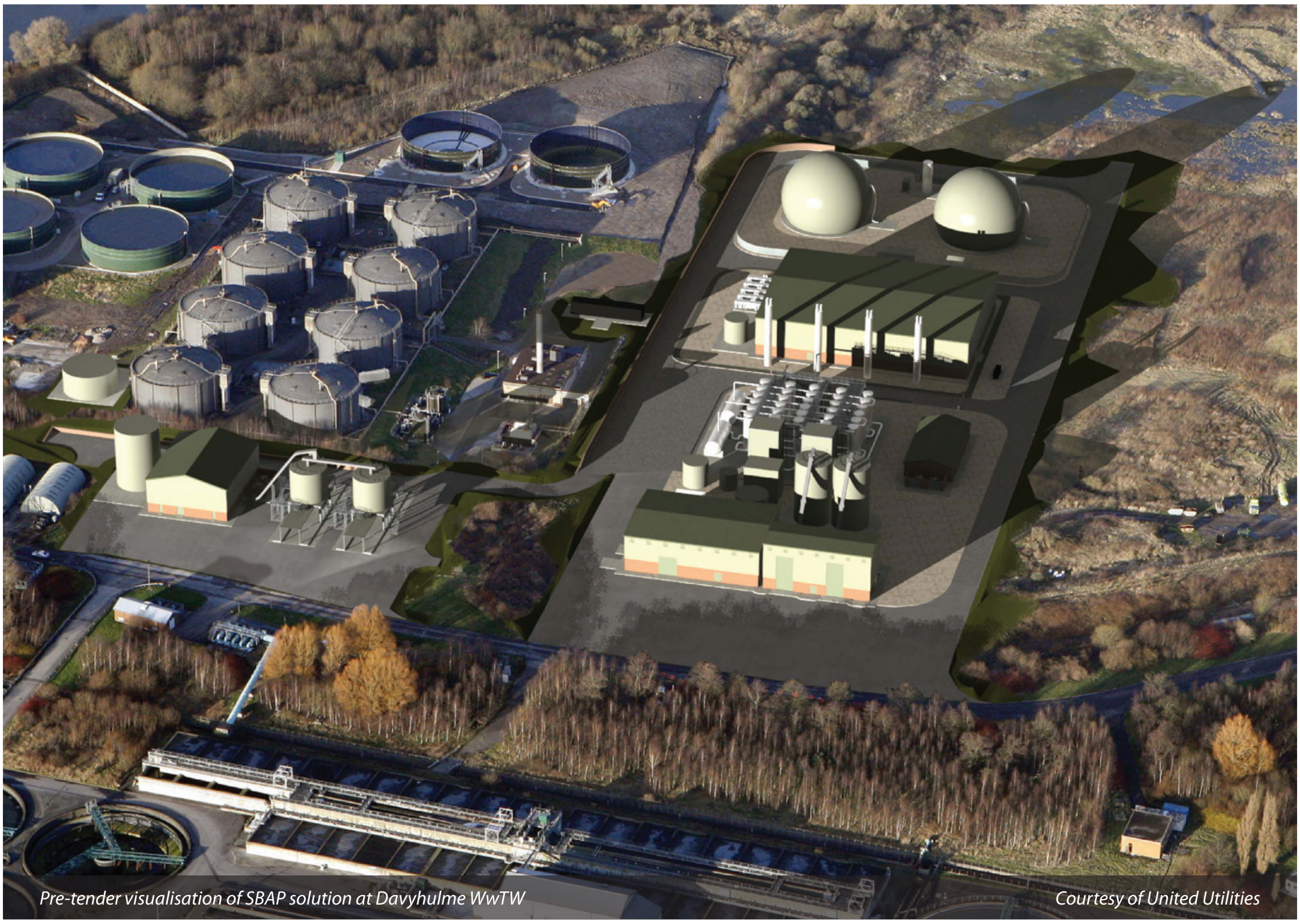
Davyhulme WwTW

delivering United Utilities' sludge balanced asset programme

by John McNeill and John Thornton

United Utilities (UU) currently produces 202,300 tonnes dry solids (TDS) of raw sludge per year and this is estimated to increase to 243,000 tonnes by 2015 due to a combination of population growth and the introduction of stricter water quality legislation. UU has an incineration facility capable of burning 30% of this sludge (after digestion) at the Mersey Valley Processing Centre (MVPC) in Widnes. The remaining sludge is recycled to land in a ratio of approximately 60% digested sludge to 40% limed. This reliance on land as a significant proportion of the disposal strategy presents many risks to UU. The landbank available to receive sludge is decreasing under pressures such as changes in farming practices, public perception, and reduction in brown-field reclamation. There will become a point at which sludge production will equal the landbank availability. This has necessitated UU to revise their strategy to reduce their reliance on land.



