Kompogas Biowastes Treatment Sites in Zurich – Otelfingen

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CASE STUDY – SOURCE SEGREGATED BIOWASTES

Kompogas Biowastes Treatment Sites in Zurich – Otelfingen

Three Kompogas anaerobic biowastes treatment sites in the greater Zurich region of Switzerland were visited.

- Oetwil Am See
- Niederuzwil
- Otelfingen

These three sites are similar conceptually and technically. As many introductory and discussion points are common to each of the three sites, a common introduction has been included before the case studies, and a common discussion section after the three case studies.

Garden waste has been source separated in Switzerland since the early 1980s, but in the early 1990s a decision was made to add kitchen and other organic wastes to garden waste, and collect all of these as one fraction (known in Switzerland and for these Swiss case studies as 'biowaste'). As such, Swiss biowaste presently consists of mostly garden waste with some kitchen waste. Unrecyclable paper and card are incinerated. Because of the history of collecting garden waste separately, it has been difficult to change public habits, although the aim has been to re-educate the public to try and secure as much kitchen waste as possible. It is thought that a large proportion of municipal kitchen waste is 'lost' to the system by citizens depositing it in the wrong bin. Switzerland is a country with a huge seasonal variation in biowastes production. In summer the volume of biowaste is much greater, and the content is overwhelmingly garden waste. In the winter the waste has a much higher percentage of kitchen waste, which has a much higher water and energy content. Some 'bulking material' (*i.e.* woody content of the digestate) is stored in the autumn to ensure that the correct mix is achievable through winter. It was estimated that municipal biowaste in Switzerland contains approximately 2 - 3% contaminants (Knecht, Personal Communication, 2006). Continuous public education is required not only to lower the percentage, but to increase the proportion of kitchen waste in the biowaste stream (as opposed to in the residual wastes scheme). Swiss citizens pay for the collection and treatment of their waste by volume. Therefore the more waste you produce, the more you pay for. The introduction of this system produced immediate and dramatic reductions in terms of personal waste arisings. The cost for the removal and treatment of one 35 litre 'black bag' is €1.50, whereas the cost to remove green waste is approximately 1/2 of this (Knecht, Personal Communication, 2006). Some valuable recyclables are collected for free, while other less valuable recyclates need to be taken to public recycling points (or thrown out and paid for depending on personal choice). These measures were designed to encourage recycling, and have been shown to work. Switzerland has very little landfill space available, and has therefore traditionally relied on incineration to minimise waste volumes. At present there is a significant overcapacity of incinerators in Switzerland.

After many years of pilot scale research the first full-scale Kompogas plant was built in 1991 in Rumlang in Switzerland. Kompogas now has at least 24 plants operating worldwide on biowaste or OFMSW, and at least five plants currently being built (Kompogas website [a], accessed April 2006). The Niederuzwil site was one of Kompogas's earlier systems, and has shown successful operation for over 8 years. Advances in the Kompogas system mean that costs have come down since 1998, and technology has improved. The technology can be considered proven and reliable, and its modular structure gives extra flexibility to the process in that it can be scaled up easily. Because of the plug flow system, an extra pasteurisation stage should not be necessary to meet ABPR, meaning less heat energy is consumed on-site. Wastewater is also minimal as dry-digestion is used and excess liquid is spread to farmland. Each site co-digests source separated municipal kitchen and garden waste (approximately 80%) and industrial organic waste (approximately 20%). The industrial organic waste is usually restaurant or fast food restaurant waste, food processing waste or supermarket food waste. Pre-treatment, digestion and post AD treatment are similar at all three sites, as is the end use for the liquid fertiliser and solid soil improver. Kompogas own and operate many of the plants they have built, but also offer varying levels of service to private clients. Many Kompogas sites are owned and operated independently, as individual legal entities, but remain part of the Kompogas group. Plants can be built, started up and handed over to clients, with differing levels of service included over different periods of time.

All Kompogas digesters operate in the thermophilic temperature range, at 55 – 60^{o}C. All digesters are based on a 14 day retention time, a 30% TS content and a maximum particle size of 50 mm. All the key criteria are kept constant, but plant managers are free to experiment with the system and make superficial modifications as they see fit. More details of the Kompogas anaerobic digestion systems can be observed on the Kompogas website (www.kompogas.ch/en/). The three sites visited will be described in more detail below.

