

From raw incineration to advanced digestion – influence of sustainability on meeting a sludge strategy

W. P. F. Barber ¹

¹ Biosolids Technical Expert, United Utilities, Haweswater House, Lingley Mere Business Park, Warrington, England, WA5 3LP, UK. (E-mail: bill.barber@uuia.co.uk)

Abstract A proposed solution of a raw sludge incineration plant had been identified to meet the changing sludge strategy requirements of United Utilities (a major UK water company) from 2005 – 2010. This solution was endorsed by a UK water Regulator as part of their 5 yearly investment program. However, due to a changing environment, and work completed by the project and strategy team responsible for the delivery of the solution, the proposed raw incinerator was reviewed. This paper presents the review process and the justification for the eventual change in direction and describes the technical complexities involved with the development of a new – more environmentally sound, and technically complex – solution which has gained full support from the Regulator.

Keywords: Advanced digestion; flexible operation; incineration; strategy; sustainable

1. Introduction

1.1. United Utilities Historical Sludge Strategy

The treatment and management of sludge in the UK and Europe has been influenced significantly by the increase in sludge volumes due to the implementation of the European Union's Urban Waste Water Treatment Directive and similar legislation, while the options available for management have been reducing. The implementation of the Waste Framework and Landfill Directives has reduced the availability of landfill, and the use of land for agricultural recycling of biosolids has become more restrictive. These limitations have been driven by strict rules on nitrogen application; concerns over metals; changes to farming practices; public perception, and phosphorus. In addition there has been a reduction in brownfield sites making the use of reclamation a highly opportunistic outlet.

Since privatisation, United Utilities – a major UK Water Company responsible for provision and treatment of water for 3.1 million household and business customers – has invested heavily in wastewater treatment improvements across the north-west of England to meet more stringent environmental quality standards. This has resulted in a significant growth in the amount of sludge to be managed in the north-west, and the treatment capacity required. In the year 2007/08 United Utilities produced and managed

approximately 202,300 tonnes dry solids per annum (TDSA) of biosolids. The vast majority (over 70%) of this is digested and recycled to agricultural land. The remainder is raw and conditioned with lime prior to land application. A fraction of the sludge is thermally destroyed in a purpose-built incineration facility.

Prior to 1998, it was legal to deposit sludge into the sea and this route accounted approximately 50% of United Utilities' sludge in the 1990s as shown in Figure 1. To enable marine recycling, United Utilities built an 80 km long pipeline into which several digestion plants fed their sludge which was pumped to the sea via Liverpool.

After 1998 – when marine recycling was stopped by The North Sea Conference – United Utilities built a biosolids incinerator at a strategically placed location on the pipeline called the Mersey Valley Processing Centre (MVPC) aka Shell Green. Biosolids have since been pumped to this plant and dewatered on arrival prior to incineration or application as standard treated sludge. The facility could treat approximately 20% of United Utilities' sludge.

Increasing taxes are discouraging the landfill use in Europe (Landfill Tax, Statutory Instrument 1996 No. 1527), and the impacts of this can be seen in Figure 1 which shows a gradual decline from the year 1990.

Following the outbreak of foot and mouth disease, United Utilities commissioned a detailed review into agricultural landbank type and availability which was updated in 2006 (Land Research Associates, 2006). The reports took into account numerous factors inclusive of:

existing and proposed legislation; environmental restrictions; agricultural support schemes; agronomic restrictions; weather and climatic restrictions, and competition from farm and other off-farm organic wastes. Based on the findings, United Utilities formulated a biosolids strategy reducing its reliance on land application from around 70% to circa 50% by the installation of additional incineration. The strategy was to be achieved by upgrading existing capacity at the MVPC by the installation of a third stream and building a new incineration plant in Lancashire called the Lancashire Processing Centre (LPC) which would burn sludge which was currently limed and recycled to land as standard treated sludge.

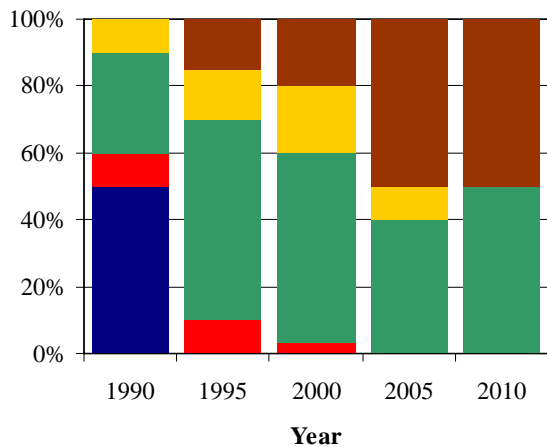


Figure 1. United Utilities' sludge outlets 1990 – 2010.

