Donnellon, Sr., retired deputy director of Plant Operations for the New York City Department of Environmental Protection and dedicated NYWEA Lifetime Member. They were married 53 years and have five children and 11 grandchildren. The NYWEA membership wishes John and his family all the best during this difficult time.

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WERF FACT SHEET
Energy Production and Energy Research – The Roadmap to Net Zero Energy

Energy-Neutral Wastewater Treatment – Balancing Energy Demand and Supply

Attempts to produce an energy neutral (or net energy positive) treatment facility starts with a "net energy balance," whereby energy needs are balanced by energy supplied. To develop a complete energy balance of the treatment facility, wastewater utility operators, engineers, and process designers must first identify energy needs which can be reduced and then use opportunities to generate or recover energy to supply the remaining treatment needs.

Energy Demand Reduction Using Best Practices

The Water Environment Research Foundation (WERF), under the Operations Optimization research program, developed tools and conducted research to promote energy efficient best practices. One of the largest set of case studies on energy efficiency and production in the wastewater sector was compiled by the Global Water Research Coalition (GWRC). Supported by WERF and other international research organizations, GWRC prepared a compendium of best practices globally. WERF compiled the energy savings achieved from energy efficiency measures in North America (stock no. OWSO4R07e) and supported the global compendium (stock no. OWSO9C09). The following table is from those case studies. It shows the potential energy savings available from switching to energy efficient practices. Energy efficiency is part of the process to reduce energy demand along the path to a net energy neutral wastewater treatment plant but cannot achieve that goal alone. Net energy neutral or positive wastewater treatment requires additional research into low energy treatment alternatives to activated sludge process. It also requires more research into energy recovery, by promoting improvements in anaerobic digestion with energy recovery or by further developing alternative processes to recovery energy from domestic wastewater.

Separation of anammox granules using the centrifuge method. Performed under the mainstream deammonification lab-scale pilot tests at Blue Plains Advanced Wastewater Treatment Plant under INFR6R11 to promote research into low energy alternatives to conventional processes.

Table 3. Summary of Potential Savings through Use of Best Practices

Energy Conservation Measure	Treatment Stage	Energy Savings Range (%)
Wastewater pumping optimization	Throughout system	<0.7%
Aeration system optimization	Secondary treatment	~15 to 38%
Addition of pre-anoxic zone for BNR	Secondary treatment	~4 to 15%
Flexible sequencing of aeration basins	Secondary treatment	~8 to 22%
High-efficiency UV	Disinfection	~4%
Lighting system improvements	Support facilities (buildings)	~2 to 6%
	Average Range	5.6 to 14.3%

Innovative Processes to Reduce Energy Demand

Changes in biological treatment processes from aerobic to anaerobic or anoxic microbes have the potential to significantly reduce the energy demand at a treatment works. These emerging processes, while not the only ones, have the potential to make the greatest shift in the path to energy neutrality.

Improved Screening: Use of the fine screens on collection mains or trunks, at satellite treatment facilities and at pump stations, is an innovative step that can recover particulate matter before deposition and particle size reduction occurs. This prevents the loss of chemical energy, reduces the need for new facilities and improves process and infrastructure sustainability (Tchobanoglous, 2009).

Research is needed to determine the conditions where such approaches can be feasible and financially attractive.

Sidestream Treatment: The liquid sidestreams removed from biosolids processing and returned to the main wastewater process are extremely high in waste loads which add considerably to the energy demand in conventional systems. Reductions in the load from these sidestreams have the potential to reduce the energy demand of the secondary treatment system. Although sidestream treatment has been used successfully overseas and has significantly reduced energy consumption, the use of such treatment processes (DEMON, Anammox, and others) in North America has been limited. Further research is needed to determine the feasibility of such systems for sidestreams and potentially scaled up for mainstream biological nutrient removal facilities.

Low Energy Secondary Treatment: The discovery of plantomycete-like anaerobic ammonia-oxidizing bacteria (anammox) allowed the development of new treatment concepts that apply the advantageous metabolic pathways unique to this organism. Anammox bacteria oxidize ammonia directly to nitrogen gas using nitrite without carbon substrate required for conventional denitrification.