Otelfingen (Kompogas) Biowastes Treatment Plant

INTRODUCTION

The Kompogas facility at Otelfingen in the greater Zurich region (Switzerland) (Figure 1), started up in 1996, has a capacity of 12,500 tpa of biowaste. The plant treats 10,000 tpa of source separated municipal biowaste from approximately 100,000 people in the municipality of Otelfingen (Zurich, Switzerland). The plant also receives 2,500 tpa of food waste from Migros (Switzerland's biggest supermarket chain). This means that the municipal biowaste to industrial/commercial food waste ratio is the 80:20 that is standard for most Kompogas systems. Biowaste has been separately collected from households in the Zurich region since the late 1980s, and contains kitchen, garden and yard waste. Biowaste is collected from households once weekly and delivered to the facility. At Otelfingen, the biogas is used not only to produce electrical and thermal energy, but is also upgraded and used as a vehicle fuel. Kompogas company vehicles use this fuel, as does a large proportion of the Migros fleet. The biogas fuel is also available to the public. The Otelfingen site is a BOO (build, own and operate) facility, in which Kompogas were fully responsible for the planning, construction and ongoing operation of the plant. Due in part to its proximity to the airport the Otelfingen site is a Kompogas 'showpiece' site, which attracts many visitors. The plant is attractive, freshly painted, entirely covered, and well landscaped. As well as the public compost pick-up point and the biogas filling station, the site was geared towards receiving visitors, as described below.

VISITOR ATTRACTIONS AT OTELFINGEN

As mentioned above Otelfingen serves as a PR focal point for Kompogas. The site receives many visits from schools, universities and other interested parties. The interactive visitor centre is impressive (Figure 1, Figure 2 and Figure 3) with displays demonstrating the full nutrient and organic cycles and how the implementation of AD systems can 'close the loop'. The visitor centre also contains a meeting centre, surrounded by a go-kart track, in which the go-karts are powered by biogas. The site also has a demonstration greenhouse (Figure 3), in which vegetables are grown direct from lumps of digestate surrounded by sand (Figure 4). The process water was used direct to grow plants. Everything in the greenhouse, and even its siting a few metres from the plant had a symbolic message. The vegetables growing direct from the digestate proved that the solid output was indeed beneficial, a 'product' and no longer a waste. The goats and fish fed on products from the greenhouse included animal production in the loop. There was even a symbolic link between the kart-track and the greenhouse to imply that the plants could use the CO_2 produced by the carts. Also on site were fishponds and attractive gardens all fertilised with Kompogas compost.

Figure 1 Kompogas biowastes treatment plant at Otelfingen

Figure 2 Kompogas Visitor Centre at Otelfingen

Figure 3 Inside greenhouse at Otelfingen

Figure 4 Inside greenhouse at Otelfingen, showing crops growing from digestate

PLANT DESCRIPTION

All Kompogas digesters are based on a similar design, with only the scales and the construction materials being different. There have also been a few modifications/improvements over time. For example, old plants (such as Oetwil Am See and Otelfingen) have a mixing unit, whereas in newer plants, such as the new reactor at Niederuzwil) the wastes are mixed with each other and with re-circulated process water in the inflow pipes. More details of the Kompogas anaerobic digestion systems can be observed on the Kompogas website (www.kompogas.ch/en/).

PRE-TREATMENT

The waste is tipped directly from the collection vehicles into a reception pit. From the pit, the waste is picked by crane, placed on a conveyor and passed through a coarse shredder and a ferro-separator.

Figure 5 Wastes reception pit and picking crane

After the coarse shredder, the waste stream passes through a hand-picking stage, where stones and plastics are removed before the wastes pass through another fine-shredder (where the waste is shredded to 50 mm). Metals are recycled and the stones are used for landscaping. The waste is stored in an intermediate storage bunker, where recycled process water is added to achieve the preferred total solids content. From this storage bunker waste is fed to the reactor via long inlet tubes in which the waste stream is heated to 55 - 60^{o}C.