Pre-tender visualisation of SBAP solution at Davyhulme WwTW *Courtesy of United Utilities*

Sludge strategy

In 2002, UU formulated a strategy reducing its reliance on land application from around 70% to circa 35% by the installation of additional incineration. The strategy was to be achieved by upgrading the existing capacity at the MVPC and building a new incineration plant in Lancashire to receive limed cake from surrounding wastewater treatment works (WwTW). These projects were supported by the economic regulator OFWAT.

The MVPC extension project was successfully delivered in 2010. A project team made up of experts within UU with support from partners MWH was set-up to design and deliver the Lancashire Processing Centre (LPC) to burn 52,000 TDSA of raw sludge. The proposed plant is shown in Figure 1 (see next page).

However, concerns grew within the team regarding the sustainability of a new incineration plant. Therefore workshops looking at many potential solutions were arranged and three options, including incineration, were identified. These were investigated in more detail by the project team with a focus on capital and operating costs, environmental impact, energy balance and carbon footprint.

Carbon calculation model

A highlight of the evaluations was the development of a pioneering carbon calculation model to provide a differentiator in the decision making process. This was the first time this had been done within UU and has subsequently become a valuable carbon assessment tool, utilised as "business as usual" on all capital projects within UU's AMP5 programme.

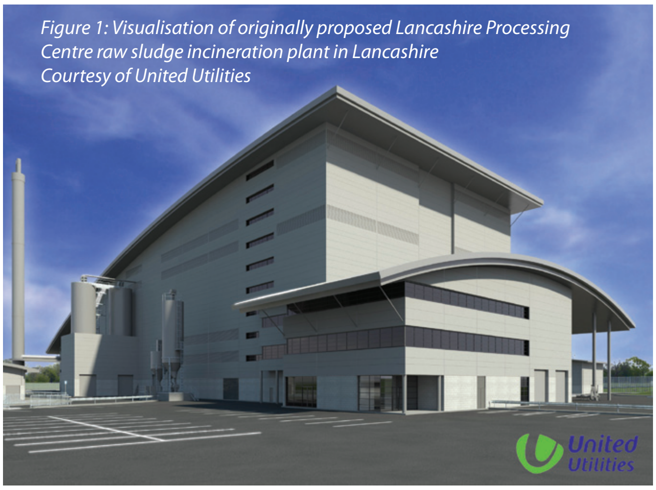


Figure 1: Visualisation of originally proposed Lancashire Processing Centre raw sludge incineration plant in Lancashire
Courtesy of United Utilities

The model was externally verified by The Scottish Institute of Sustainable Technology (SISTech), which stated the work *"is an excellent example of a tool designed to provide an in-depth assessment of options for responding to a specific problem."* Results from the model, along with the other decision making parameters, demonstrated that, based on the knowledge and constraints at the time, it was very difficult to justify the raw sludge incineration project.

SBAP – a new solution

In September 2007 an alternative solution, which was more environmentally beneficial than the LPC, was approved by UU at board level. It was entitled Sludge Balanced Asset Programme (SBAP) to reflect the innovative approach which maximises the use of existing distributed assets by considering them as a holistic system.

SBAP involves the construction of an advanced sludge treatment plant at Davyhulme WwTW, Manchester, to treat both on-site sludges and imported sludges from 7 (No.) WwTWs predominantly based in Lancashire. The plant will reduce quantities for disposal and produce an enhanced quality, pathogen free product. The product will be suitable for recycling to grassland, arable land and cultivation, and the increased sludge quality will improve take up from farmers and growers.

This approach required a thermal hydrolysis process (THP), upstream of the existing digesters, which will improve sludge characteristics allowing increasing volumes to be pumped to the MVPC. This will give greater flexibility in dealing with increased sludge volumes. The SBAP sludge will have better burning characteristics, reducing the fossil-fuel requirement at the MVPC.

The pre-treatment process also improves the digestibility of the sludge such that the amount of biogas produced is increased. Utilising this biogas increases the amount of renewable electricity generated at the WwTW enabling the entire works to be self-sufficient thereby significantly reducing operating costs and ultimately benefiting customers. Surplus power can be exported to the grid.

Planning permission has been granted for the proposed development and tender documents were issued in 2009 for a competitively tendered lump sum performance based specification. In November 2009, Black & Veatch were appointed as the main contractor to deliver the works.

Delivery of SBAP

Following contract award the Black & Veatch in-house engineering team immediately started detailed design. A significant number of the project team transferred from the tender, bringing with them

the technical and process knowledge gained during the tender phase. From the outset Black & Veatch used 3D design techniques for the whole works. This proved particularly beneficial during the HAZOPS and Access and Lifting reviews when the delivery teams including UU's Operations team at Davyhulme had the opportunity to visualise the whole scheme.