Several sidestream processes, such as DEMON, have utilized this microbial pathway to provide low energy treatment of concentrated wastewater. The problem is that anammox bacteria are very slow growing, making transition to full-scale systems difficult. Successful mainstream deammonification treatment processes must retain slow growing anammox bacteria in the system. Recent research suggests that anammox bacteria can form heavy granules that can be separated from the waste activated sludge, whereby the heavier anammox-laden sludge can be retained and concentrated in the system. Research is needed to determine the conditions where such approaches can be feasible and to develop the operating conditions and parameters to expand anammox to provide mainstream treatment. Other anaerobic or innovative fixed film and membrane processes also have potential to provide low energy treatment based on emerging research.

Energy Production Opportunities

The second half of the energy balance equation is energy production. This side of the equation has the greatest potential for growth. There are several types of technologies and opportunities to recover energy throughout the wastewater treatment process – from influent to biosolids. Some of these opportunities are well established; others are innovative technologies that will require additional research and development. Following is a description of the prime areas for energy recovery at a wastewater treatment facility.

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New anaerobic digester process – Columbus (GA) biosolids flow through thermophilic treatment Anaerobic Digestion (Biodegradation Pathway).

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Biosolids to Energy

The most developed opportunity for energy recovery at treatment plants is from biosolids. Unprocessed biosolids typically contain 18,000 kj/kg (8,000 Btu/lb) on a dry weight basis. The potential for energy recovery from biosolids is a function of their composition, specifically the relative proportions of inert material, biodegradable volatile solids, and non-readily biodegradable volatile solids. There are two established pathways for energy recovery from biosolids: anaerobic biodegradation and thermal conversion.

Anaerobic Digestion (Biodegradation Pathway): In anaerobic digestion, the readily biodegradable portion of the volatile solids in biosolids is converted to biogas, primarily composed of methane (60–65 percent) and CO_2, (35-40 percent). Biogas can be converted to electricity using onsite power generation. Heat can be recovered from the power generation units to heat the digesters, or to generate stream power.

Anaerobic digestion, coupled with combined heat and power facilities for energy recovery, is regarded as one of the more mature and successful energy recovery approaches. Efforts to boost energy recovery from biogas include the following: *Co-digestion of Organic Wastes with Wastewater Solids.* Fats, oils and grease (FOG) are the most common high-strength organic waste co-digested with biosolids, however many food processing operations produce wastes that are also well suited for co-digestion in anaerobic digesters at wastewater treatment facilities. FOG digestion has a high rate of biogas generation, with reported values of up to 1.3 times that of typical biosolids gas generation. Recent research indicates that the addition of FOG has a symbiotic effect on the digestion process, with higher biogas yield than would be expected by the sum of separate biosolids and FOG digestion. Other organic wastes that could be used in the co-digestion process include glycerin from biodiesel production, airplane de-icing fluid waste, manure and other organic wastes (brewery, cheese production, etc.) For more information on this topic, refer to WERF research project no. OWS05R07 at www.werf.org.

Solids Pretreatment: There are several emerging technologies that improve the digestibility of solids by breaking open the bacterial cells. These technologies include thermal hydrolosis, mechanical disintegration and electrical pulse treatment. Based on experience to date, solids pretreatment has the potential to more than double the readily biodegradable fraction, resulting in a 30–60 percent increase in biogas production compared to digestion without pretreatment. For more information on this topic, refer to WERF stock no. 05CTS3.

Advanced Biogas Cleaning: Biogas includes contaminants, such as moisture, hydrogen sulfide (H_2S) and siloxanes. Hydrogen sulfide combines with moisture to form sulfuric acid, which can damage gas utilization equipment. H_2S can be removed by adsorption onto iron, either in liquid or solid form, or other selective media. Siloxanes are compounds containing silicon, oxygen and methane. During combustion of the biogas, siloxanes are converted to silicon dioxide, an abrasive solid, similar to fine sand causing accelerated wear and loss of efficiency. Siloxanes must typically be removed to protect gas utilizations equipment and are typically removed by adsorption onto selective media or activated carbon. Siloxanes also appear to be adsorbed onto dessicant media, but effectiveness is largely unknown.

If biogas is to be used as a vehicle fuel or for injection into a natural gas pipeline, H_2S must be removed to trace amounts (less than 4ppmv), and siloxanes must be removed to increase the heating value of the gas to that of natural gas (-37MJ/m^3). Several technologies can be used to remove both CO_2 and H_2S.