Key: Sea (■); Landfill (■);
Agricultural Recycling (■),
and Incineration (■)

1.2. From Lancashire Processing Centre (LPC) to Sludge Balanced Asset Programme (SBAP)

A project team designed the Lancashire Processing Centre (LPC) to burn 52,000 TDSA of raw sludge. The proposed plant had been designed to comply with the Waste Incineration Directive (WID – 2000/76/EC) with three-stage flue gas clean-up consisting of electrostatic precipitation for dust removal, followed by liquid scrubbing to remove acid gases, and finally adsorption for removal of mercury, traces of other metals, and dioxins/furans. However, major concerns grew within the team regarding the long-term sustainability of a new incinerator. The initial public response was poor and long-term planning and permitting issues were expected to be a problem. Also, technical problems added to the team's concerns. Untreated

raw sludge (assumed better for burning) limited contingency during planned shutdown as it was difficult to maintain a recycling outlet on an intermittent basis.

In addition, whilst biosolids treatment emits greenhouse gases, when used as a fertiliser displacement product it can offset carbon emissions from fertilizer manufacture. These offsets would be lost by incineration. Published work (Kroiss and Zessner, 2007) has shown that every 1 kg N fertilizer requires approximately 10 kWhr of energy during manufacture. Based on standard conversion factors (Defra, 2007), 1 kg N fertilizer generates a carbon footprint of 5.2 kg CO₂equivalents. The UK Water Industry is responsible for over 1% of the UK's carbon footprint. Subsequently, The Water Services Regulation Authority (OFWAT) now requires that water companies provide data on both construction and operational carbon footprints for all new projects. Therefore, there is an emphasis on delivering solutions which have minimal carbon impact.

Since the project started, other factors had become (and continue to be) increasingly influential. The cost of fertilizer has increased making biosolids more economically attractive in the short term. Phosphorous, vital to food production, is in dwindling supply. Various estimates put the reserves of (easily mined) phosphorous at anything from as little as 30 to 100 years. According to The Times newspaper (June 23, 2008), the price of phosphate rock increased 700% within the last year. To counter this argument, concerns over diffuse pollution caused by phosphorous have increased the focus on the phosphorous index of soils and concentrations of phosphorous applied to agriculture based on crop uptake.

Although design of the raw incineration facility got to the stage of planning and architectural drawings, workshops looking at other potential solutions for the project were arranged. An expert panel made up of United Utilities, MWH and Entec was assembled to examine the feasibility of over 30 different technologies. The procedure to determine a short-list of potential solutions is set out in Figure 2.

After sensitivity analysis, incineration coupled with various forms of advanced anaerobic digestion pre-treatment consistently scored highest. In line with governmental advice and United Utilities core strategy, sludge will be preferentially recycled to land with incineration as a back up if required and a solution involving incineration downstream of advanced digestion was consistent with United Utilities' requirements of a 50:50 split of recycling and incineration. Therefore this solution was compared in more detail against the original proposal of a raw incineration plant, and the existing scenario of liming followed by cake recycling. The three options were investigated further with a focus on

environmental impact, energy balance, operating expenditure, and carbon impact.

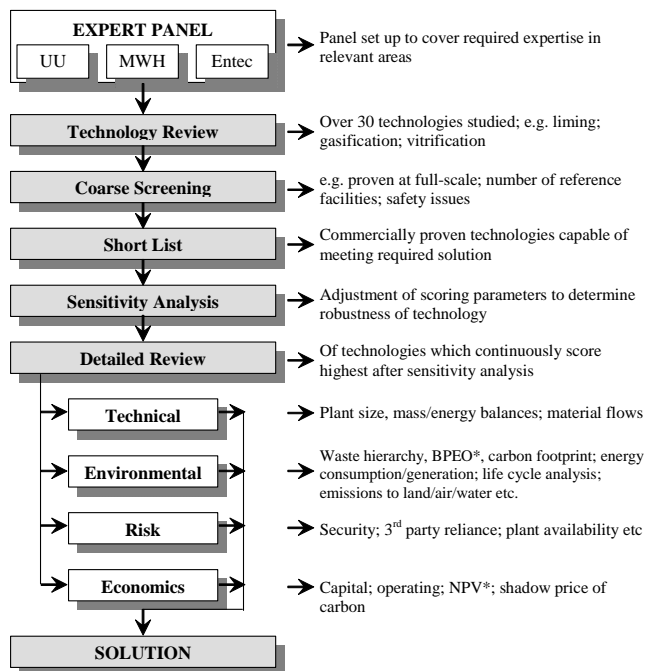


Figure 2. Flowchart showing steps taken during evaluation process. *BPEO = Best Practice Environmental Option; NPV = Net Present Value