ANAEROBIC DIGESTION

The inlet and digestion systems are identical to other Kompogas systems. The digester is 32 metres long, with a 6 metre diameter and a volume of 900 m^3. Digestion is at 55^{o}C and retention time is 14 days, with the waste mixed as it is pushed through the reactor from one side to the other in a plug flow manner. Total solids content is 30%. The process is monitored on-line. The exact parameters monitored were not revealed. Samples are taken for off-line analysis if the on-line parameters pass out of an acceptable range. No other details about the anaerobic digestion system were made available.

POST AD TREATMENT

After digestion the digestate is de-watered in a screw press, with the liquid fraction stored and removed by farmers and the solid fraction composted in a Thoni Composting system (Thoni Industries GmbH). Residence time in this Thoni system, which is an in-vessel system with intense forced aeration is 2 days. The Thoni system is shown in Figure 66. After 2 days in the Thoni system the solid fraction of the digestate is windrow composted (indoors) for a period of 1 – 3 weeks, before it is fully biostabilised and can be size-sorted, wind-sifted and removed from the site. The Thoni system added extra expense to the plant, but greatly minimises the time required to fully biostabilise the digestate to compost, and thus greatly reduces the space required.

Figure 6 Thoni in-vessel composting system at Otelfingen

DIGESTATE

After post-AD composting, the digestate is graded into different grades, according to size. Those grades that will be sold or used agriculturally pass through a wind-sifter to remove plastics and therefore enhance quality. After size separation, the bulky fraction of the digestate (which consists mainly of wood, bark and plastics) is sold to local CHP plants. In this case the local CHP plant that receives the bulky digestate is the local prison. The best quality grades are bagged and sold to horticultural industries and private gardeners, while the intermediate grades are removed from the site by local farmers. There is also point outside the site gates where the public can come and pick up medium grade digestate for their own personal use (Figure 7).

Figure 7 Public compost pick-up point at Otelfingen

At Otelfingen (unlike at other sites where the compost attracts a revenue) this compost can be picked up for free. At Otelfingen the majority of the digestate is picked up by local farmers (for free, but at their own expense) and spread to land. The final compost (one of many grades) is shown in Figure 8.

Figure 8 Final compost from Otelfingen (one of many grades)

BIOGAS UTILISATION AND ENERGY PRODUCTION

The Kompogas facility at Otelfingen produces 100 – 130 m^3 of biogas per tonne of incoming waste. The average methane content is 60% CH_4. Obviously the exact biogas production and methane percentage is dependant on the exact content of the incoming waste. The biogas is utilised in a CHP plant onsite (electrical conversion efficiency = 35 – 38%). Generally a Kompogas site uses about 10 – 15% of its electricity production for its own operational needs and exports 85 – 90% to the grid (Knecht, Personal Communication, 2006). The situation is different at Otelfingen due to the fact that some of the biogas is upgraded and used as a vehicle fuel. At Otelfingen, the demonstration units use a proportion of the excess heat.

At Otelfingen, a proportion of the biogas is upgraded and used as a vehicle fuel. Biogas is upgraded by de-sulphurisation, compression, water vapour and carbon dioxide removal to a methane percentage of 97%. Biogas is then compressed to 250 bar, stored (Figure 9) and made available at a filling station outside the plant (Figure 10). The proportion of biogas that is upgraded is variable and depends on the amount required to fill the available storage capacity. Once the storage capacity at the filling station is full, all biogas is diverted back to the CHP route. In this way the best possible use can be made of the biogas, and if demand for biogas fuel grows, as expected, then storage capacity can be increased proportionately and greater percentages of the biogas can be used in this way. The filling station at Otelfingen is an 'island' solution. It is not connected to any gas grid, and (for now) there are few other biogas fuel facilities. The system would be better suited to areas with a natural gas grid, but the extra expense involved in upgrading the biogas and setting up the filling station was deemed to be justified due to the experience that the company would gain, and the positive aspects of having a full-scale useable demonstration plant at the showpiece site. Economy and convenience will improve as more facilities become available. All biogas vehicles are flexi-fuel vehicles that can also operate on petrol.

