Holsworthy (Summerleaze) Biogas Plant

Case studies were produced following site visits undertaken during 2005 and 2006 and information is therefore relevant for operating conditions at the time of visit only. Some plants now operate under different conditions to those specified within the case studies.

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CASE STUDY – OTHER AD WASTE TREATMENT SYSTEMS

Holsworthy (Summerleaze) Biogas Plant

INTRODUCTION

The Holsworthy Biogas Plant is owned and operated by Summerleaze AnDigestion. Information used in this case study was either from personal communication (Prior, Personal Communication, 2006), from the Holsworthy biogas website (accessed September 2005) or from the Strathclyde University website (accessed April 2006).

The Holsworthy Biogas Plant remains the only full scale anaerobic digester in the UK with the primary aim of producing renewable energy. The site was bought by Summerleaze in March 2005, after initially being owned and operated by Farmatic Biotech Energy UK Ltd. The plant is designed for a maximum throughput of 150,000 tpa of animal manure. Current throughput is around 100,000 tpa. The majority of this throughput is cattle manure from surrounding farms, other wastes accepted include pig manure, poultry litter, bakers waste, Ginsters food production waste and abattoir waste (Prior, Personal Communication, 2006). Around 30,000 tpa of food waste is currently accepted, but this figure is constantly changing depending on what wastes are available and what contracts are won. A process flow diagram (Strathclyde University website, accessed April 2006) is shown in Figure 1.