Although options including entire new build of a super-centre and combinations of new smaller facilities were considered, the natural conclusion to installing a new facility configured with advanced pre-treatment; anaerobic digestion and incineration was to maximise use of existing assets. As previously described, United Utilities already own a digested sludge incinerator fed via a pipeline. Therefore, there is potential that the solution could be met by installing the pre-treatment plant upstream of one of the digestion plants feeding the pipeline. Davyhulme (Manchester) is on the pipeline and is United Utilities' largest digestion facility contributing over a third of the throughput into the incineration plant. Based on the existing hydraulic retention time of >20 days, the engineering team calculated that it was possible to import all of the LPC sludge into the site for digestion if the organic loading rate could be significantly increased.

Other prerequisites for the project to succeed were:

- Achievement of enhanced treated sludge (6-log pathogen kill) to enable greater flexibility of land use for recycling, both grassland and arable throughout the year (with stockpiling *in-situ* over winter);
- Improvement in dewaterability (to maximise incineration capacity at Shell Green);
- Improvement of volatile solids destruction (to maximise renewable energy generation and reduce load into Shell Green); and
- Altered sludge rheology (to enable the existing pipeline to accommodate increases in flow)

In September 2007, a new solution was recommended – and approved at Group Board Level – which was more environmentally acceptable than the raw incineration plant and entitled “Sludge Balanced Asset Programme”. This was to be achieved by the installation of advanced digestion pre-treatment at Davyhulme to treat of all the 52,000 TDSA raw sludge (originally LPC sludge) along with its indigenous sludge. The plant would consist of sludge reception, centrifuge thickening, pre-treatment plant, dewatering and liquor treatment facilities. The advanced treated sludge could be dewatered and land recycled from Davyhulme, or pumped to the MVPC for dewatering and burning. Due to the unique nature of the solution, various studies were commissioned to quantify and address potential concerns.

Benefits of the “Sludge Balanced Asset Programme” over the previous solution of raw incineration were as follows:

- A reduction in operational carbon footprint of 46,000 tonnes CO₂/yr (details in Barber, 2008);
- Reduction in embodied carbon footprint (Barber, 2008);
- Maximised existing asset use;
- Significant increase in renewable energy generation;
- Improved sludge quality enabling land recycling to new outlets;
- Minimised incineration requirement; and
- Operational flexibility

The ability of the MVSP to accommodate additional Davyhulme sludge is fundamental to the success of the project and the remainder of this paper describes the technical issues involved in realising the capacity.

2. Results

2.1. Raw versus digested and advanced digested incineration

Generally, raw sludge is preferred for incineration due to higher volatile solids content which leads to a greater calorific value on a dry basis. Raw sludge contains approximately 75% volatile matter with the remainder inert. When sludge is digested, a fraction of the volatile matter is converted to biogas and this reduces calorific value by reducing volatile content with typical values for digested sludge being upwards of 60% volatile matter. Several pre-treatment technologies exist, which, when installed prior to anaerobic digestion can improve biogas production and volatile solids destruction (Hunt and Wilson, 2008). With these technologies, volatile solids (and hence energy content) reduces further with typical values of 55% volatile content on a dry basis.

Sensitivity analysis conducted by altering the volatile solids content whilst maintaining dry solids at 27% (typical historical average at MVSP) shows that 1% difference in volatile content is equivalent to 60 kJ/kg in the cake. Therefore, at constant dry solids, advanced digestion could potentially reduce calorific value by 300 kJ/kg. A similar analysis conducted to investigate the impact of dry solids on energy content (by keeping volatile content constant at 60%) between 25 and 30% dry solids showed that each percentage point increase in dewatering could increase calorific value by nearly 140 kJ/kg. Therefore, improved dewaterability has a greater impact on energy content of sludge cake than the volatile content of the dry solids and this is shown in Figure 3.

Figure 3 shows calorific data for two advanced digestion pre-treatments. “Ad dig 1” refers to biological hydrolysis and “Ad dig 2” to thermal. Whilst volatile solids destruction is assumed the same for both (at 58%) it is assumed that thermally hydrolysed cake dewateres better. Figure 3 shows that if dewaterability is improved, the calorific value of thermally hydrolysed sludge cake can be as high as 80% of the equivalent raw cake even accounting for significant reduction in volatile solids content due to the digestion process.