Figure 9 Biogas storage at filling station at Otelfingen

Figure 10 Biogas filling station at Otelfingen

Renewable electricity will always be easy to utilise, as will renewable transport fuel once the infrastructure is in place, but any new-built Kompogas facility should be sited intelligently to maximise the potential usages of the heat energy produced. Indeed, all the renewable energy available in the biogas should be utilised in the most advantageous manner given the local circumstances of any new facility.

WATER AND WASTEWATER TREATMENT

Similar to other Kompogas facilities, the process uses very little water, and stored rain water can cover this use. As with the other Kompogas facilities, process water is collected by farmers as a fertiliser, meaning that no wastewater treatment is necessary. Kompogas rightly go to great lengths to demonstrate that their process water is 'useful fertiliser' and not 'wastewater'. This is demonstrated by the process water meeting Swiss Organic Farming regulations and also in the greenhouse at the visitor centre.

EXHAUST AIR TREATMENT

Buildings are retained at a negative pressure, and the exhaust air treated in a biofilter system to minimise odour emissions before being released to atmosphere.

VISUAL AND LOCAL IMPACT

The facility is located in a semi-rural area, close to neighbouring office complexes. No odours were detectable outside the plant, and its visual impact was minimal. The plant had agricultural fields on one side, and office blocks on the other and managed to blend in well with both. In fact, the plant actually looked visually appealing in comparison to the nearby office blocks. With the entire process covered in an attractive freshly painted building, the go-kart track, greenhouses, fishponds and the attractive visitor centre the site was more like a tourist attraction than a wastes treatment plant.

COSTS AND ECONOMICS

No costs were given for the site at Otelfingen. Were it not for the extra demonstration features the plant would have cost something similar to other Kompogas plants of the same scale. The capital cost was given as US$5.35 million in Beck (2004). This would work out at €4.17 million (or £3.45 million) using 1996 exchange rates. The extra features for demonstration, such as the visitor centre, the greenhouse and the kart-track will have increased costs considerably. The biogas filling station would not be economic at present. As an investment for the future it appears sound, as the advantage (and experience) of having the demonstration plant in place will give Kompogas a significant advantage in the future, when oil prices dictate that biogas as a transport fuel will be economic.

CHALLENGES AND DISCUSSION

Conclusions common to all three Kompogas case studies are discussed below.

Kompogas Biowaste Treatment Plant Case Studies – Discussions and Conclusions

Kompogas facilities range from trial/demonstration scale operations treating a few thousand tonnes per annum, up to 40,000 tpa (Passau, Germany). Kompogas are currently building a 100,000 tpa plant to treat OFMSW in Montpellier (France), which will be their biggest reference site to date. With so many successful reference sites operating for so long, the system can be considered a reliable and robust wastes treatment technology.

All Kompogas digesters are designed similarly, with only the scales and the construction materials being different. There have also been a few modifications/improvements over time. For example, old plants (such as Oetwil Am See and Otelfingen) have a mixing unit, whereas in newer plants, such as the new reactor at Niederuzwil, the wastes are mixed with each other and with re-circulated process water in the inflow pipes. At older Kompogas sites the plant was engineered into one building. At newer Kompogas plants different parts of the process can be delivered in modules (in porto-cabin-like metal containers), which can be 'bolted-on' or off the overall system. The advantage of the more modular system is the increased flexibility and the decreased cost. Also, for certain sections of the plant that are used only intermittently, such as the shredder and the deck sieve, these process parts can be moved between sites to save capital investment costs. These mobile shredding and deck sieve units are used in the Zurich region, where there are many Kompogas facilities.

The fact that Kompogas systems are based on modular units means that the scaling up of the process is easy. In this way the total capacity of a site could be easily expanded in phases as more wastes became available, or as more funding became available (as in Niederuzwil, and as is being planned in Oetwil Am See). The smaller scale of the systems makes them ideal solutions for smaller municipalities, or for local authority areas. The many smaller scale reference sites (treating 8000 – 15,000 tpa of source separated biowastes) should make the Kompogas system of particular interest to many Welsh local authorities, dealing with a similar volume of biowastes per year.