In early 2010, site accommodation was erected at Davyhulme WwTW providing accommodation for the Black & Veatch and United Utilities delivery teams to co-locate.

Ground preparation

One of the earliest activities was the preparation of ground for the main items of equipment including the Cambi™ THP and the combined heat and power (CHP) and steam plant. This involved the removal of buried concrete drying beds which covered the main construction site. All this material was excavated and stockpiled, before being crushed and re-used for other construction activities on site. To date no excavated material has been taken off site.

Major improvements to the liquid sludge storage facility are being carried out as part of the project. Air mixing will be installed in each of the existing storage tanks.

The existing sludge screens and strain press are being replaced with a new sludge screening plant utilising the existing building with minor modifications. Temporary screening plant will be provided during these improvements to maintain operational capabilities.

Sludge handling

The screened liquid sludge is pumped to the new thickening facility consisting of 4 (No.) centrifuges, each capable of processing 100m³/hr @ 2% dry solids. These are located in the newly constructed main treatment building, which includes the polymer plant.

THP plant and Main Treatment Building at Davyhulme
Courtesy of United Utilities

The capacity in the existing odour control plant created when the existing belt thickening facility is decommissioned will be used to odour control the main process plant. An ionised air odour control plant will be used to control the H_2S levels in the dewatering and thickening plant.

Sludge cake import facilities are provided by 2 (No.) 85m³ cake reception hoppers. These are capable of accepting deliveries from the contributing sites in 28-tonne articulated vehicles. The cake will be transferred from these by elevated Chainlink conveyors to 2 (No.) 800m³ glass lined storage silos.

The thickened sludge and cake is then blended within a range of 16% to 19% dry solids and fed to the Cambi plant. The Cambi plant, which has 4 (No.) streams each with 5 (No.) reactors, is capable of processing 333TDS/d when all streams are in use. Treated sludge is transferred to the existing digesters which have had additional spray polyurethane insulation to maintain the temperature differential between the inside and outside surfaces of the structures due to the higher operating temperatures of the sludge after it has passed through the THP plant.

To accommodate the additional gas, 2 (No.) flexible membrane gas holders, each with a volume of 9,000m^3, will be erected to replace the existing plant. The gas storage system includes a flare system sized at maximum gas production rate with a 75% turn-down facility and a Siloxane removal plant to provide protection for the CHP engines. The existing Siloxane plant will be relocated to give additional capacity.

Biogas

The biogas from the gasholders is fed to 5 (No.) 2.4mW Jenbacher CHP engines. Two of these engines are new, the others are existing units relocated. Relocation must be in a phased manner to ensure current energy production capability of Davyhulme WwTW is not compromised. The engines generate electricity for which UU receive Renewable Obligation Certificates (ROCs) which are 'green' certificates issued for the generation of renewable electricity.

Hot gasses from the engine exhaust are cooled and used to generate 12-bar steam in one of three steam boilers. Steam is then injected into the reactors for use in the THP. Biogas is also used in the boilers to supplement the steam required by the Cambi plant. To ensure that the steam generation plant produced sufficient steam at the various operating cycles of the THP, Black & Veatch developed a dynamic steam model to optimise the efficiency.

Digested sludge

The treated digested sludge can either be transferred to the MVPC or the new dewatering facility. This consists of 2 (No.) centrifuge capable of producing an enhanced treated cake in the region of 28.5% dry solids before storing in glass lined export silos ready for loading into transport and distributing on to farm land.

Conclusions

The project is currently well progressed in construction of what is an exceptionally challenging programme. The success of the project is dependent on 10-sectional completion dates being achieved whilst not compromising the site operational capability. Members of the Davyhulme operations team have been integrated into the delivery team ensuring a smooth transition between the new and existing facilities.

Black & Veatch also identified at the start of the project the importance of the early involvement of the supply chain because of the complex nature of some of the major subcontract packages. They have worked closely with the Black & Veatch team during the design using the 3D model to finalise the plant layout.

The added involvement of Black & Veatch's quality control team working closely with the subcontractors during manufacture has ensured that the manufacturing and installation process has progressed smoothly and to the highest standards.

The continued teamwork, dedication and performance of the co-located Black & Veatch and United Utilities/MWH teams, many of who will transfer through the design construction and commissioning phases of the project, will ensure that it is delivered on schedule and will successfully achieve the take-over and performance test required in the contract.

The Editor & Publishers thank John McNeill, Project Manager (Special Projects) with United Utilities and John Thornton, Project Manager with Black & Veatch, for preparing the above article for publication.

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