Anglian Water's Special Biosolids Projects
programme enhanced through integration

by

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Anglian Water's Biosolids programme exemplifies a water utility successfully integrating the expertise of its contracting and consulting partners to deliver benefits at the strategic level. Cotton Valley and King's Lynn, two of the programme's schemes, exemplify how using a successful integrated design and construction capability can deliver significant benefits at the project level. Cotton Valley, near Milton Keynes and King's Lynn, in Norfolk, represent two of the four schemes that comprise Anglian Water's Special Projects Biosolids Programme. It is impossible to discuss these projects to design and build advanced sludge processing centres without first discussing Anglian Water's innovative approach to the whole programme because, in these cases, the latter has had a significant influence on the former.

Kings Lynn Biosolids Treatment Centre *photo courtesy of GTM*

Anglian Water recycles 90% of its biosolids to land, using lime as the predominant method, to ensure pathogen kill. Lime dosing, however, significantly increases the volume of the treated sludge: 112 tonnes of treated product for every 100 tonnes of sludge. Transporting this volume of material around the countryside, and importing lime to the treatment centres, has a significant environmental impact. Additionally, with lime there is the impact of quarrying and manufacture. The aim of the Biosolids Programme is to ensure biosolids are treated to an enhanced standard, suitable for recycling to agricultural land, while reducing overall environmental impact.

To fulfil this goal, Anglian Water identified the need for five sludge treatment centres collectively capable of processing 77,000 tonnes of sludge per year, to an "enhanced treated" standard. The first centre had to be operational within 30 months. To meet these challenging targets the utility formed a collaborative project team to determine the delivery and procurement strategies and commercial model.

The team

The team comprised Anglian Water, Mott MacDonald, as the programme management consultant and two contracting entities GTM, a joint venture between Galliford Try and Imtech Process; and

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Morfa Bychan, Dŵr Cymru Welsh Water

Kings Lynn, Anglian Water

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photo courtesy Black & Veatch Water, Europe

Black & Veatch (B & V), which was able to provide an integrated process and construction capability in-house. All the contracting entities had a major role in shaping the programme as a whole. Black & Veatch are responsible for delivery of the sludge treatment centres at Milton Keynes and Norwich with GTM responsible for delivery of the sludge treatment centres at Kings Lynn and Northampton.

The programme's final structure was largely determined by a steering group of programme and framework managers from Anglian Water, Black & Veatch, GTM and Mott MacDonald. Following a reappraisal of the best way to meet Anglian Water's needs, the group proposed an alternative to the original five treatment centre plan. Using only four centres but providing hydrolysis treatment, the revised delivery programme would be able to give a greater annual treatment capacity: 100,000 tonnes as opposed to 77,000 for the original proposal. Under the new programme, capital expenditure (capex) would increase by 10% but this would be offset by an operational expenditure (opex) saving of **£3M per annum.** These opex savings would pay back the increase in capex within three years.

The substantial opex savings were achieved as a result of opting for hydrolysis processes to treat the sludge, a valuable consequence of this approach being a substantially increased biogas yield.

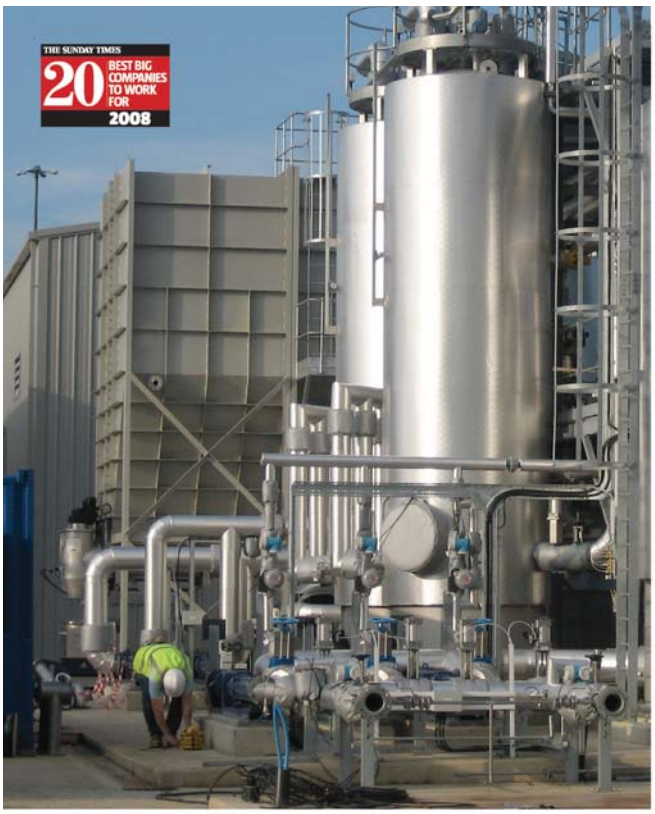
Combined heat and power (CHP) units are able to convert sufficient quantities of the biogas to meet the heat requirements of the hydrolysis process and generate enough electricity to run the new and retained existing works. As a result, the four treatment centres will be energy self-sufficient. A further element of the opex reduction resulted from the cut in bulk lime purchases. In sustainability terms, this approach greatly reduces the treatment centres' reliance on fossil fuels for power and road fuel.