Innovative Uses of Biogas: The methane in biogas can be converted to a liquid biofuel (methanol) by microbes. This innovative process employs ammonia oxidizing bacteria (AOB) to biologically oxidize methane to methanol. AOBs are known to lack the capacity to produce CO_2 and use CO_2, which is typically present in digester gas in significant quantities (35–40 percent) as a growth substrate. Dr. Kartik Chandran of Columbia University has been awarded WERF's Paul L. Busch Award for exploratory research into process, where methanol may also be a carbon source for biological nutrient removal.

Thermal Conversion Pathway: In thermal conversion processes, the entire volatile fraction of the biosolids is either completely or partially oxidized. Energy can be recovered from the heat liberated during the oxidation, or in some technologies, from gaseous or carbon-based solid residues. Thermal conversion processes include incineration, gasification, pyrolysis, supercritical water oxidation, and steam reformation.

Incineration is the most commonly used thermal conversion process. Biosolids are combusted with excess air (oxygen) to form mainly CO_2 and water. The combustion gases pass through a heat recovery system to produce steam and a steam turbine for power generation. Incineration has long been used for volume minimization, but waste heat recovery for power generation is currently underutilized.

Gasification involves the chemical reaction of the volatile organic fraction of biosolids with air, oxugen, steam, a carbon dioxide, or a mixture of these gases at elevated temperatures (500–1400°C). In contrast to combustion, gasification operates in oxygen-starved conditions, with only enough oxygen to generate heat to drive chemical reactions to produce syngas (synthetic gas). The products of the process include heat, which can be recovered, and fuels, where the energy is in the form of carbon monoxide (CO). The energy content of the end products is affected by operating conditions, temperature and pressure, and the characteristics of the biosolids. An example of syngas and its potential uses is shown in ***Table 4***. Gasification typically uses dried biosolids, which is challenged by the cost and energy required for solids drying. While gasification has long been used in the coal industry, biosolids gasification systems are still in the early stages of implementation.

Pyrolysis is a thermal conversion process where a solid fuel is heated in the absence of an oxidizing agent at temperatures in the range of 300–900°C. Pyrolysis yields a combustible gas, a bio-oil, and a solid residue called char. All of these products have energy value. A single application of the pyrolysis process using biosolids is in operation in California. The solids resulting from this process are made into a slurry that is thermally dried and pelletized into a solid fuel which can be combusted directly in pulverized coal boilers, gasifiers, fluidized bed incinerators, or used offsite as an alternative fuel.

Steam reformation is a chemical process that converts hydrogen-containing fuels into hydrogen gas in the presence of steam, oxygen, or both. The reforming reaction is carried out in the 670–1270°K temperature range, requiring a secondary fuel source to provide heat. Steam reformation of biomass is a new application of this technology driven primarily by the increased interest in using renewable sources of energy combined with the environmental benefits, high energy yield and growing market attractiveness of hydrogen as a fuel source.

Table 4. Fuel Material Generated in Biosolids Gasification

Energy Type	Energy as a Percentage of Natural Gas	Use
Low energy gas	10–27	Gas turbine fuel, boiler fuel
Medium and high energy gas	27–94	Hydrogen production, fuel cell feed, chemical and fuel synthesis
Substitute natural gas	>94	Directly substitute for natural gas with no additional treatment

Other Steps to Improve Solids Capture for Energy Recovery

Improved primary treatment increases the volatile solids content of the waste solids using technologies such as chemically enhanced primary treatment (CEPT), ballasted flocculation/settling, and fine screens. Solids with higher energy content are sent to the anaerobic digester increasing the yield of biogas. This approach has the added benefit of reducing the pollutant load on any downstream biological processes, hence reducing aeration energy requirements.

Advanced filtration uses screens or membranes (e.g., UF followed by reverse osmosis (RO) or nanofiltration (NF) process) to directly treat primary effluent and eliminate the energy-intensive activated sludge process. Solid material removed by this step can be returned to anaerobic digesters to improve biogas production. Research on appropriate filtration solutions may make this approach attractive and may result in significant reduction in net energy consumption.

Other Renewable Energy Sources

Ammonia in wastewater can be burned directly in an internal combustion engine, converted to electricity in an alkaline fuel cell, or decomposed to provide hydrogen for a non-alkaline fuel cell. The temperature required for the process depends on the catalyst. High conversion efficiencies are achieved at temperatures of 650–700°C. There is a potential at wastewater treatment plants to use the ammonia from high-strength, high-temperature sidestreams as a fuel source to produce electrical energy, heat and/or hydrogen. Nitrous oxide (N_2O) can be burned in an internal combustion engine as a fuel enhancer. Exploratory research into the adaptations necessary to use nitrous oxide is underway, but this has not reached the point for a full-scale demonstration.