All Kompogas digesters operate in the thermophilic temperature range, at 55 – 60^{o}C. All digesters are based on a 14 day retention time, a 30% TS content and a maximum particle size of 50 mm. All the key criteria are kept constant, but plant managers are free to experiment with the system and make superficial modifications as they see fit. Each plant is run independently from others under the Kompogas umbrella. Managers/foremen are free (within given limits) to make their own decisions about the level of centralised support, the sub-contractors they need to use, and other similar issues. Each manager/foreman is accountable to the centralised company. Important decisions are made centrally, to help steer the company forward in the best possible way. In this way an entrepreneurial spirit is generated within the company, and best practice is continuously evolving. Although Kompogas plants are ABPR compliant and can deal with food wastes potentially containing meat products, an extra pasteurisation step would be required to treat slaughterhouse waste. Despite the fact that Kompogas systems are technically capable of treating slaughterhouse waste (provided an extra pasteurisation stage was added) it is the company view that the risk greatly outweighs the potential payback. The risk spoken of is not technical risk of not meeting the relevant legislation, but ‘market risk’ in terms of the negative image that the acceptance of slaughterhouse waste would bring to the liquid fertiliser and solid soil improver. The main reason for this stance is ‘image’. It is anticipated that the negative associations with compost from slaughter waste would significantly damage the process marketability. The image of these products as valuable compost sources could be damaged by the inclusion of slaughterhouse wastes, despite the fact that all legislation could be met and the quality of the compost and liquid fertiliser would not be compromised. As such no Kompogas system treats slaughterhouse waste, and company policy is that no Kompogas facility will treat slaughterhouse waste in Switzerland. Table 1 and Table 2 show the key data in terms of energy for Kompogas plants with capacities of 20,000 tpa and 10,000 tpa respectively.

Table 1 Key data of a Kompogas plant treating 20,000 tpa of biowastes (Kompogas website [c], accessed June 2006)

Data of an installation with an annual capacity of 20,000 metric tonnes	
Property surface area required (total concept)	**~ 5000 m^2**
Building height	**9 m**
Biogas produced daily	**6500 m^3**
Approximate equivalent to heating oil quantity	**4000 l**
Compost produced daily	**25 m^3**
Installed machine power	**310 kW**
Total energy produced daily	**~ 40,000 kWh**
Of which own energy requirement	**~2500 kWh**
Of which is fed into the public power grid	**~10,000 kWh**

Table 2 Key data of a Kompogas plant treating 10,000 tpa of biowastes. (Kompogas website [c], accessed June 2006)

Energy Production		
Biogas production	1,054,000	m^3/a
Total electrical power production in BTPP*	2,078,000	kWh/a
Total heat production in BTPP*	3,240,000	kWh/a
Energy Consumption of Fermenting System		
Electrical power consumption	290,000	kWh/a
Heat consumption	1,650,000	kWh/a
Energy Production		
Electrical power surplus	1,788,000	kWh/a
Heat surplus	1,320,000	kWh/a

* BTPP = Co-generation unit

Values may vary as a function of plant design and wastes composition (Kompogas website [c], accessed June 2006). All figures are approximate.

If all the municipal biowaste in Switzerland was anaerobically digested in a Kompogas (or similar) system, it is estimated that 10% Switzerland's total transport fuel requirements could be met by the biogas produced (Knecht, Personal Communication, 2006). The realisation of this target would have very positive impacts on renewable energy targets and on regional air quality.

As well as systems treating source separated biowastes such as the three described in the case studies above (Niederuzwil, Oetwil and Otelfingen), Kompogas also provide 'MBT' type systems aimed at residual waste streams. The biological sections of the treatment system, based on the Kompogas anaerobic digester, are very similar, while the mechanical pre-treatment stages are significantly different. More information on these systems is available on the Kompogas website (www.kompogas.ch/en/). The mass balance for the MBT system is shown in Figure 11.

Kompogas systems are proven and reliable. There are currently at least 24 Kompogas plants in operation worldwide, with the longest running plant (Rumlang, Switzerland) having been successfully operational for over 15 years. In systems treating source separated biowastes, only the non-organic contaminants that can not be recycled or incinerated are landfilled. Solid and liquid end products are both used beneficially in agriculture and in addition usually attract a revenue.

