BIOSOLID BOOST: Pictured at a wastewater treatment plant, the Turbotec THP reactor couples a mixing and separation technology with efficient heat recovery.

PHOTO: DMT

How to Value Biosolids

Wastewater treatment plants face challenges treating their biosolids, but there are solutions to achieve maximum value in an evolving market.

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The core task of a wastewater treatment plant (WWTP) is to clean domestic waste water before reuse or disposal. Treatment is separated into primary treatment and secondary treatment. Primary treatment has wastewater continuously pass through a clarifier, or settling tank, to settle out solids, or primary sludge. In secondary treatment, wastewater is aerated in a basin to promote microbial growth. These microbes form flocs and settle out as activated or secondary sludge. The combined biosolids must be treated on-site or transported to another facility for treatment and disposal.

Sludge treatment facilities have two to four main steps of treatment: thickening, digestion, dewatering and sterilization. Small-scale WWTPs do not have the digestion step, and usually thicken and dewater sludge before transporting to another facility. Sludge thickening is done by all WWTPs to increase solids content of the sludge. Sterilization is done only if this is legally mandatory for Class A land application. At larger facilities, thickened sludge is anaerobically digested to break down complex matter via bacteria and reduce the sludge volume, reducing volatile solids and pathogens in the sludge, along with eliminating foul odors.

Depending on treated sludge quality, the final product can be land applied, landfilled, incinerated or composted. Sterilized sludge is higher-valued as Class A land application; nonsterilized sludge that is landfilled is typically Class B. Biogas obtained from the sludge digestion is either used on-site or flared. For WWTPs, biogas and biosolids pose three challenges—quantity, quality and finance.

Biogas Handling

Sludge digestion produces biogas, the amount of which depends on sludge composition (ratio of primary to secondary), digester residence time, bacteria metabolic rate and several other parameters that influence how it is managed. If biogas production is meager, it is usually flared or used in a small boiler for digester heat.

If a substantial quantity of biogas can be produced, it can used as a cogeneration fuel source. Power can be used for internal purposes and/or sold to the electricity grid. Heat can be used to maintain digester temperature, but only a small part of the available heat is required. Excess heat is dissipated into the surrounding environment. Another option is upgrading to renewable natural gas (RNG), which increases the methane concentration by removing fouling components. Upgraded biogas can be injected into the gas grid or transported as compressed natural gas. RNG is currently valued at $15-25/MMBtu within the within the renewable fuel standard as a D5 RIN (renewable identification number).

Challenges

Biosolids are faced with three main challenges: volume (quantity), biosolids classification (quality) and cost (finance). Sludge volume is reduced through AD and dewatering, but the output biosolids are classified as Class B with biogas as a byproduct. Addressing the challenges of biosolids has led to the innovation of continuous thermal hydrolysis process (cTHP), which elevates the sludge treatment efficiency. This unique technology exploits life steam injection, breaking down cell structures, leading to higher availability of volatile organic compounds and lowering overall viscosity. As a result of this process, digesters can handle higher biosolids loads, final sludge volumes are reduced, and output biosolids are Class A. An additional benefit is increased biogas generation by 25–50 percent.

How It Works

Sustec, part of DMT Group, patented the trademarked TurboTec, the first continuous THP process. A simple cooking analogy can be used to explain the essence of thermal hydrolysis process. Pasta in its raw form is inedible, but after boiling in a high pressure cooker, it's softened and edible. Similarly, sludge waste is pressured and heat treated, breaking down cell structures, simplifying complex organic matter and lowering feedstock viscosity prior to digester feeding, accelerating microbial activity. This allows digester bacteria to spend less time decomposing the organic matter, and more time converting it into biogas and digestate.

The TurboTec THP process operates at standard pressure of 4–6 bar (60-90 pounds per square inch) and temperature of 285-320 degrees Fahrenheit. Treatment at this temperature kills all microorganisms, pathogens and bacteria, and ensures waste stabilization. Moreover, due to lower viscosity, solids-loading of the digester can be increased by pre-thickening of the sludge up to 10–12 percent solids content. By coupling a mixing and separation technology with an efficient heat recovery, TurboTec THP can achieve this with only 800 kg/total dissolved solids (tDS) of steam being continuously injected into the hydrolysis reactor. Life steam injection serves to maintain the operating temperature and lower sludge viscosity by rupturing microorganisms into short-chained fragments, and the energy is reused to maintain digester temperature. Due to the continuous process design, the system works more efficient than conventional batch processes, satisfying two of the three challenges. All that remains is whether this technology is economically feasible.