Heat recovery from wastewater is possibly the greatest at the head of the plant, before the wastewater has a chance to cool. Use of low-grade heat from the influent wastewater is a challenge to capture due to low efficiency at the low temperatures typical of domestic wastewater, and the potential for influent wastewater to foul heat exchangers. However, it has been done successfully. Plants can also recover hydraulic energy by installing micro-hydro water turbines or hydrokinetic devices in channels and conduits prior to discharge. Inline hydro is a well-established technology with efficiencies already close to 90 percent.

Anaerobic treatment such as Upflow Anaerobic Sludge Blanket (UASB), Anaerobic Migrating Blanket Reactor and other process variations are improved anaerobic treatment processes. Anaerobic treatment of raw wastewater allows direct conversion of the chemical energy in wastewater to biogas, thereby reducing downstream aeration energy requirements and recovering energy. Anaerobic treatment is a well-established technology for high-strength, high-temperature wastewaters. Performance in warm (25°C+) municipal wastewater applications primarily in South America has been good. Though several research and pilot projects have been conducted on lower temperature domestic wastewaters, process and mechanical difficulties have not been overcome to make anaerobic treatment of the liquid stream a viable, cost effective alternative.

Microbial fuel cells (MFCs) generate electricity from the organics present in wastewater and are a promising innovative approach

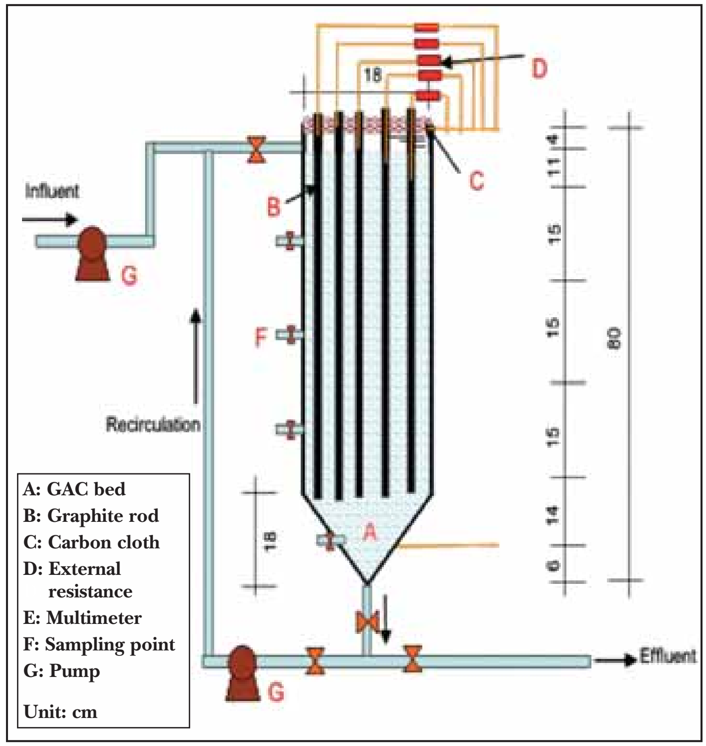

Diagram of the first 16-liter pilot-scale granular activated carbon microbial fuel cell system tested at the Gloversville-Johnstown, NY facility under WERF Project No. OWSO8C09.

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Table 5. Summary of Energy Recovery Potential Using Established Technologies

Biosolids Technology	Percentage of Net Energy "Gap" Reduction Possible	Other Technology	Percent of Net Energy "Gap" Reduction Possible
Anaerobic Digester (AD)			
Biogas with boilers	13%–57%	Enhanced solids removal	10%–71%
AD Biogas with co-gens	11%–61%	Anaerobic primary treatment	25%–139%
AD Biogas with microturbines	5%–38%	Heat recovery	13%–49%
AD Biogas with turbines	7%–46%	Hydraulic	0%
AD Biogas with fuel cell	6%–42%	Ammonia as fuel	-6%–12%
AD Biogas after WAS pretreatment	-2%–60%	Heat from centrate	13%–49%
AD Biogas with co-generation	2%–128%	Microbial fuel cells	8%–110%
Incineration	2%–69%	Biofuel from algae	-39%–208%
Gasification	-9%–82%		

continued from page 59

to renewable energy from wastewater. MFCs utilize the bacteria commonly found in biological wastewater treatment processes to harvest the chemical energy stored in contaminants and convert it to electricity. A great amount of research effort has been invested to test MFCs at the bench-scale level for wastewater treatment, yielding increasingly effective power generation rates; however, full-scale use of MFC will be in the future. Also, chemical hydrogen peroxide (H_2O_2) can be produced from a bioelectrochemical system. Studies show that the bioelectrical system used to make H_2O_2 is a better option than the MFC itself.