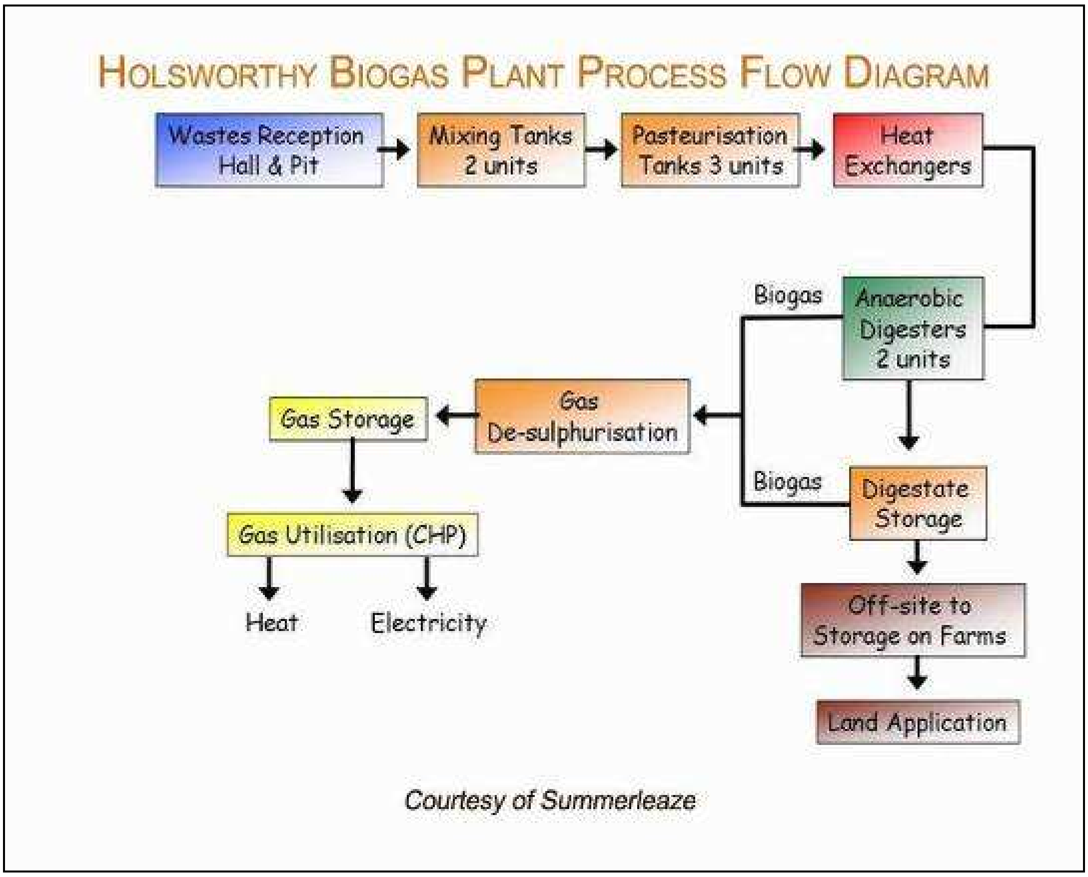

Figure 1 Process flow diagram of Holsworthy Biogas Plant

WASTES COLLECTION

All the manure is collected from farms within a 6 mile radius of the plant. Within a 10 mile radius, five times more manure is produced than is required. Summerleaze owns 3 specially designed tankers (Figure 2). These tankers collect cattle slurry from around 17 surrounding farms (five days a week).

Figure 2 Summerleaze tanker on lanes outside Holsworthy Biogas Plant

The tankers hold 20,000 litres (around 20 tonnes), and have specially designed pumps to 'suck up' and deposit the slurry, so that the filling or emptying of a tanker takes approximately two minutes. It is estimated that there around 20 tanker 'drops' per day, which equates to around 400 tonnes per day of manure. Other waste arrives through the week in different lorries and tankers. On-site, the tankers empty the slurry into a reception pit in an enclosed hall (Figure 3). The enclosed hall has a sealed entrance and exit, and a disinfectant wheel washer.

