Kahlenberg (ZAK) MBT Plant

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CASE STUDY – CENTALLY SEGREGATED BIOWASTES

Kahlenberg (ZAK) MBT Plant

INTRODUCTION

The plant is owned and operated by ZAK (Zweckverband Abfallbehandlung Kahlenberg), which is the regional municipally owned waste handling company. The planning and the management of the building of the new site was carried out by ZAK, with the individual areas of expertise sub-contracted to companies with specific areas of expertise. The anaerobic digester was built by Wehrle Werk (www.wehrle-werk.de). The MBT Plant and landfill site accepts 100,000 tpa of residual waste from a population of approximately 600,000. This is the equivalent of 170 kg per person per year. Recyclates are separately collected and sent elsewhere for processing or recovery. Kitchen waste is not source separated and is included in the residual waste stream.

Ringsheim is a village on the edge of the Black Forest, and is a popular tourist destination in Germany, due to the attractions of the Black Forest and the proximity of Ringsheim to Germany's premier Theme Park (Europa Park). The existing landfill site, opened in 1973, was running out of space, and German and European law dictated that all biodegradable waste needed to be treated before landfilling, and that more recyclates should be removed before landfilling. Construction of the plant commenced in March 2004, and the plant started accepting waste in May 2006.

PLANT DESCRIPTION

The ZAK Ringsheim plant is currently the only one of its kind in the world. It incorporates (what the management hopes) are the best practices from other MBT plants to provide the best possible solution for local wastes management. Aside from the existing landfill, the plant incorporates five main features. These are:

- Mechanical (and manual) sorting.
- Percolation and Anaerobic Digestion.
- Biodrying.
- Mechanical material separation (heavy/light fraction separation for SRF production).
- Exhaust gas treatment.

Each of these features has been tried, tested and found to be successful at other plants, but the ZAK MBT is the first time that these processes have been designed and implemented as part of the same system. The combination of processes meant that some of the individual process needed to be adapted, in order to fit in with the rest of the system. This required innovative thinking and engineering on the part of the project managers (ZAK). Several parts of the process are original and have been patented by ZAK. As the plant has only just started up, it is too early to call the concept 'proven', but early indications look good (Gibis, Personal Communication, 2006). Due to its innovative nature the plant is promoted by the European Union in by the LIFE Program (www.ruk-online.de/life-ZAK-Kahlenberg/index.html, Accessed August 2006). An aerial photograph of the ZAK MBT plant and landfill site is shown in Figure 1. A process flow diagram is shown in Figure 2.

ZAK Ringsheim has 50 employees in total, including many administrative staff. The plant operates a five day week (Monday to Friday). The plant is operational 12 hours per day.

