Harnessing nature enhances energy generation from waste

Drylet's bioremediation solution, which boosts the production of biogas and reduces sludge quantities, can help municipalities and industries manage wastewater cost effectively while meeting the growing demand for renewable natural gas. Laetitia Mailhes of Drylet, LLC reports.

The promise of energy from waste is real. And so is the need across the globe.

In Europe, there are more than 17,400 biogas facilities, accounting for two-thirds of the world's 15 gigawatts of biogas electricity capacity.[1] In Denmark, a country of just 5.8 million people, more than 160 operating biogas systems produce over 1750 GWh/year. In July 2018, 18 percent of the gas consumed in Denmark came from renewable natural gas (RNG) produced by its anaerobic digesters. Encouraged by their success, Danish bioenergy firms estimate the country's natural gas may be fully replaced with RNG within 20 years.

The United States (US) is behind Europe, with barely more than 2,200 biodigesters in operation, according to the American Biogas Council. State legislatures, led by Vermont and California, aim to lower methane emissions from organic waste and have been working with local gas utilities to further develop the renewable natural gas market.

As a transportation fuel alone, RNG made up 32 percent of all on-road fuel used in natural gas-fueled vehicles (about 772 million gasoline liter equivalent or 204 million gasoline gallon equivalent) in 2018, while production more than doubled from 2015 through 2018 under the Renewable Fuel Standard, according to the *2018 On-Road RNG Use Report*, published by Natural Gas Vehicles for America and the Coalition for Renewable Natural Gas. Assuming a steady growth rate, the RNG Coalition estimates that annual production could reach an estimated 3.8 billion liters (1 billion gallons) of RNG transportation fuel in 2022.

Shocking statistics, motivation for improvement

With approximately 380 billion cubic meters (m^3) of municipal wastewater creating an estimated 53.2 billion m^3 of methane annually worldwide, enough electricity could be generated to power 158 million households or about the population of the United States (US) and Mexico combined, according to a recent report by the United Nations (UN) University's Canadian-based Institute for Water, Environment and Health (INWEH). This assessment does not include the biogas potential contained in the liquid waste generated around the world by livestock production and industrial waste-intensive operations, such as rendering facilities or pulp and paper mills.

The risks posed to natural ecosystems, public health, and social peace by the various streams of pollution that comprise municipal and industrial wastewater are well known. "Development of wastewater treatment still has, as one of its objectives, the minimization of solids production," reported the UN-HABITAT in 2008. The statement is even more significant when considering that global volumes of municipal wastewater alone are projected to rise about 24 percent by 2030 and 51 percent by 2050, according to INWEH.

Ageing, insufficient, or even unavailable wastewater treatment infrastructure fails to address the increasing human waste stream generated by the growing global population.

A water resource recovery facility in New Mexico meets 95 percent of its energy demand using onsite solar power and biogas generation. Photo by Drylet LLC

More municipal and industrial wastewater treatment operators, as well as dairy farmers and pig producers, are embracing the opportunity of improving waste management to grow revenue and reduce costs.

For the water sector alone, governments will need to invest about US$7.5 trillion over the next decade to meet infrastructure needs – a massively expensive, disruptive, and time-consuming undertaking. The need for cost-effective solutions to upgrade ageing sewer systems and optimize new wastewater systems has never been greater.

Fortunately, proven products have been developed, tested, and are commercially available, that can boost nature's processing power by enhancing the activity of beneficial microbes, which accelerate the mass-to-gas conversion process, boosting biogas generation while reducing biosolids. Such bioremediation solutions do not involve capital expenditures, changes to existing processes or systems, and are low-capital, low-maintenance, and easy-to-use.

Alabama's biosolids problem and the circular economy

Solids management challenges are a reality around the world, including in the US, as residents in the state of Alabama can attest to. In 2018, a freight train carrying approximately 4.5 million kilograms (kg) (10 million pounds) of sludge from water resource recovery plants in the city of New York City, New York, and the state of New Jersey was stranded for two months in Parrish, Alabama, subjecting its 1,000 inhabitants to odor and flies. The shipment was eventually hauled by trucks to a landfill a little more than 40 kilometers (25 miles) out of town.

The Alabama Department of Environmental Management (ADEM) seized the opportunity to get to work on enacting rules regarding the

management of biosolids by companies in the state, especially the "beneficial use of by-product materials for the purpose of land application." Earlier this year, concerned citizens packed an ADEM public hearing to denounce what they deem insufficient rules to protect the environment and public health. The rules passed unanimously five weeks later.

Proponents of the "circular economy" – where an economic system is focused on recycling resources and eliminating waste – argue that such situations can be remediated and increasingly prevented in the future by shifting the resource recovery process from controversial land applications to energy generation.

In the US, federal and state regulations now exist that promote bioenergy and renewable energy projects, including the federal Renewable Fuel Standard, California's Low-Carbon Fuel Standard, Oregon's Clean Fuel Program, North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard, as well as cap-and-trade programs.

As capital investments turn to developing waste-to-energy facilities, return on investment becomes a concern. Questions arise – how much can be saved on electricity bills and disposal of remaining biosolids? How much revenue can be generated from energy price, tax credits, and renewable fuel credits?

A beneficial microbe

Through the complexity of a growing sector where new opportunities and unknown players emerge daily, it may be easy to forget that everything, ultimately, truly hinges on a very small actor. An invisible actor, in fact: a beneficial microbe.