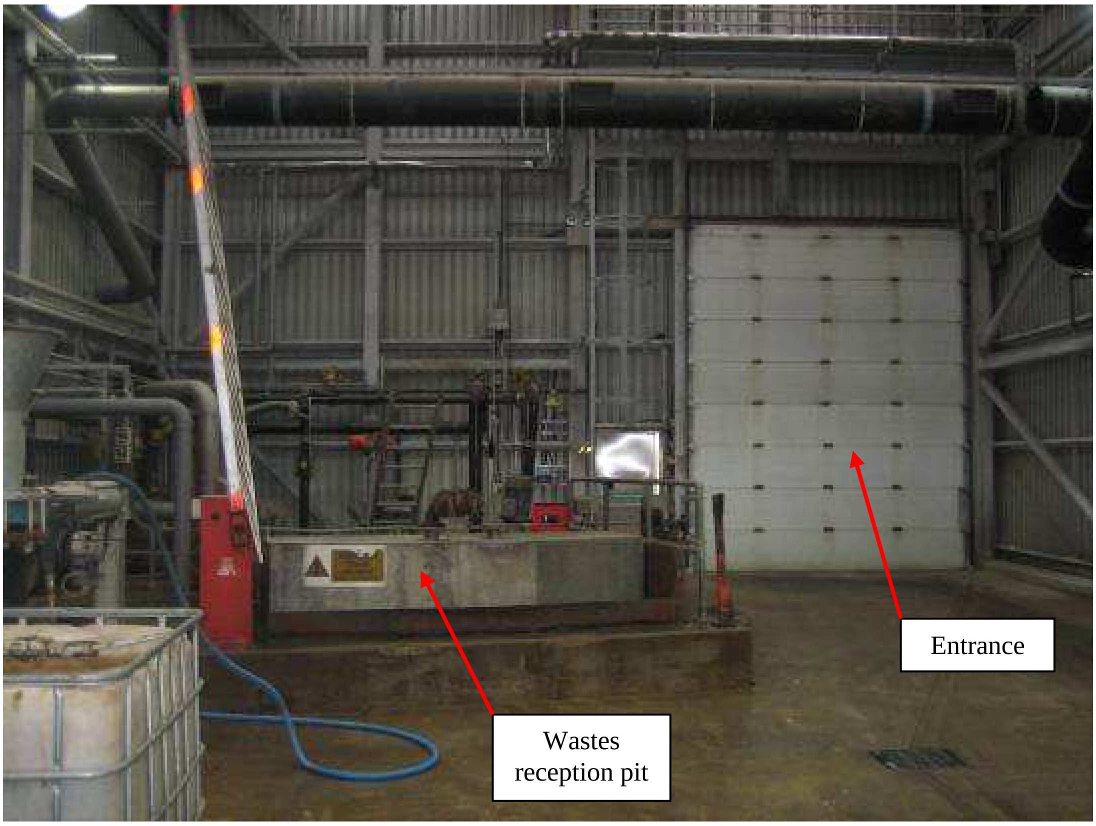

Figure 3 Wastes reception pit in enclosed wastes reception hall

PRE-TREATMENT

After the waste is pumped or tipped into the reception pit, everything in the pit is mixed together and pumped to one of two larger mixing tanks. There is no mechanical separation stage required here (as in all plants receiving BMW), as all the waste accepted is known to be free from non-organic contaminants. This is a major advantage of not accepting any municipal waste, and significantly reduces costs as reliable mechanical separation equipment can be very expensive. The reception pit is in an enclosed hall to reduce odour emissions, and waste air is oxidised prior to being re-released to the atmosphere. In the mixing tanks, it is sometimes necessary to add water to reach 12 – 15% TS, despite the high water content of manure. The mixing tank acts as a buffering tank, as if wastes were added straight to the digester as they arrived there would be great fluctuations in feeding volume, strength and content, which could lead to reactor instability and potential failure. The biological cultures in the digester thrive on stability, with the optimum culture evolving to meet the incoming waste. If feed strength and content is too unstable, no optimum culture can evolve. After the wastes are thoroughly mixed, the influent stream is passed through a macerator to reduce particle size to 12mm and then to a pasteurisation unit, which heats the waste to a minimum of 70^{o}C for one hour. This ensures compliance with the UK ABPR, by ensuring that all seeds and pathogens (including Foot and Mouth disease and TB) are killed off. This is a necessary step legally (UK ABPR), and also gives peace of mind to the farmers that they will not be introducing diseases or weeds to their land by accepting the digestate for land-spreading. There are three pasteurisation tanks to allow continuous operation. At any given hour, one tank is filling up, one tank pasteurising waste, and one tank emptying out. After pasteurisation the waste is pumped to the anaerobic digesters, via heat exchangers to recover heat energy from the 70^oC waste and cool it to 40^oC, in order to keep the reactor operating as close to 37^oC as possible. The heat required for pasteurisation is a by-product of electricity production from biogas and so does not represent any expenditure on energy (after the initial engineering and maintenance).

ANAEROBIC DIGESTION

The anaerobic digesters (of which there are two) have a volume of 4,000 m^3 each (Figure 4). The tubes in the foreground in Figure 4 are heat exchangers, extracting the heat from the waste stream between pasteurisation and digestion.

Figure 4 Anaerobic digesters and heat exchangers

They operate as basic continuous stirred tank reactors (CSTR). Average hydraulic retention time is 28 days. This is a long compared to other digesters observed as part of this project. The reason for the longer retention time is that the aim of this operation is simply 'the production of biogas', and longer retention times will enable more biogas production. Other digesters visited have the primary aim of 'waste treatment', with energy production as a bonus, and therefore the throughput rate of the waste is of more importance than volume of biogas production. The digesters are single stage digesters, operating in the mesophilic temperature range at 37^oC. Heat is provided by the heat of the influent. The reactor is heavily insulated to prevent heat loss. Mixing is provided by paddle-stirrers from the top of the reactors. Digestate is continuously removed at a similar rate to that at which the feed is added. Gas production and content, liquid levels, and gas pressure are monitored on-line, and monthly samples are taken for later lab analysis for pH, dry matter, nutrient concentrations pathogen content. These samples are not analysed on-site, but sent to a nearby private lab. Summerleaze plan to build a small lab on-site to do the necessary analysis (Prior, Personal Communication, 2006).

POST AD TREATMENTAND DIGESTATE

There is no further treatment of the digestate, only storage, before it is transported off-site and back to the farms by tanker. The digestate is stored on site (Figure 5) in a covered sealed container (although any biogas produced while in storage can be collected), until the tankers transport it back to the farms from which the manure came. Digestate is tested regularly the relevant regulatory criteria of pathogen reduction are met. Extra storage facilities to store the digestate are provided on the farms by the Holsworthy plant. EU and DEFRA grants at the start-up stage of the project made this possible. This extra storage means that the farmers can save on fertiliser costs (although they would have spread their manure anyway). They also have more flexibility as to when they apply the digestate to land, and can spread more digestate during the growing season, which reduces nitrate leaching by around 20%. The reduction in odour emissions when the farmers spread digestate (rather than manure) is estimated to be around 90%.