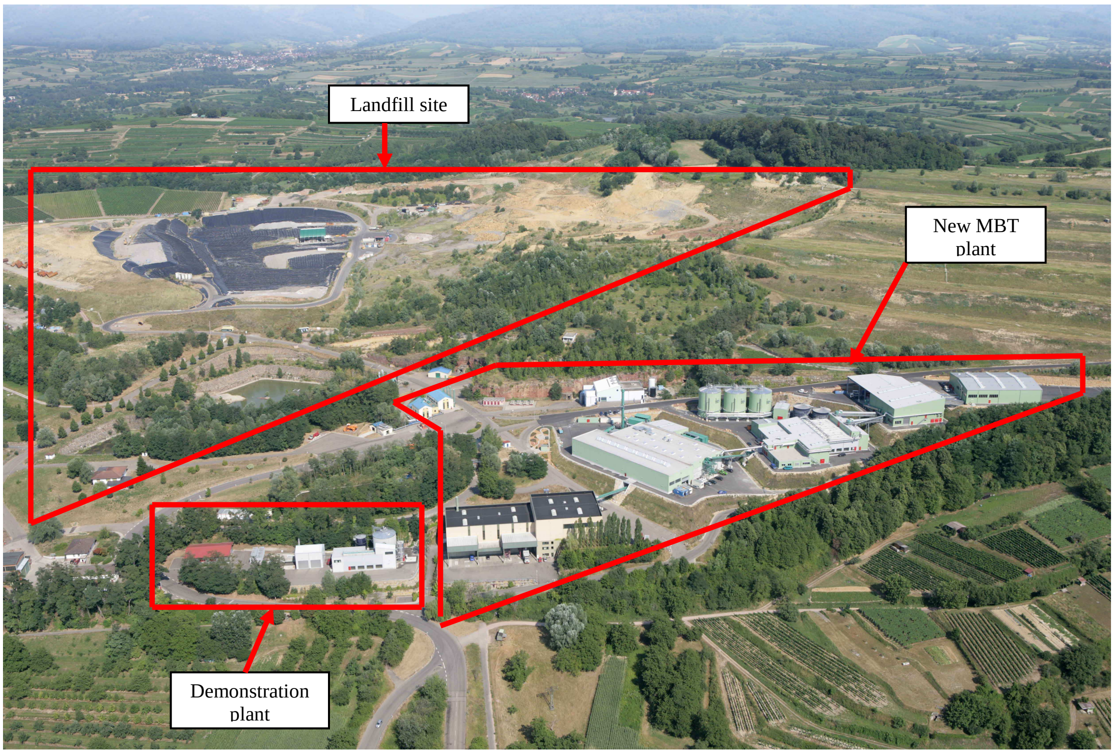
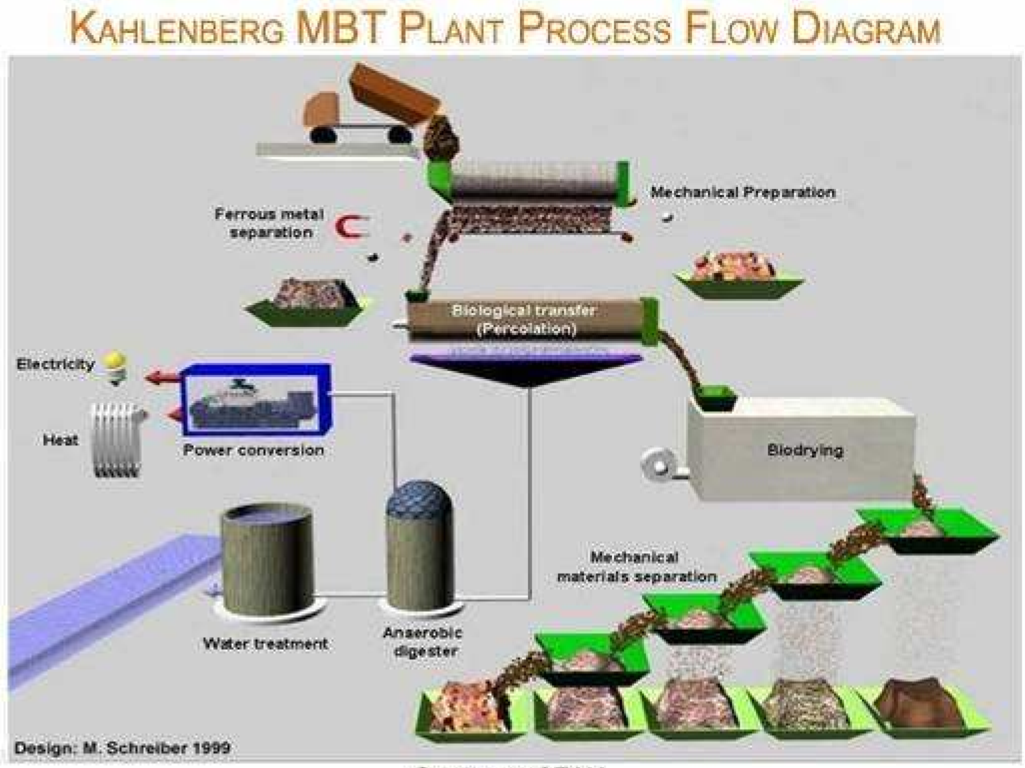


Figure 1 Kahlenberg MBT aerial photograph



Courtesy of ZAK

Figure 2 Process flow diagram (ZAK Promotional Information)

PRE-TREATMENT DESCRIPTION

After being weighed on the weighbridge, the waste is emptied from the collection vehicles onto the floor in an enclosed reception hall. The purpose of emptying on to the floor is so that the digger and crane operators can 'pick' out large obvious items from the waste stream (for example bicycles, wardrobes *etc*.). The wastes reception building is kept at negative pressure, so that no odours escape. In comparison to other sites, this negative pressure was very noticeable as, standing in the doorway, a breeze could be felt as soon as the door was opened. There was also no detectable odour whatsoever outside, despite the fact that a fresh load of waste had just arrived (Figure 3).