A tool has been developed for analyzing the full potential of TurboTec THP process for a greenfield and existing-field situations in collaboration with DMT Clear Gas Solutions and Sustec. The tool considers operating parameters of the different sludge and biogas treatment steps, and evaluates the business case. For an existing-field, a digester was reviewed with adding a THP and gas upgrading system. But this is also compared to the situation where additional capacity is required. For a greenfield situation, digester size is reduced when using a THP, and the biosolids treated is kept equal. For either case, the tool can be used to determine the optimal strategy for biosolids disposal and biogas handling.

Digester Volume	10 Million Gallons (300–700 SCFM biogas)				
Development / Parameters	Boiler	Upgrading			
	Conventional	CHP-1	THP-1	CHP-2	THP-2
Project investment	—	$7.3 M	$ 14.5 M	$ 17.5 M	$ 17.9 M
Total treated solids (tDS)	27,633	27,633	27,633	45,775	45,775
OPEX					
Average interest (5%)	—	219,962	436,950	530,347	540,000
Maintenance (4%)	—	163,563	324,915	394,365	401,544
Sludge disposal	4,939,474	4,939,474	863,544	8,182,304	1,430,473
Poly-electrolyte	1,422,568	1,422,568	1,658,005	2,356,504	2,746,508
AC + caustic	8,390	8,390	11,039	13,897	18,285
Natural gas	—	516,981	993,553	563,803	1,645,834
Power	927,078	—	—	—	—
Revenue					
Renewable natural gas	—	1,686,015	2,325,784	2,792,906	3,852,692
Power via CHP	—	—	409,161	—	973,211
Net cash flow/year	-$7,297,510	-$5,584,923	-$1,553,062	-$9,248,314	-$1,956,741
Cost/metric dry ton solids	-$264	-$202	-$56	-$202	-$43
Savings from THP/year	—	$4,031,862		$7,291,574	
Return of investment	—	1.7 years		0 years	

Existing-field Scenario

The project investment in an existing-field represents the capital required for treatment facility improvements. This accounts of the equipment costs, building/civil, installation, piping, electrical/gas grid connection(s), contractor, contingency, engineering and legal administration. The economics of a business-as-usual case (i.e., combustion of biogas in a boiler) is used as reference to compare when biogas is upgraded and existing digester capacity is optimized as seen in Table 1. For the four different upgrading cases, biogas is converted to RNG and a CHP engine is operated using natural gas to explain the economics with respect to THP.

As aforementioned, implementing THP prior to AD allows the system to handle more sludge in the same digester capacity. The CHP-1 case has a project investment $7.3 million USD and treats about 27,500 metric tons of dry solids annually. In this case, all power produced from the CHP is utilized for operating sludge treatment process and revenue is from RNG grid injection. THP-1 case is the same as CHP-1 case, but the project cost includes a TurboTec unit. Because of the THP installed, the existing digester operates under capacity, but yields 25–30 percent more biogas, which reflects in the overall revenues. Additionally, operation costs are much lower for THP-1 than CHP-1, because of the sludge disposal cost difference. With implementing THP, the quality of the sludge changes from Class B to Class A, a high to disposal cost, so immediate savings from THP are about $4 million, leading to a faster payback period.

Cases CHP-2 and THP-2 treat about 45,800 metric of dry solids per year and have project investments of $17.5 and $18 million, respectively. The case THP-2 is the maximized version of THP-1 where digester capacity was not optimized. Conversely, CHP-2 required extension of digester space to treat same amount of solids as digester in THP-2 case. Since the amount of solids treated increased, the operational costs, revenue and saving from THP all increased proportionally. Hence, the payback period for these two cases is nonexistent.

The ROI for existing field is nonexistent because the project investment difference is minimal, and the savings earned from investing in THP are significant in comparison. Simply from the sludge disposal difference, profit can be made when disposal cost per wet ton of Class B is much greater than Class A. The profits can be further increased, depending on the RNG price available.

Turbotec is a viable solution to retrofitting existing digester plants, but also greenfield applications. Implementing THP offers the potential for reduction of sludge output and increase in biogas production. Furthermore, environmental regulations are becoming stricter regarding sludge disposal, emphasizing its earth-enriching benefits, as land application of biosolids helps the soil rejuvenate and promote plant grow. Moreover, with increased biogas output, the option of upgrading biogas to RNG is a viable source of revenue. With the energy paradigm shifting from fossil fuels to alternative carbon neutral sources, RNG pricing is expected to have high valorization, providing more incentive for investing in thermal hydrolysis to achieve Class A quality biosolids and to export or utilize biogas.

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