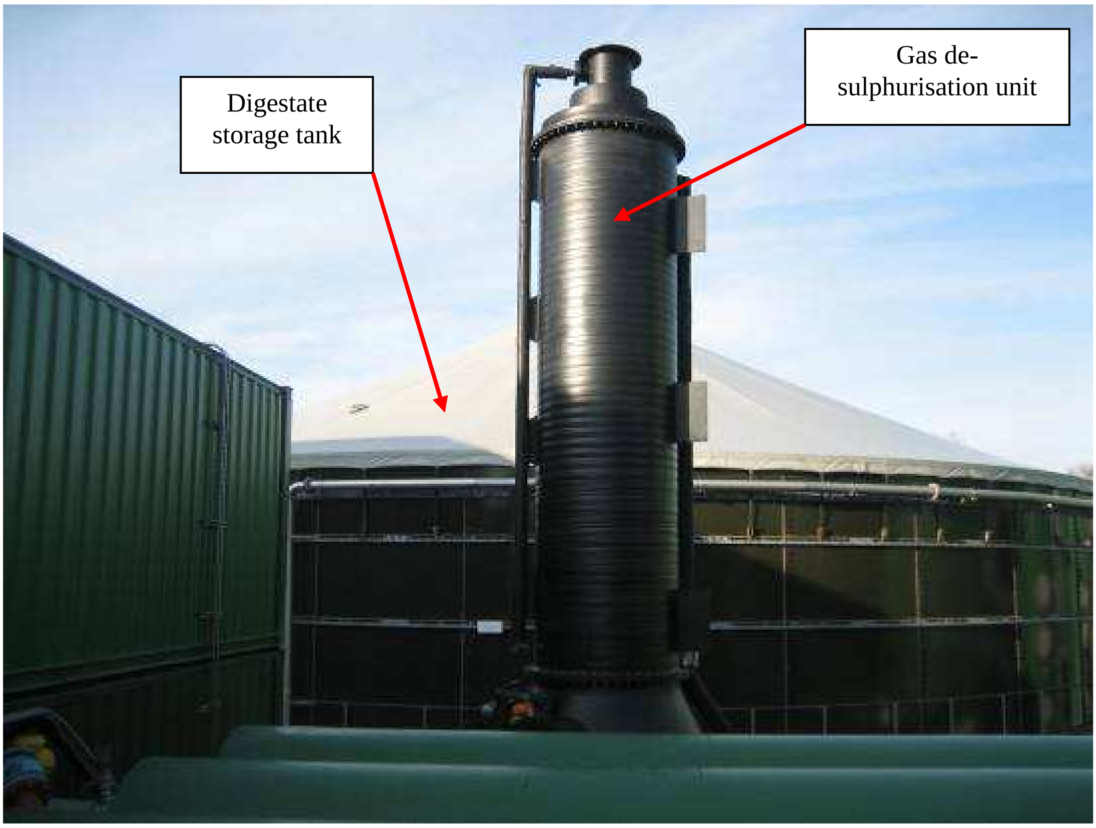

Figure 5 Digestate storage tank (with gas de-sulphurisation unit in the foreground)

The specially designed tankers described above transport the digestate back the farms for spreading on land. No money changes hands between the plant and the farmers for either the manure or the digestate, however, all slurry collection and digestate removal transport costs are paid by Summerleaze. The plant relies on the co-operation of the farmers to allow the digestate to be spread on their land, without which digestate disposal would be a major problem and the plant would not be viable.

Although the digestate is a useful resource (more beneficial to soils than manure) the farmers already have an unlimited supply of manure that they can apply direct to their land at low cost, and therefore would not be willing to pay for the digestate.