The bond of trust and co-operation between contractor and client that made such a contribution to the overall shape of the biosolid's programme is manifest on the each of the first two projects which are described in detail below.

Cotton Valley Sludge Treatment Plant

The quality of the relationship with the client is paramount to the success of a project such as Cotton Valley. The site is live so contracting and operational staff need to understand and accommodate each others' needs. The relationship has proved strong and Black & Veatch is now close to integrating the advanced sludge treatment plant with the site's existing wastewater treatment processes.

Because the project has been undertaken within the boundaries of an existing works, limited space has been a defining feature at Cotton



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Cotton Valley's thermal hydrolysis plant - system demanded small space *photo courtesy Black & Veatch Water, Europe*

Valley. For example, the Cambi thermal hydrolysis system was chosen by virtue of its small footprint in comparison to other hydrolysis technologies. The Cambi process achieves pathogen kill through a combination of high temperature and pressure, essentially 'pressure cooking' the sludge.

The new plant at Cotton Valley will treat up to 21,000TDS/annum and consists of screening, pre-dewatering, Cambi Thermal Hydrolysis, anaerobic digestion and gas holding. The Cambi plant treats the sludge by injection steam from a 5 tonne steam boiler at 8 bar. This process kills the pathogens and breaks down the sludge making it more readily digested and hence producing an increase gas yield.

Constructing Cotton Valley's sludge treatment plant has been like completing a Rubik's Cube. Unlike a greenfield site, it has been constantly necessary to build one structure in order to move or remove another. This is the only way it has been possible to keep the WwTW operating during the project.

For example, the only location suitable for the new steam boiler was already occupied by the existing gas holder. Hence, a new gas holder had to be built before the old one could be decommissioned, dismantled, and replaced by the boiler. Similarly, it was necessary to build a new sludge cake bay, to replace the existing one, which had to be demolished to make way for the Cambi plant.

A delay in one area would hold up progress on everything because it would have been impossible to move on to another element of the project. Although the structures themselves were straightforward, sequencing the work was very challenging. Exacerbating this problem was the plethora of existing services. Almost every excavation revealed a cable or pipe that had to be diverted before work could proceed.

The nature of the site also meant that it was not always possible to build structures in the ideal location. Logically, for example it would have been best to build the steam boiler next to the waste heat boiler and CHP unit. This could not be done, however.

To overcome these complex challenges Black & Veatch construction teams on site had to work very closely with the business' process, mechanical, electrical and civils designers to achieve consensus on the optimum solutions. Having these people working for the same company made the progress significantly easier. In addition to these strong internal relationships, B & V teams established very productive partnership with their Mott MacDonald design colleagues.

In many instances the B & V design and construction staff had worked together for periods in excess of ten years. This meant they had a great understanding of what each other was trying to achieve. The construction team knew what the designers would be looking for when they made suggestions, the designers had direct knowledge of how the construction team would want to build.

With the £16M project at Cotton Valley due for completion in July 2008, B &V has already begun work on the biosolids programme's second Cambi installation - at Whitlingham, Norwich. The main civil works are complete and much of the mechanical plant is now in place. Like Cotton Valley, Whitlingham is a live works, and like Cotton Valley using integrated design and construction capability promises to deliver great benefits to Anglian Water.

Kings Lynn Sludge Treatment Centre

A key part of the successful delivery of the new Kings Lynn sludge treatment centre was based around the proven relationship that Galliford Try/Imtech Process has fostered on previous projects. This ensured a totally integrated approach with all the other partners within the Biosolids programme.

