

# Innovation and recovery: sewage sludge treatment



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**T**he UK water industry is frequently accused of a reluctance to embrace innovation within its treatment processes, many of which have changed little in the last century. However, such accusations overlook the many changes that have taken place in our approach to handling and recycling the sludge that is an inevitable end product of wastewater treatment. It is just 15 years since the disposal of sludge to sea was phased out. At that time, the industry produced just over 1 million dry tonnes of sludge, with 25% disposed of to sea.

By contrast, this year, around 1.4 million dry tonnes will be produced. Sixty-two percent of this sludge will be anaerobically digested, generating of 1TWh of energy, followed by recycling of the resulting biosolids to agricultural land. So great this change has been that sludge reception or treatment centres now export energy either to the grid or to locally-sited wastewater treatment works. The

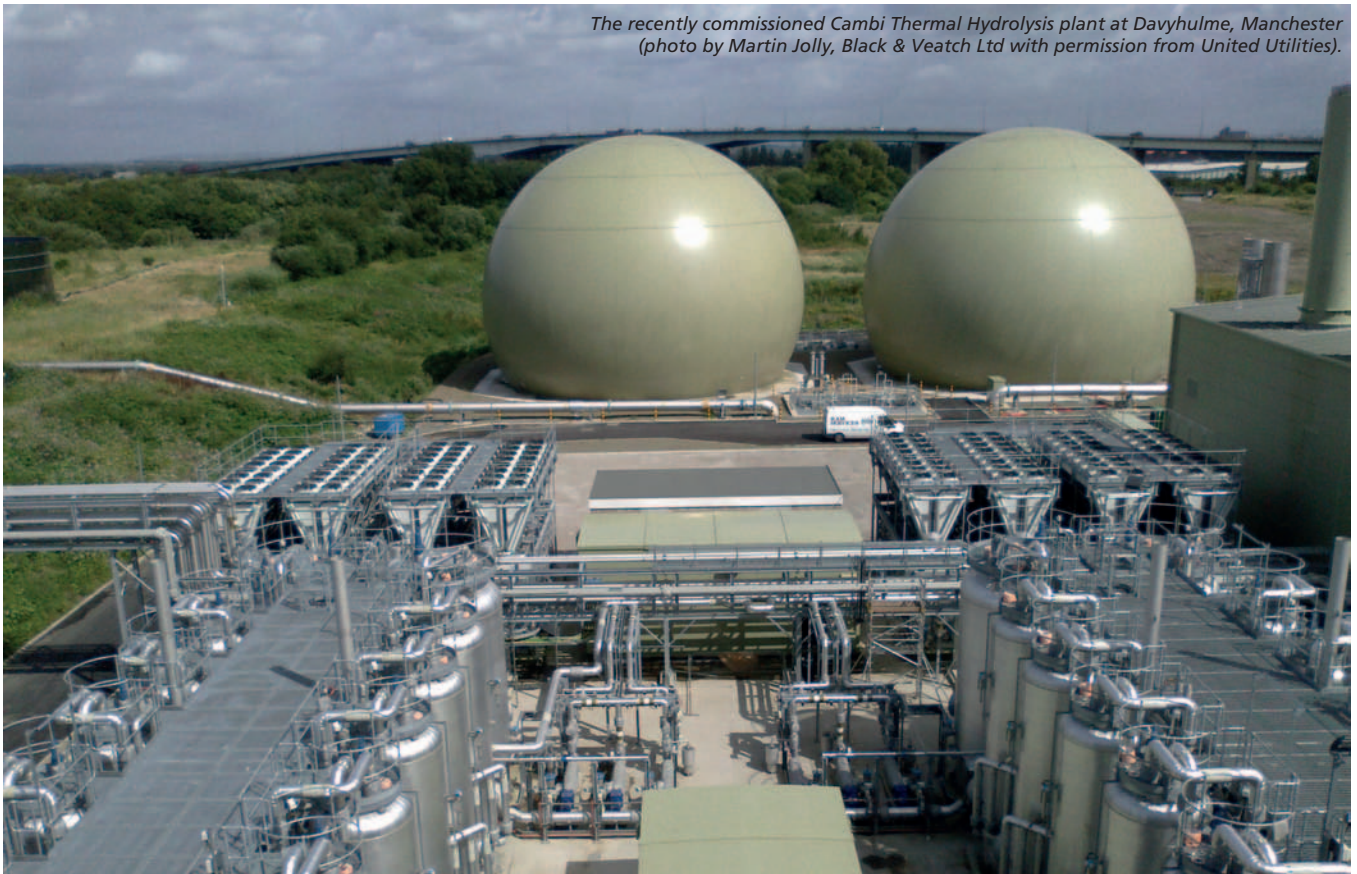
quality of the biosolids produced is so high that in many situations, the farmers are willing to pay a high price.