Figure 4 shows the overall energy generation for the raw, digested and advanced digested incineration of 52,000 TDSA. It is based on the use of a pre-drying plant upstream of the incinerator to partly dry sludge as required to enable autothermic operation.

As expected, when sludge is not digested, there is greater energy generation at the incineration plant and the raw scenario generates almost four times the energy

compared to standard digestion at the incinerator (black bars).

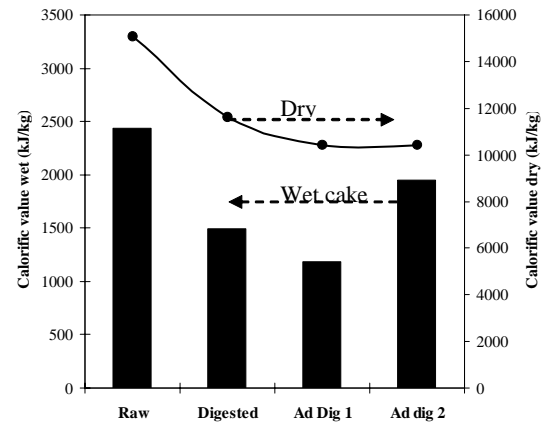


Figure 3. Calculated gross calorific values for raw, digested and two advanced pre-treatments followed by digestion.

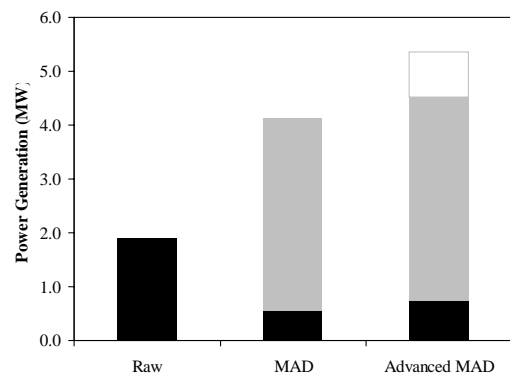


Figure 4. Electrical Energy production over incineration (■) and digestion (■) for 52,000 TDSA sludge. (□) potential energy generation but lost as parasitic demand

However, the advanced digestion option generates more energy than the standard digestion option in spite of lower (dry basis) calorific value, and this is due to enhanced dewaterability resulting in a cake with higher energy content and therefore lower energy demand for drying. When upstream energy generation from digestion is included, twice as much energy is recovered for standard digested option compared when digestion is absent, with nearly 4 MW of generation. Due to improved volatile solid destruction, the advanced digestion option (based on thermal hydrolysis) generates over 5 MW of energy in total. However, due to inherent demand for steam, there is a

parasitic load of energy (shown by the grey outlined box in Figure 4) and this reduces net energy generation to approximately 4.5 MW. The analysis shows that when comparing raw to digested incineration, more energy is recovered during digested incineration when biogas energy is included.

As well as greater energy recovery, digestion also destroys a fraction of the sludge; therefore any downstream processing requirements are reduced. For instance, the flue gas generated for the raw, digested and advanced digestion simulations are: 67,400, 37,000 and 28,600 Nm³/hr respectively. Since most of the consumables in an incineration plant (e.g. chemicals, energy demand) are directly correlated to throughput, their requirements – and cost – are significantly reduced by digestion.

A further and important benefit of digestion prior to incineration is that fact that the sludge can be recycled with no further treatment when the incineration plant is unavailable for planned shut-down and maintenance.

Finally, previous work (Auty and Blake, 2008; Barber, 2009) on modelling of carbon footprints of sludge treatment solutions has shown that, regardless treatment type, installation of anaerobic digestion upstream of a sludge treatment train significantly reduces carbon footprint, especially if dewaterability is improved.

2.2. Mersey Valley Processing Centre (MVPC)

The MVPC currently has 2 incineration streams which have a design capacity of 2.8 tonnes of dry solids each (i.e. 5.6 TDS/hr); equivalent to 41,700 TDSA at 85% availability. Prior to incineration, digested sludge pumped to the facility at approximately 3.5% dry solids are dewatered using plate presses. The incineration plant design was based on receipt of 33% dry solids from the dewatering facility but actually receives in the order of 27% dry solids. Therefore, the actual capacity of the two streams is closer to 2.1 TDS/hr each, equivalent to approximately 31,275 TDSA. Loss in calorific value due to reduced dewaterability is replenished by burning auxiliary fuel in the form of natural gas.