Figure 3 Waste reception hall

After being unloaded on the floor, the waste is pushed by a digger and lifted by a crane (Figure 3) to a hopper, from where it is transferred through to trommel sieves (Figure 4). There are two trommel sieves, operating in parallel. The first half of each trommel sieve separates the waste stream into a fraction less than 60mm and an oversize fraction. The undersize fraction is sent to a specially designed and patented ‘battery separation unit’. The ‘battery separation unit’ consists of an especially powerful magnet station that removes batteries and even weakly magnetic components such as electrical scrap (Person, Personal Communication, 2006). The oversize fraction (>60 mm) is passed through to the second half of the trommel sieves, where the separating size is increased to 150 mm. Fractions between 60 and 150mm are also sent through a battery separator, metal separators and a manual sorting stage before being sent to the percolators (together with the fine fraction <60 mm). Oversize fractions passing through both size distinctions in the trommel sieves are wind-sifted to separate light fractions (which are used as RDF) and heavy fractions (which go to landfill).

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Figure 4 Trommel sieves

The manual sorters, of which there are two per shift, separate large stones and leather shoes from the waste stream. The stones are removed as they can cause problems later in the plant, especially to pumps and piping. Other plants have mechanical separation techniques that can (reportedly) successfully remove stones. Leather shoes are removed as they contain a high chromium content, which would jeopardise the quality of the fuel being produced at the back-end of the plant. These shoes are presumably re-introduced to the RDF stream that is destined for a municipal wastes incinerator. Although inside the plant, odour was detected at the manual sorting stations, and considering the commendable lack of odour elsewhere more care could perhaps be taken to improve working conditions at this point of the plant. After batteries, metals, leather shoes and stones are removed, the fractions (<150 mm) are passed to the percolators (Figure 5). There are six percolators, which are horizontal cylindrical tanks, around 20 m long with a volume of 250 m^3 each. The waste is introduced at one end of these percolators, mixed with cold water and passed through, towards the other end, where it exits. The total residence time in these percolators is 2 days.

The incoming waste has a 40-50% water content, and the volume water required in these percolators was not considered to be excessive. No figures for water usage were given. After two days passing through the percolators, the waste stream is de-watered in screw-presses (one screw-press after each percolator). Two of the six screw-presses can be observed in Figure 5. The liquid fraction is sent through a specially designed and patented unit to removed small stones and grit. If not removed these fine inerts could damage pumps and piping, and lead to sedimentation in the anaerobic reactors. Some fine inerts removed by the unit can be observed in Figure 6.