Microbes have been the operating system of wastewater treatment ever since Chief Chemist William Joseph Dibdin of the London County Council in England first devised the process in the 1880s. Developed to modern standards in 1914 by Edward Ardern and William Lockett, the approach remains relevant today: Microbiology is the most readily available, scalable, affordable, and effective technology to remediate sludge through mass-to-gas conversion. Microbiology is the critical engine of any wastewater resource recovery facility. It is the basis of the remediation process at the front and back end of the plant, regardless of the design of the system.

Anaerobic digestion is a three-step process. In the first phase called hydrolysis, secondary and primary solids are broken down into smaller molecules. In the second phase, the products of hydrolysis are converted into short chain fatty acids (SCFA) (for example, acetate), carbon dioxide (CO_2), and H_2 during acidogenesis and acetogenesis. In the final phase, methanogens convert SCFA, H_2, and CO_2 into methane in the methanogenesis phase.

WAS (Waste Activated Sludge) is the portion of the solids that is most difficult to degrade in the hydrolysis phase because it is made up of excess bacterial cells from the activated-sludge process. In order to overcome the hurdle of breaking down the bacterial cell wall, which potentially impedes the efficiency of the whole process, various technologies and processes have been developed to improve lysis through brute force or chemical trauma to the cell, namely thermal hydrolysis, chemical hydrolysis, pressure homogenization, and ultrasound – all solutions that require significant capital expenditures and have high operating costs.

However, innovative proven products exist that can improve lysis without large capital expenditures. These products protect beneficial microbes from predation and allow them to thrive in the sludge, greatly enhancing the breakdown of excess bacterial cells. An innovative technology developed by Drylet, for example, enables the enhanced degradation of undigested solid waste (hydrolysis), promoting a reduction in biosolids and an increase in biogas generation. Drylet's biocatalyst is comprised of an engineered inorganic and porous particle embedded with carefully selected beneficial microbes. The particles are approximately 200-600 microns (µm) in size and contain 140,000 square meters (m^2) of surface area per kg of product. Drylet's process embeds the microbes inside the media where they are protected, allowed to thrive, and quickly replicate so they can be effectively integrated into microbial ecosystems. In the process, they accelerate mass-to-gas conversion, reducing solids while improving biogas generation by up to more than 30 percent with unchanged gas composition.

Utilizing Drylet's biocatalyst in biodigesters demonstrates consistent results in the range of 500 to 1,000 kgs of additional solids reduction per kg of product. Considering that 1 kg of volatile solids reduction (VSR) generates 0.85 m^3 of biogas, this amounts to between 0.42 and 0.85 cubic meters (m^3) of incremental biogas generated per kg of Drylet biocatalyst. With zero capital expenses required, the financial benefits include increased capital recovery, increased revenue from biogas (whether used to produce electricity or scrubbed for RNG), savings from increased onsite energy generation, and reduced sludge handling costs (see sidebars for more information.)

According to Drylet Chief Executive Officer Trevor Turbidy, "Producing biogas is quickly emerging as a desirable strategy to generate revenue while complying with increasingly stringent climate policies. More municipal and industrial wastewater treatment operators, as well as dairy farmers, pig producers, are embracing the opportunity of improving waste management to grow revenue and reduce costs. Optimizing the value of their capital investment in AD systems is made possible by simply adding our mass-to-gas conversion booster in their digesters."

Author's Note

Laetitia Mailhes is director of public affairs and communications at Drylet, LLC, based in Houston, Texas, US.

Municipal water resource recovery plant boosts biogas production

A 200,000-m^3-per-day water resource recovery facility in New Mexico, which has been a leader in the use of renewable energy for wastewater treatment, imports only five percent of its energy requirement from the local power utility. Onsite solar power and biogas generation meets 95 percent of the facility's energy needs.

Drylet proposed the addition of product to the primary and secondary digesters to enable up to a 20- to 30-percent boost in solids destruction and biogas generation. To achieve this goal, Drylet engineers worked with facility staff to develop a comprehensive dosage protocol. Data was collected on a broad range of operational parameters such as biogas generation, biogas composition, alkalinity, sludge-haulage volumes, and solids flows to and from the digesters. Training was provided to facility personnel on the best points of product application. The product was fed to the 10 primary and three secondary digesters in varying amounts, totaling 22.6 kg per day. The demonstration took place over 90 days.

As a result, biogas generation increased by 32 percent and natural gas use decreased by 10 percent. In addition, a 9-percent total solids reduction (2.55 dry tonnes per day) saved at least $10,825 monthly cost savings in solids handling. Total gross monthly savings amounted to approximately $22,000, accounting for both solids handling and natural gas use cost reductions.

Industrial operation reduces total solids

A food-rendering facility in Texas, which treats all the wastewater it generates, found a way to significantly reduce total solids produced in its wastewater lagoon system. The facility's treatment is comprised of two anaerobic lagoons, followed by three anoxic-aerobic lagoons that feed into the retention pond. Water is then recycled back to the operations.

Drylet's products were applied to all lagoons, treating the two anaerobic lagoons with BioReact AD and the two aerobic / facultative lagoons with Aqua Assist. Analysis of samples from the full wastewater lagoon system resulted in approximately 576,000 kilograms (1.27 million pounds) of total solids reduction in three months. In addition, biogas generation, measured by flare hours in operation, has more than doubled from about 3.5 hours per day to an average of 11 hours per day.

Microbiology is the most readily available, scalable, affordable, effective technology to remediate sludge through mass-to-gas conversion.

Reference

Scarlat, N., Dallemand, J., & Fahl, F. (2018). Biogas: Developments and perspective in Europe. *Renewable Energy*, Volume 129, Part A, pages 457-472