## Improved handling

Modern sludge handling facilities utilise technologies that were either unknown thirteen years ago or very much at the development stage. Improvements have taken place at every stage of the sludge handling process. Thickening of primary and secondary sludge has improved, and dry solids of 6% or more can be achieved as a result of understanding the importance of both the age of the sludge and the fraction of primary sludge in the blend. The methane yield from digestion of this sludge has been enhanced by recognising the importance of achieving a minimum temperature of 35°C throughout the digester and the need for good mixing to achieve this and to avoid stratification of the contents.

## Speeding up hydrolysis

The biggest advancement, perhaps, has been the recognition of the hydrolysis stage of the digestion process as the limiting step, and the introduction of biological and physical processes to speed it up. Hydrolysis is the process by which the large macromolecules of protein, lipid and polysaccharides are broken down to their component monomers of amino acids, fatty acids, glycerol and hexose sugars. It is achieved enzymically by inserting a water molecule (in the form of H<sup>+</sup> and OH<sup>-</sup>) between inter monomer bonds (for many large molecules, particularly those found in waste biological sludge, it is a slow process). Technologies such as enzymic hydrolysis and thermal hydrolysis both reduce the reaction time and improve the reaction efficiency.



*The recently commissioned Cambi Thermal Hydrolysis plant at Davyhulme, Manchester (photo by Martin Jolly, Black & Veatch Ltd with permission from United Utilities).*



*The BioThelys thermal hydrolysis plant at Esholt is designed to treat a nominal throughput of 30,000 tonnes of dry solids per year of a mixture of primary and secondary sludges which are produced both at the Esholt works itself as well as sludge imported from other sites. A BioThelys plant at Oxford is in construction phase with a process commissioning planned for the beginning of 2014.*



hydrolysis of the sludge. Both biological and thermally hydrolysed sludge are then treated by conventional mesophilic anaerobic digestion (MAD), albeit with the ability to feed the digester at sludge dry solids concentrations of up to 12%, due to their reduced viscosity. As a result, the specific methane yield ( $\text{m}^3$  methane/ $\text{m}^3$  reactor volume/d) is much enhanced.


The former biological process is in operation at many sites across the UK as the Monsal EH process. It provides a number of reactors in series with different operating conditions of pH and organic loading rate, supporting optimum conditions for the bacteria that are responsible for biological hydrolysis.

After the digestion process, the resulting sludge (by this stage known as biosolids) will dewater more readily to give a dry solid concentration often in excess of 30%, which reduces transport costs in moving the cake to agricultural land for recycling.

The latter thermal process is known as the Cambi THP, and more recently, also the Veolia Thelys<sup>TM</sup>, uses steam at a temperature of 150 - 170°C to raise the pressure of the sludge to as high as 11 bar. Sludge is then held for around 30 minutes and flash released, resulting in a rupture or


### Methane recovery

The digestion process produces methane. Each 1  $\text{m}^3$  of methane produced contains 9.9 kWh of energy. There




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are many ways to recover this energy – perhaps the most common route is to burn the methane in a combined heat and power (CHP) system. With this method, around 32% of the energy is captured as electricity with the rest recovered as heat. This heat is used to provide heat for the digester and the thermal hydrolysis unit, though it can also be used as space heating.

Both the electricity and heat generated attract government subsidies through Renewables Obligation Certificates (RoCs), Feed in Tariffs (FiTs) and the Renewables Heat Incentive (RHI). But finding uses for all of the waste heat can be difficult, especially for sludge treatment centres that import a lot of sludge. In these circumstances, it may be more economic to use only a fraction of the sludge in CHP based on the amount of heat needed. The remainder can then be used either for direct injection to grid, after appropriate clean-up, or liquefied for use as a biofuel for vehicles. For all of these options, the specific site circumstances and the value of the subsidies available will drive the process decision.

### Nutrient recovery

The technological innovations continue with nutrient recovery. The dewatering process generates a liquor that is rich in nitrogen and phosphorus, both valuable plant

nutrients. Traditionally, this dewatering liquor was returned to the head of a treatment plant to receive aerobic, energy intensive treatment. However, it is now cost effective to recover these nutrients as crystals of struvite or magnesium ammonium phosphate, a crystallization reaction that is achieved by the addition of magnesium under controlled conditions and in a suitably engineered reactor will produce a granular product that is an excellent high-value, slow release fertilizer that finds a ready market under the trade name of Crystal Green®. The first full-scale systems in the UK are now under operation.

### The future

With wastewater treatment plants now practicing recovery of both energy and nutrients, the UK's treatment plants now more resemble resource recovery factories than sewage treatment plants. Energy neutral treatment is the next goal and there are many exciting and innovative projects underway to ensure our water industry will deliver this goal – surely a beacon of innovation and sustainability for other industries to follow.

*For more information on about CIWEM's Wastewater Management Panel, visit [www.ciwem.org/knowledge-networks/panels/wastewater-management.aspx](http://www.ciwem.org/knowledge-networks/panels/wastewater-management.aspx)*