Typically, 65,000 TDSA of sludge arrives at the MVPC, of which approximately 30,000 TDSA are burnt in Streams 1 and 2 and the remainder land recycled as standard treated product. As part of the strategy to reduce United Utilities' reliance on land application a third stream is being constructed. This stream has a design capacity of 5.7 TDS/hr; equivalent to roughly 42,440 TDSA. In addition to a third stream, the plate press dewatering plant is to be replaced by centrifuges to optimise operating costs and minimise maintenance requirements. It is assumed that

the centrifuge plant will not achieve the dry solids required for autothermal operation, therefore stream 3 will also include a pre-drying plant using steam from the waste heat recovery section to dry sludge entering it to a level where autothermic operation can be achieved. With stream 3 in operation, the MVPC will increase its capacity to 9.9 TDS/hr which is equivalent to < 75,000 TDSA.

2.3. Increasing throughput at the MVPC

To determine if additional capacity can be realised at the MVPC to accommodate the additional sludge generated by the SBAP project, United Utilities commissioned MWH to conduct various studies, based on their experience in incineration. The following Figure 5, adapted from the MHW report (Spooren, 2007) shows the incineration line diagrams for Streams 1 and 2 (identical) and the new Stream 3.

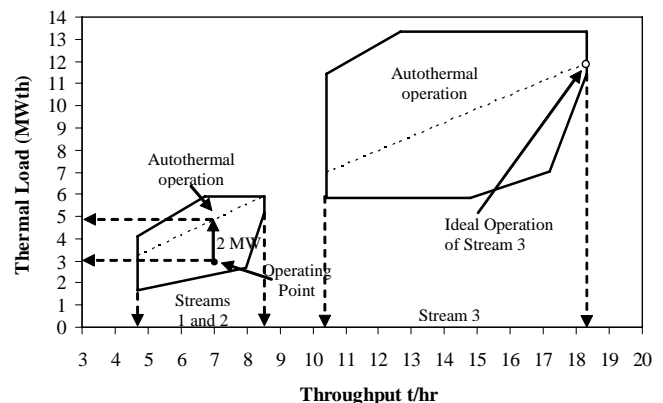


Figure 5. Incineration line diagrams for Steams 1, 2 and 3 at the MVPC (adapted from MWH report by Spooren 2007)

Incineration diagrams are plot based on various limiting factors, such as sizes or capacities of various plant items within an incineration plant and demonstrate the operating window available. Therefore, any combination of throughput and thermal load which lies within the incineration diagram can be accommodated within the system. For example, from Figure 5, Steams 1 and 2 can potentially burn between just under 5 to circa 8.5 tonnes of cake per hour each as long as the thermal content of the cake lies within the incineration diagram. For example, the operating point plotted on Figure 5, corresponding to a throughput of 7 tonnes cake/hr with a thermal load of approximately 3 MW/t/hr can be accommodated.

The dotted lines within the incineration diagrams show

the limit of autothermal operation, i.e. the point where auxiliary fuel is no longer required. Above the line, there is sufficient energy within the sludge to be burnt by itself, below the line auxiliary fuel is required. The quantity of supplementary fuel required is the difference between the point of operation and the dotted line as demonstrated in Figure 5. Here the point of operation has approximately 3 MW/t/hr of energy, but needs to be at nearly 5 MW/t/hr to be autothermal, i.e. there is a requirement for nearly 2 MW/hr of auxiliary fuel.

As previously mentioned, streams 1 and 2 have a requirement to burn auxiliary fuel as the dry solids content of the sludge entering the incineration facility is lower than expected. Whilst stream 3 should not require auxiliary fuel, the pre-drying process comes at the expense of lost energy generation from the turbines as a proportion of steam would be diverted from energy generation to sludge pre-drying.

Existing throughput at is 2.1 tonnes/hr dry solids for both Streams 1 and 2, and 5.7 tonnes/hr design for Stream 3. Assuming 85% availability this is approximately 74,000 tonnes/year dry solids (of digested sludge). The challenge for the SBAP project team was to find ways of burning additional sludge in the existing system, but without changing the design. As previously mentioned, the incineration diagrams show that capacity is fundamentally influenced by cake throughput and energy content within the cake, therefore, if either or both of these parameters could be altered, additional capacity could be made available. With the existing design, Davyhulme contributes a third of the load to the incineration facility. Therefore, a change in operation there, could free capacity downstream at the incinerator. A sensitivity analysis was conducted for the base case scenario and two advanced digestion options: namely biological (Le *et al.*, 2006) and thermal (Panter and Kleiven, 2005) hydrolysis. It was assumed that both pre-treatments were capable of 58% destruction of volatile solids but that thermal hydrolysed sludge dewatered better than either digested sludge or biologically hydrolysed sludge (Evans, 2006) which was assumed to have similar dewaterability (Evans, 2006; Kopp and Ewert, 2006).