BIOGAS UTILISATION AND ENERGY PRODUCTION

Total gas production is expected to be in the region of 4 million m^3/a, but this depends on the exact quantity and content of the waste received. If 100,000 tpa of wastes are received then the average biogas production would be 40 m^3/tonne. This figure is dependant on the exact quantity of high energy food waste compared to low energy manure. The biogas produced in the digesters is treated to remove hydrogen sulphide, a necessary step as hydrogen sulphide is highly corrosive. De-sulphurised biogas is stored in a sealed expandable unit within the top half of the digestate storage tank. Prior to utilisation in the gas engines a steady volume of the biogas is passed through a condensation unit to remove water vapour. The gas engines have a combined power capacity of 2.7 MW with a budgeted power production of 14,400 MWh/a. Of this approximately 90% (12,960 MWh/a) is exported as electricity. The plant covers its own electricity use and heat use. There is a considerable heat excess for which no use has yet been found. Plans are being made to make more use of the heat produced on-site (estimated to be in the region of 15,000 MWh/a). It was planned that the heat would be used for a district heating scheme, to heat public buildings, school, hospital, swimming pool *etc*. as well as domestic heating, but the infrastructure to put this scheme into place is prohibitively expensive at present. Other options being considered to utilise this heat energy include the production of wood pellets for commercial and domestic heating.

WATER AND WASTEWATER TREATMENT

No figures were available for the biogas plant's water consumption. No wastewater treatment was necessary as all of the digestate is transported back to the farms and spread on the land.

EXHAUST AIR TREATMENT

Waste air was previously treated by biofilter prior to being re-released to the atmosphere. This biofilter system has not always worked very well and the plant received several complaints from local residents about odour in previous summers. The biofilter for odour control was recently replaced with a thermal oxidation odour control system. The new set-up is judged to be more reliable and better suited to the task (Prior, Personal Communication, 2006).

VISUAL AND LOCAL IMPACT

The plant is situated in an agricultural area, approximately 2 km outside the town of Holsworthy. The site is invisible from the public road, as it is in a natural depression in the land (Figure 6).

As mentioned above, the plant has received complaints about odour in the past, but appears to have solved or at least minimised these problems with a series of odour control measures. Initially the original owners had to deal with complaints that the tanker traffic was blocking up the small rural lanes around the plant and the farms. These roads are very quiet anyway.

Figure 6 Holsworthy Biogas Plant from the road

COSTS AND ECONOMICS

Capital cost was between £7.7 and £8.2 million (in 1998), although significant work has been done on improving and updating the plant both by the previous owners and by Summerleaze. Capital grants were obtained for 50% of the plants cost. Contributors were the EU, DEFRA and the local authority. It was also necessary to have local farmers on board, without whose co-operation the biogas plant would not be possible. The project was difficult to finance, with UK banks being uninterested. A 15 year loan was eventually obtained from a German bank.

Operating expenses were not disclosed by Summerleaze, but were estimated at £450,000/a (Strathclyde University website, accessed April 2006). This corresponds to £4.50/tonne, based on 100,000 tpa, or £3.00/tonne based on 150,000 tpa. Expected income from electricity sales was stated to be £800,000/a (Strathclyde University website, accessed April 2006), but based exporting 90% of a total electricity production of 14.4 million kWh/a at today's prices (£90/MWh, Prior, Personal Communication, 2006) the income should be more in the region of £1.2 million. Each year the plant receives gate fees for any commercial or industrial organic wastes it accepts. This represents a significant revenue, and one that the plant operators would be looking to expand. More food/abattoir waste not only means more gate fees, but also more biogas production. Benefits in terms of biogas production potential may enable the plant owners to pay for the transport of 'high energy wastes' to the plant and still be economic. Any new waste being added could also potentially improve the nutrient balance entering the reactors. Thorough testing would be carried out before new feedstocks were introduced on a full scale.

De-watering the digestate prior to transporting back to the farms could significantly reduce transport costs, although it is not necessary, as both the solid and liquid fractions will go to the farmers anyway. De-watering could be either mechanical or biological (biodrying). Digestate de-watering equipment could prove expensive, and would take up more space (especially biodrying). De-watering could also cause problems to the current tanker fleet (and probable the farmer's muckspreading equipment) which are designed to cope with slurry/digestate.