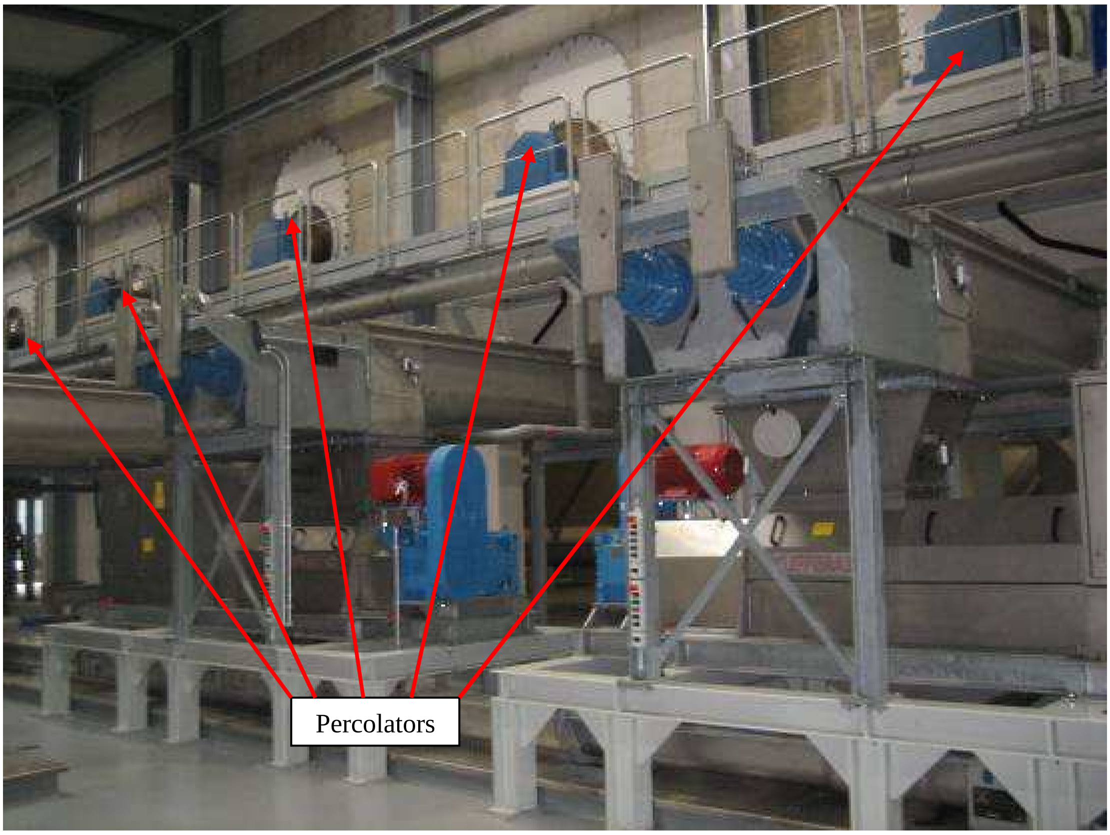

Figure 5 Percolators and screw presses

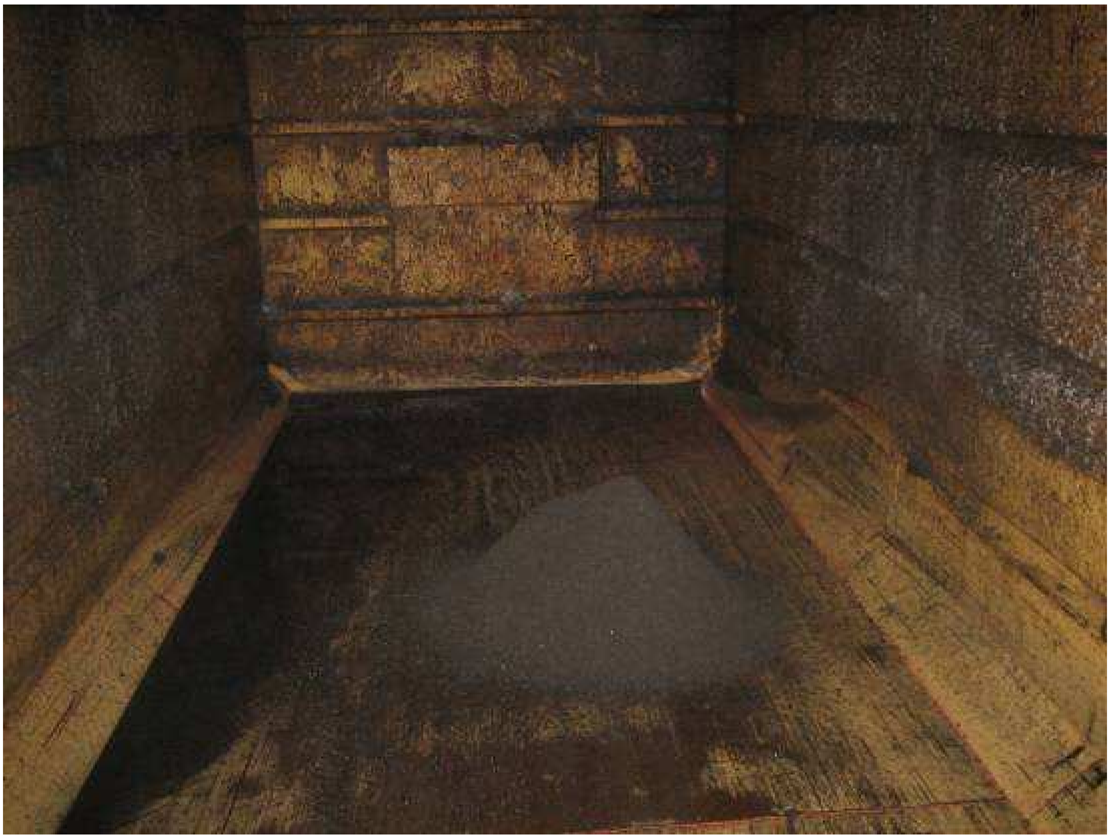

Figure 6 Fine inerts

The liquid fraction, now with fine inerts greatly minimised, is passed an underground buffer/storage tank prior to being introduced to the anaerobic digesters. The solid fraction of the waste stream after percolation and de-watering is passed by conveyor to the biodrying units.