The three scenarios were run through a model linked to the incineration line diagrams to determine if additional capacity was available. It was assumed that operationally, Stream 3 would be preferentially used – due to increased efficiency and availability of the pre-drying plant thus negating the requirement for auxiliary gas. Analysis showed, that for all options, throughput in Stream 3 could be optimised with the ideal point of operation is shown in Figure 5, corresponding to circa 18.2 tonnes/hr with 12 MW/t/hr energy content. This is the point of maximum cake throughput with minimal pre-drying to meet (but not exceed) autothermal operation. Additional drying would not

increase throughput but would further decrease electricity output due to unnecessary over-drying. For the baseline scenario and the biological hydrolysis option, drying power requirements are approximately 4.8 MW. However, due to a slightly dryer input for the thermal hydrolysis option only 3.5 MW is needed as less drying is required.

However, Streams 1 and 2 do not have a pre-dryer to rely upon and are strictly limited by cake quality. Figure 6, shows the incineration diagram for streams 1 and 2.

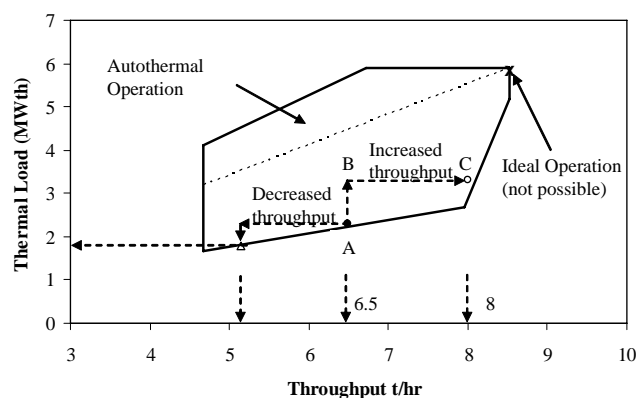


Figure 6. Stream 1 and 2 incineration line diagram showing impacts of advanced digestion on incineration: (●) standard digestion; (△) biological hydrolysis; (○) thermal hydrolysis. The point of ideal operation (x) is demonstrated but is not actually possible.

Point A, in Figure 6 is a typical operating point based on 27% dry solids. At this point, the energy content of the sludge limits throughput to approximately 6.5 tonnes/hr cake. If more sludge is to be burnt, the operating point must move towards the right. However, as the base of the incineration diagram is skewed, in order to move to the right (and gain capacity), the operating point must first move upwards, i.e. the sludge must contain more energy within it. It has been assumed that installation of thermal hydrolysis increases dry solids entering the incinerator to an average figure of 30%, which, in spite of reduced calorific value on a dry basis due to improved volatile solids destruction, increases the energy content of the sludge from 2.3 MW/t/hr to 3.3 MW/t/hr (in accordance with Figure 3). This moves the operational point to point B in Figure 6. Once there, throughput can be maximised until the point of operation meets the edge of the operating envelope. This is shown at point C and corresponds to 8 tonnes/hr. Therefore, a capacity of 1.5 tonnes/hr cake can be burnt in each of streams 1 and 2 corresponding to an additional capacity of 22,400 tonnes of cake.

However, the operating point now meets a very steep

line within the incineration diagram. To gain further throughput, dry solids must now be increased significantly. Calculations show that the maximum dry solids that Streams 1 and 2 can burn is 37% and this only frees up a further 0.1 tonnes/cake/hr/stream. If dry solids increase further, cake quantity drops below the minimum throughput required by the incinerator to induce fluidisation. However, the plant still requires auxiliary fuel at 37% dry solids. Therefore, Steams 1 and 2 would not benefit from pre-drying unless throughputs were significantly increased, therefore they would always require auxiliary fuel.

Whilst increases in dry solids to 30% can realise additional capacity in Streams 1 and 2, improved volatile solids destruction can decrease throughput. This is the case for biological hydrolysis (shown in Figure 6). It is assumed that biological hydrolysis destroys 58% volatile solids during digestion, and this lowers calorific value on a dry solids basis. However, as dewaterability is not improved, this loss of energy causes a decrease in throughput. In this instance throughput is decreased from approximately 6.5 tonnes/cake/hr to just over 5 tonnes/hr.