The new Kings Lynn sludge treatment centre utilises an enzymic hydrolysis process, rather than the Cambi thermal hydrolysis used at Cotton Valley. The centre is designed to treat up to 19,000

Heat exchangers arrive at Cotton Valley courtesy Black & Veatch Europe

TDS/annum. The enhanced treated sludge achieves a 6 log reduction in *E.coli* concentration, an absence of *Salmonella* and cake dry solids above 24%w/w.The following description gives a detailed explanation of the treatment process that has been selected to deliver an enhanced sludge product at King's Lynn.

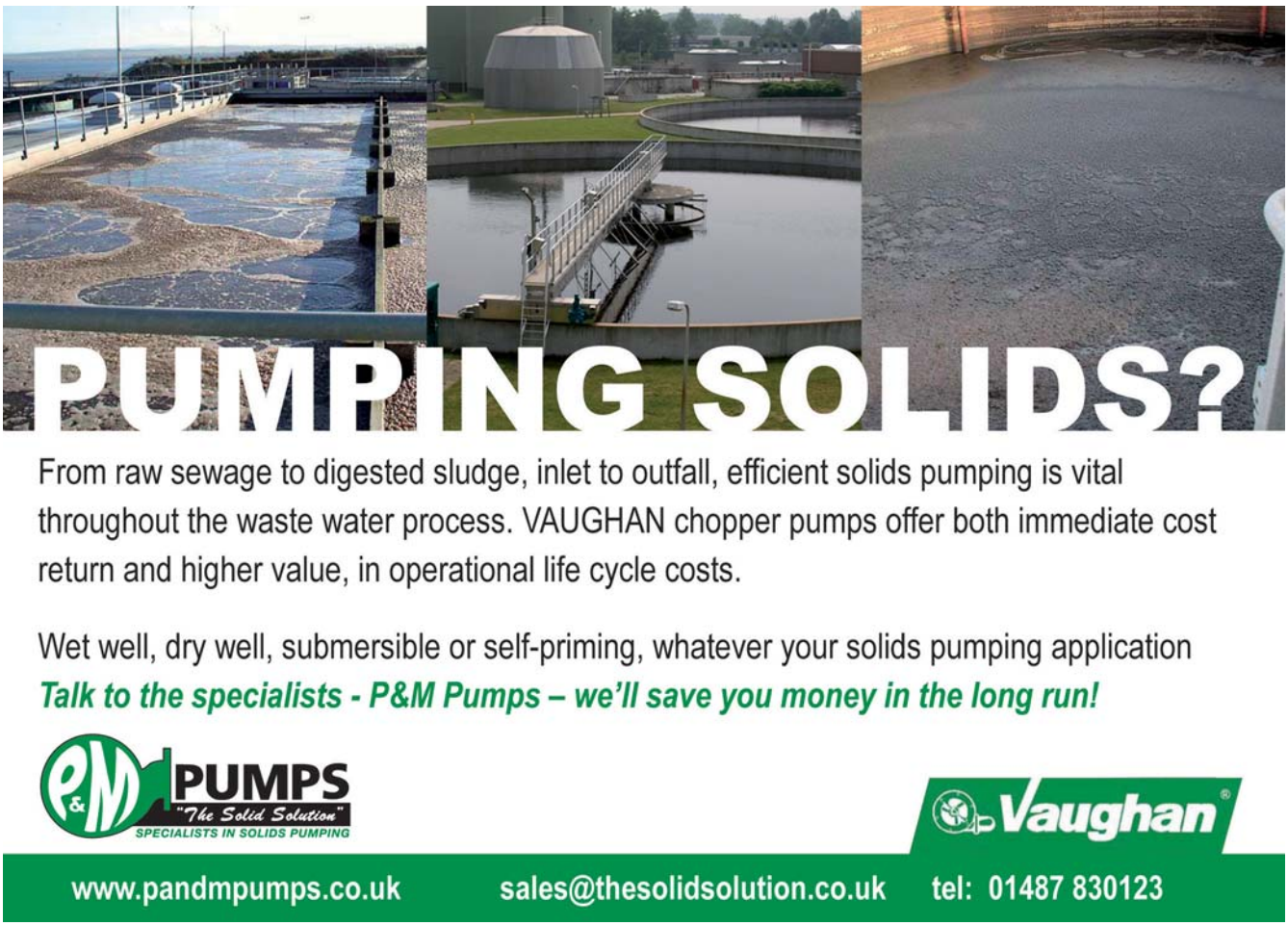
Treatment process

Blended sludge is passed through Strain presses, then thickened to an average of 7%w/w DS using gravity belt thickeners. Sludge treatment is by enzyme hydrolysis and pasteurisation (Monsal Enhanced Enzymic Hydrolysis EEH process) followed by mesophilic anaerobic digestion. After digestion the sludge is dewatered by centrifuge and conveyed to skips for disposal off-site. Intermediate sludge holding tanks are provided between each stage of treatment. Sludge liquors gravitate to a return liquor pumping station from where they are pumped to the head of the adjacent existing WwTW.