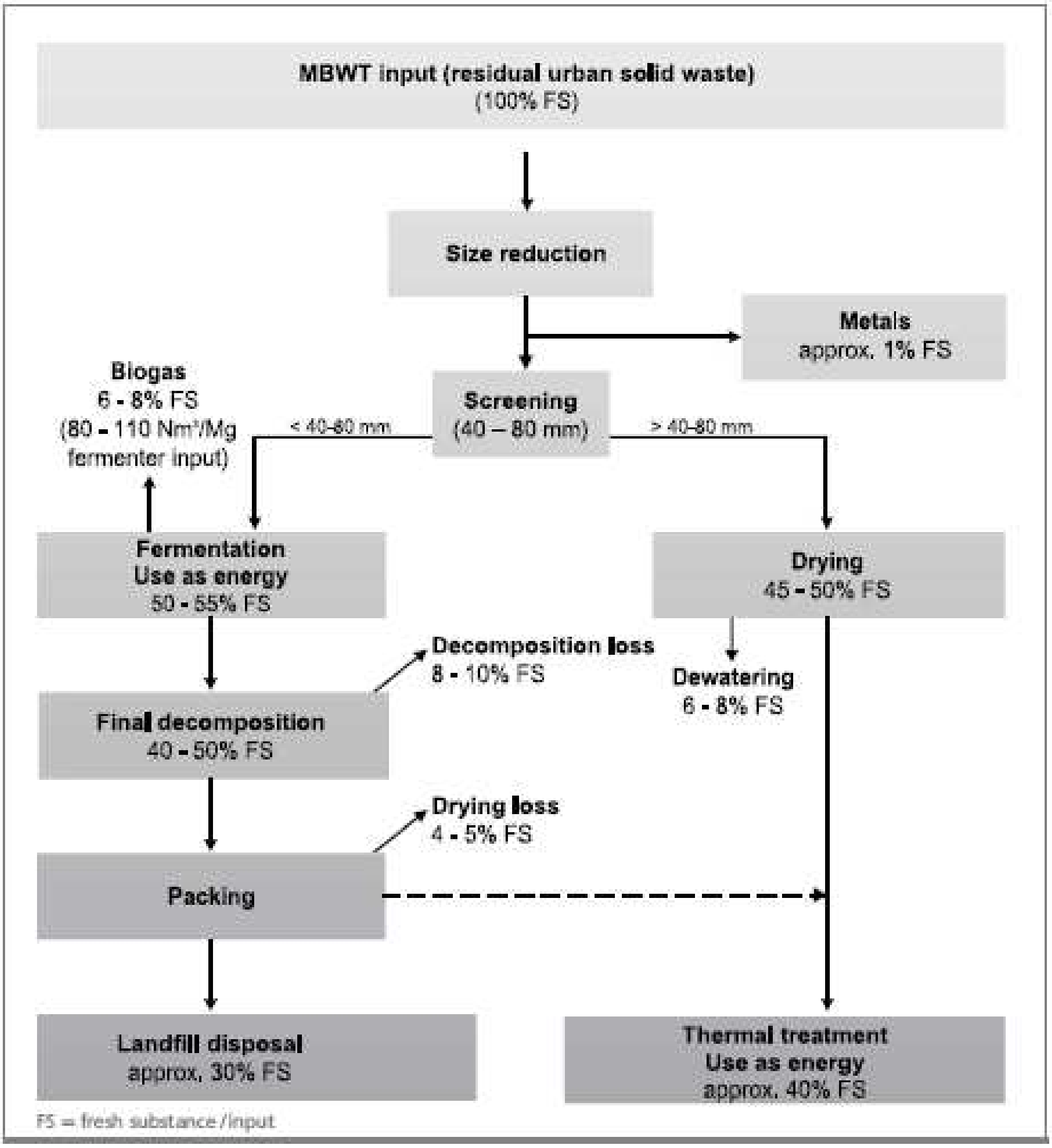

Figure 11 Mass balance of Kompogas MBT systems, treating residual wastes (Kompogas website [c], accessed August 2006)

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