An additional “virtual capacity” is gained by improving volatile solids destruction at Davyhulme due to the installation of advanced digestion. Installation of advanced digestion converts a further 5000 TDSA into biogas therefore reducing load to the incinerator by the same quantity compared to the baseline situation. Combining volatile solids destruction at Davyhulme and additional capacity in Streams 1 and 2, both pre-treatment technologies gain 5,000 TDSA capacity due to improved volatile solids destruction. However, improved dewaterability for the thermal hydrolysis option gains a further 9,000 TDSA capacity at Shell Green (totalling 14,000 TDSA incineration capacity). As dewaterability is not improved for the biological hydrolysis option, 5000 TDSA capacity are lost at the MVPC, therefore installation of biological hydrolysis cannot increase capacity compared to the baseline scenario.

2.4. Dewatering Trials

Whilst it is well understood that thermally hydrolysed sludge dewateres better than other sludge (Evans, 2006) one of the fundamental assumptions made during the analysis was that, when blended with non-thermally hydrolysed sludge (as would be experienced at the MVPC) it would have no influence on overall dewaterability of the mixed sludge. i.e. the dewaterability of the blended sludge could be predicted assuming a weighed average.

Aquaenviro (2008), a specialist consultancy based in

Wakefield, UK, were commissioned to investigate the behaviour of blends of thermally and non-thermally hydrolysed sludge. This work was done in conjunction with Dr J. Kopp (2008a) a renowned expert in predicting dewaterability behaviour. Aquaenviro simulated expected Davyhulme operation, in order to generate samples for dewatering analysis. As well those samples, the other input streams into the incineration plant were also tested. All samples were analysed individually, and in expected blends to enable comparison between measured and predicted dewaterability. Additional work (Kopp, 2008b) was conducted to replicate the analysis and to investigate thermally hydrolysed sludge from different full-scale plants to provide comfort in the data obtained. Figure 7 shows the impact of sludge type on measured dewaterability.

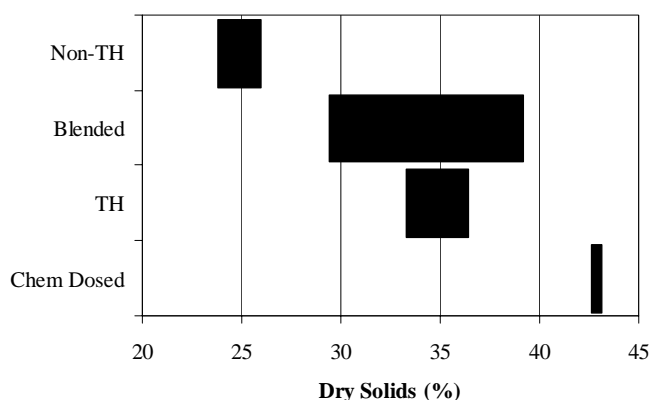


Figure 7. Influence of sludge type on dewaterability

In accordance with previous work (Kopp and Ewert, 2006) the thermally hydrolysed sludge dewatered consistently better (34 – 36%DS) than non-thermally hydrolysed (24 – 26%DS). However, the greatest potential dewaterability was attributed to a chemically dosed sample which had not been thermally hydrolysed. This sample came from a works where chemical dosing is employed. Whilst high in dewaterability potential, other work (Barber, 2007) showed that the sludge has high inert content and concomitantly low calorific value.

The data from the individual samples were then used to predict the behaviour of the blended samples. The ratio of measured values versus calculated ranged from 1.17 (for dry solids) to 0.93 (for ammonia) with almost exact matches for volatile solids and particle size data. Therefore, a good correlation between measured and predicted values was observed, and this confirmed that the initial assumptions made in order to calculate potential capacity in the incineration plant were valid.

With respect to dewatering centrate quality, COD, ammonia and particle size data were also collected.

Thermally hydrolysed sludge caused increases in both COD (by approximately a third – from 800 to 1100 mg/l) and ammonia (by a factor of 3 – from 700 to 2000 mg/l) compared to untreated digested sludge. Ammonia concentrations are generally higher with thermally hydrolysed sludge due to a combination of higher volatile solids destruction (which releases ammonia) and higher feed solids concentration. With respect to particle size, thermal hydrolysis caused a drop in average size from approximately 70 to 35 microns, probably due to the decompression of the sludge particles during the last stage of the process. Whilst expected, this may explain data from full-scale plants which show relatively poor solids capture rates from dewatering devices dealing with thermally hydrolysed materials when compared to dewatering of digested sludge.