Algae Bioreactors: Wastewater can be a good medium to grow algae to produce biofuels, which can be combusted in boilers and/or converted to fuel to produce heat and electricity. Research to identify appropriate algal groups to produce these biofuels, and to optimize associated nutrient removal rates to polish BNR effluents and reduce nutrient levels when consuming significantly lower energy by cultivating algae, is necessary. The biofuels produced from algae are diverse (such as methane, biodiesel, ethanol, hydrocarbon chains and hydrogen). The major limitations of this technology for application at wastewater treatment plants are the requirements for large land area, consistently high levels of solar radiation, and high wastewater temperatures. Algae cultivation shows much promise, but currently there are significant limitations to its application at a larger scale.

Many wastewater treatment facilities are located on sites with opportunities for energy using a variety of solar, wind and geothermal technologies. WERF's *Green Energy Life Cycle Assessment Tool (GELCAT)* developed under the project no. OWSO6R07c can be used to plan for green energy recovery opportunities.

WERF Research Roadmap

The primary goal of WERF's five-year research plan for Energy Production and Efficiency is to increase the number of wastewater treatment plants that are net energy neutral by understanding of the type and extent of the action currently taken by treatment plants already achieving net energy neutrality. Based on the experiences of these forward-looking wastewater utilities, a clearer picture of the roadmap to move more plants from current baseline to net energy neutrality can be developed. As a secondary objective, WERF's research will promote energy management within the wastewater sector and promote the wastewater sector as a green renewable energy industry. The research roadmap has three major elements.

- Promote underutilized anaerobic digestion with the recovery and use of biogas for heat and energy.
- Develop viable low energy treatment alternative to activated sludge secondary processes.
- Develop innovative energy recovery processes for wastewater and residuals.

To focus further and define research on sustainable alternatives, this research will evaluate and compare the triple bottom line sustainability of the many different energy recovery options which use biosolids.

To view the complete WERF Fact Sheet, including listed references (Stock no. ENER1fs, August 2011), visit www.werf.org, or for more information contact Lauren Fillmore, WERF Program Director, 571-384-2107 or lfillmore@werf.org.

Resources

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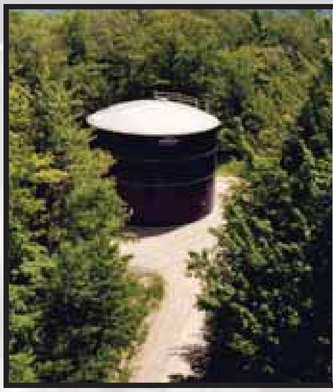

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Outside Sales Representative – Vellano Technologies

Vellano Technologies brings focus to special products in the gas, water, and wastewater industry. We are looking for a full time outside technical salesman to cover the western New York territory. This position is responsible for establishing new accounts while maintaining and growing existing customer relationships by calling on municipalities and contractors in the territory.

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The Town of West Monroe's 25-Year Success Story

These pictures show Town of West Monroe Operators, Kevin Davis (left) and Dakota Hyde, at one of the Town's E/One Extreme grinder pump stations. Oneida Lake is in the background.

Located in Oswego County, the **Town of West Monroe, NY** lies on the north shore of Oneida Lake and has a population of roughly 5000.

The Town has more than 200 E/One grinder pump stations, with the first ones being installed over 25 years ago. With the help of **Environment One** and **Siewert Equipment**, the Town started replacing the older units - after more than 20 years of reliable service - with E/One Extreme Series grinder pump units. To date, the Town has experienced no failures of the Extreme pumps in 6 years of operation.

DPW Supervisor Randy Shaw and **Operators Kevin Davis, Dakota Hyde, and Joe Bishop** are all pleased with the new Extreme pumps and the overall performance of the Town's E/One grinder pump stations.

"I like that E/One listens to us and continuously improves the design of their grinders. The Extremes have been in service for over 6 years now without any failures."

- Kevin Davis, Operator, Town of West Monroe

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