Plant economics (of all AD and composting plants) would be greatly improved if a sustainable market could be established for the digestate. Any digestate sale strategy will be limited by the relatively large cost of transporting the digestate to the buyer. The main input to the plant, cow manure, is low in solids content, relatively low in energy, and requires the transport to and from the site at the expense of the owners. Therefore, from this point of view, the plant is run as a co-operative with local farmers. Securing more commercial and industrial organic waste contracts to supplement the manure must be a major goal for the owners. To increase the gate fees received but also to provide a more balanced reactor input and to increase the production of biogas. Based on 14.4 million kWh of electricity being produced, and 90% of this being available for export (10% used on-site) the annual income from electricity (in April 2006) would be:

14,400,000 kWh x 90% = 12,960,000kWh
12,960,000 kWh x 8.95p/kWh = **£1,159,920.**

CHALLENGES AND DISCUSSION

As this is the first site of its kind in the UK, there have been many 'teething problems' that have had to be overcome in order to fully optimise the process. This is to be expected, as is the fact that new owners will want to fine-tune the process and upgrade it. It seems that the main problem for the previous owners was that they did not receive the waste that the plant had been designed to receive, therefore they did not produce enough energy to be economically viable. Some specific problems and solutions are noted below:

- The enclosed loading bay around the reception pit was corroded and needed galvanising because of the corrosive atmosphere.
- Some pumping problems have been experienced pumping the waste from the bottom of the reception pit to the mixing tanks, due to the depth of the reception tank and the (potentially, not always) high solids concentration of the waste. For this reason, the current pump, which is on ground level (and pumps by sucking waste upwards), is being replaced by a submerged pump (which will 'push' waste upwards). It is anticipated that this pumping solution will be more reliable.
- It is unclear how sand/grit/fine inerts are removed from the waste stream. If these fine inerts are not removed from the digester, or as part of the pre-treatment, then it is possible that they will accumulate in the digesters. This sedimentation will decrease active digestion areas, and could eventually cause more serious problems such as blockages or downtime.
- In the past, the site has experienced significant odour problems. On summer days, with certain wind directions, complaints would be received from

Holsworthy town (1.5 miles away). The new owners have taken steps to reduce the emission of odours. These steps have reportedly met with considerable success, and are described briefly below.

- When the site was taken over by Summerleaze, the mixing tanks had canvas roofs. These roofs were not airtight and as such odour was a major problem, especially in the summer months. One of these roofs has been replaced by an airtight plastic roof, which has solved the problem. The remaining canvas mixing tank roof is due to be replaced soon, after which there will be no further odour emissions from the mixing tanks.
- The biofilter for odour control was replaced with a thermal oxidation odour control system. The new set-up is judged to be more reliable and better suited to the task.

Environmentally, the combined preparation, pasteurisation, digestion and storage of the treated material is considered as ‘Best Practice’ and is an environmentally and socially responsible form of waste management. Not only is renewable energy produced, but the digestate the farmers receive is more stable, with a higher fertiliser and compost value than the manure they donated. Advantages of the biogas plant, aside from the organic wastes treatment and renewable energy production are;

- Employment creation. The biogas plant employs 15 people in a rural area. Importantly, the jobs created are at a variety of levels, including approximately 5 managers/engineers, 5 on-site technicians and 5 drivers.
- Digestate can reduce pollution of water courses by reducing run-off (when compared with manure). Run-off is the liquid slurry which is sprayed onto farmland, but then drains into surface water. It can carry sediments and pollutants into the receiving waters.
- AD can lessen the risks of the spread of disease and contamination by destroying bacteria, viruses and weed seeds.
- Well-managed AD can decrease methane (CH_4) release more effectively than conventional waste management, because the methane is converted into carbon dioxide (CO_2), a less potent greenhouse gas.

As oil prices rise, significant potential exists to roll out similar manure-based anaerobic digestion systems across the UK with the main aim of renewable energy production. Fundamental to the success of the project, and other similar future projects (amongst a multitude of other technical and planning factors) are;

- The co-operation of local farmers, without whom there would be no manure and no free disposal of digestate.
- The signing of long term contracts for other high energy organic wastes, without which biogas production would be beneath levels that ensure profitable operation. Gate fees from these organic industrial wastes also impact positively on plant economics.

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