3. Conclusions

- Various parameters are contributing to increased sludge production in Europe whilst recycling of the sludge to land is becoming increasingly difficult
- United Utilities proposed to increase incineration capacity by upgrading its existing facility and building a new raw sludge incinerator to burn 52,000 TSDA
- Analysis conducted by a project team could not justify the installation of a new incinerator for a number of reasons including: energy recovery; no contingency plan; changing drivers encouraging land recycling; sustainability of solution and carbon footprint
- An alternative solution involving advanced pre-treatment, anaerobic digestion and optimised use of an existing incinerator has been adopted

Acknowledgements

The author would like to thank Rick Lancaster, United Utilities' biosolids strategy manager, and Ian Cashon (previously Engineering Manager on the SBAP project, but currently) Head of Engineering Services for Special Projects, Competitive Tenders, External and International work within United Utilities for their valuable comments on the manuscript. Thanks also for the invaluable help from MWH (Marcel Goemans and Tom Spooren) on incineration.

References

Aquaenviro (2008) Advanced digestion validation tests, Report for United Utilities, Wakefield, UK.

- Auty, D. and Blake, J. (2008) Strategic carbon technology – how to use sludge to your advantage, *Aqua Enviro/CIWEM 13th Biosolids and Organic Residuals Conference*, Wakefield, UK.
- Barber, W. P. F. (2008) Calculation of the carbon footprint of United Utilities' Sludge Balanced Asset Programme, *Aqua Enviro/CIWEM 13th Biosolids and Organic Residuals Conference*, Wakefield, UK.
- Barber, W. P. F. (2007) Observing the effects of digestion and chemical dosing on the calorific value of sewage sludge, *IWA Specialist Conference: Moving forward Wastewater biosolids sustainability: Technical, managerial, and public synergy*, June 24-27, 2007, Moncton, Canada, 351 – 358.
- Barber, W. P. F. (2009) The Carbon Footprints of Various Biosolids Treatment Processes, World Environment Federation – WEF, *Biosolids Technical Bulletin*, May/June 2009, 8 – 11.
- Defra (2007) Guidelines to Defra's GHG conversion factors for company reporting, Online: <http://www.defra.gov.uk/environment/business/envrp/pdf/conversion-factors.pdf>
- Evans, T.D. (2006) Sludge dewatering performance – a survey of real operational performance, *Floculants & Coagulants Conference, Intertech Pira International*, 29–30 November, Budapest.
- Hunt, P., and Wilson, T. (2008) Overview of recent developments in anaerobic digestion Technologies, *Aqua Enviro/CIWEM 13th Biosolids and Organic Residuals Conference*, Wakefield, UK.
- Kopp, J. (2008a) Dewaterability trials for United Utilities, Kläranlagen Beratung Kopp, April.
- Kopp, J. (2008b) Dewaterability trials for United Utilities, Kläranlagen Beratung Kopp, September.
- Kopp, J., and Ewert, W. (2006) New Processes for the Improvement of Sludge Digestion and Sludge Dewatering, *Aqua Enviro/CIWEM 11th Biosolids and Organic Residuals Conference*, Wakefield, UK.
- Kroiss, H., and Zessner, M. (2007) Ecological and Economical Relevance of Sludge Treatment and Disposal Options, *Proceedings of the IWA Moving Forward, Wastewater Biosolids Sustainability: Technical, Managerial, and Public Synergy Conference*, Moncton, Canada, p47 – 54.
- Landbank Research Associates (2006) Recycling sewage sludge to land in North-West England – 2006 landbank capacity study, Report for United Utilities.
- Le, S., Briddon, T., Harrison, D., and Werker, A. (2006) Enzymic Hydrolysis Technology Demonstration – Production of Enhanced Treated Biosolids for Agricultural Recycling, *11th European Biosolids & Biowastes Conference*, Wakefield, UK.
- Panter, K., and Kleiven, H., (2005) Ten years experience of full scale thermal hydrolysis projects, *10th European Biosolids & Biowastes Conference*, Wakefield, UK.
- Spooren, T. (2007) Evaluation of the Effect of Davyhulme Sludge on the Shell Green EfW Plant, MWH n.v., Battelsesteenweg 455 D, 2800 Mechelen, Belgium, Report Number 47501215.001.R01.