The biogas produced from the hydrolysis and digestion processes is collected in a 2,000m^3 membrane gas holder. As with Cotton Valley, the gas is used by High efficiency CHP units and a standby steam boiler which provide electrical power, hot water and steam.

To obtain maximum gas recovery and optimise power generation, the normally combined methanogenesis and acidogenesis stages are detached to give the separate enzyme hydrolysis and digestion stages.The Monsal EEH process comprises of six reactors in two stages, a front end enzyme hydrolysis stage (Stage 1) and a back end pasteurisation stage (Stage 2).

For enzymic hydrolysis up to 1.9MW of hot water (engine jacket cooling water) raises the sludge temperature to 42 degrees C. For pasteurisation up to 1MW of steam heat is injected directly into hydrolised sludge to achieve 55 degrees C in the fourth reactor. This was the first project to utilise steam as the method of heating for the pasteurisation. Direct steam injection eliminates the risk of Vivienite formation in a hot water heat exchanger. These heat demands are normally supplied by two CHP engines and an associated CHP waste heat steam boiler. Alternatively, both these heat demands can be met by the standby steam boiler, which supplies steam and can also raise the temperature of hot water circulating in the primary hot water



Cotton Valleys Cambi thermal hydrolysis plant with small footprint *photo courtesy Black & Veatch Europe*

circuit (ring main) by condensing steam in a steam/water heat exchanger. Final effluent is circulated from the existing works outfall chamber as the cooling medium to ensure the digesters operate below 40°C.

The combination of enzymic hydroysis with anaerobic digestion increases the yield of biogas, which is used to power two 1Mega Watt CHP engines. In keeping with the programme's aim of making new treatment centres energy self sufficient, excess power from the CHP units will be exported to the grid only after satisfying power demands from the existing WwTW and new STC.

The outline design and target costing phase of the scheme commenced in January '06 and was completed in May '06. Construction completion was achieved in December '07 and the plant was officially handed over to AWS in May '08. During the outline design stage it was necessary to revise the layout; firstly by maintaining a safe margin between overhead 144kV power lines and the construction works and secondly, to enable a safer and faster construction by allowing space in between structures and buildings to enable them to be built consecutively. The additional space was obtained by purchasing additional land and the relocation of existing land drainage ditches.

Although the structures and buildings were constructed in parallel, the principal structure (two 6,000m^3 above ground digestion tanks) were on the critical path throughout the project. However, innovative construction methodology ensured that their delivery would be on time and to the specification, despite significant weather related delays. The tanks were constructed using climbing shutters, a set for each digester. These were manufactured at site on top of pre-formed concrete cambers which represented the inside and outside diameters of the tanks. The tank walls are 600mm thick.

In order to accelerate commissioning and plant start-up, temporary steam boilers were hired and digested 'seed' sludge was imported from an existing digestion plant. This allowed the completion of the M & E installation and the testing and commissioning phases to run concurrently.

Whilst King Lynn remains the flag ship project of GTM's contribution to Anglian Water's Biosolids Programme, the JV has also developed and is currently constructing what will be Anglian Water's largest sludge treatment centre at Northampton's Great Billing WwTW. This £28M Sludge Treatment Centre is designed to treat an impressive 40,000TDS/annum utilising the Monsal EEH process. Full scale operation is anticipated from April '09.

Although the Biosolids Programme comprises a quarter of individual and district projects, a spirit of co-operation and the willingness to integrate has been common for all four sites. This integrated approach has been the key to the successful delivery of each scheme as well as the programme as a whole.

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Containerisation is the choice for ferric dosing at **Anglian Water's** King's Lynn STW...

...and the **Michael Smith Systems KTB concept** delivers the solution.

Provision for ferric chloride dosing for feed stock at the new on-site CHP (Combined Heat and Power) bio-solids plant at King's Lynn, a fully containerised 30 cubic metre KTB dosing unit was the choice of Anglian Water and the contractor, GTM consortium.

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