<u>AD PLANT DESCRIPTION</u>

There are three identical anaerobic digesters, two of which are shown in Figure 7, with a combined volume of approximately 5,000 m^3. The digesters operate in parallel, but can each be fed, monitored and controlled separately. As mentioned above, the digesters were built by Wehrle Umwelt GmbH. Digester design was not given, but a high rate reactor (such as a standard single-stage UASB, EGSB or anaerobic filter type reactor) is presumably utilised. As only the liquid fraction is digested, digestion is ‘wet’. The total solids percentage in the reactors was 2.5 – 4%. Digestion occurs in the mesophilic temperature range at 37^{o}C. Retention time is 4 days. As digesters were still in the start-up phase (having operated less than 6 weeks), and given the lack of available information, no comments can be made on their status, reliability or efficiency of operation.

Figure 7 Two (of the three) anaerobic digesters

<u>BIODRYING</u>

The solid fraction of the de-watered percolated waste stream is sent to the biodrying hall, where a biodrying unit is filled and sealed. There are 9 fully enclosed biodrying units, in which a ‘batch’ of waste is left, with intermittent forced aeration with warm air, for a period of approximately 5 days. In these five days, the forced aeration facilitates partial aerobic composting, resulting in considerable heat production (over 55^{o}C in places), which serves to drive off excess moisture from the waste stream. As well as reducing the moisture content, this reduces the mass of the waste stream, and makes it more suitable for use as a fuel. As with the anaerobic digesters the biodrying units are all completely enclosed to minimise odour escape, and exhaust gases are fully treated.

Figure 8 Biodrying bays (5 of 9)

MECHANICAL MATERIALS SEPARATION

The heavy and light fractions of the waste stream are separated by air classification for SRF production. The SRF can be made to a required standard in terms of content, quality and particle size. The difference between this SRF and RDF is that the SRF (due to its strictly controlled contents) is recognised as a fuel and its combustion does not cause plants to install expensive exhaust air treatment (because it will not produce extra contaminants). RDF can usually only be utilised at an MSW incinerator, an EFW plant, a co-firing power plant or another facility with specialised exhaust air treatment facilities. Cement kilns (or other industries) can occasionally be exempted from air emissions legislation and these facilities could also provide an RDF disposal route.

WATER USE AND WASTEWATER TREATMENT

The incoming waste has a 40-50% water content, and the volume of water required in these percolators was not considered to be excessive. No figures for water usage were given. The MBT Plant has an aerobic wastewater treatment plant to treat wastewater, prior to discharge to sewer. It is assumed that the sludge from this plant is probably re-circulated to either the percolators or the anaerobic digesters, although this information was not given.

FINAL SOLID PRODUCTS

As well as biogas the plant can produce 6 grades of stones/inerts, ranging from a maximum size of 1mm up to rubble. These products are currently landfilled, but it is hoped that (construction-based) markets can be found in the future. The plant can also produce 4 different ranges of 'solid fuel', ranging from a specified quality SRF that meets the requirements of industry and therefore attracts revenue, to unspecified RDF that can be used to produce energy in a municipal incinerator, cement kiln or other thermal treatment. Despite its energy value, incinerators or industries must be paid a gate fee to accept this poorer quality 'fuel'. The finest grade SRF (which is so fine that it can be co-fired with pulverised coal) is shown in Figure 9, and the RDF is shown in Figure 10. The investments made to upgrade the SRF to different quality grades can be made according to contracts negotiated with other industries.

Figure 9 Fine grade SRF from residual waste

It is to help guarantee the standard of this SRF that items such as leather shoes and electrical scrap are removed from the waste stream. The guaranteed removal of batteries would also be necessary to ensure the heavy metal content of the SRF is minimised. These heavy metals (including chromium) would mean that the fuel could not be accepted by industries without expensive adaptations to their air emissions treatment systems.

Figure 10 RDF from residual waste stream

BIOGAS UTILISATION

At the time of our visit the plant had only been started up for 6 weeks, as such the digesters were still in their start-up phase, and were producing a combined total of 360 m^3 of biogas per hour. It was expected that this would eventually rise to 700–800 m^3/hour once the digesters were successfully started up and fully operational. This corresponds to approximately 61–70 m^3 of biogas per tonne of residual waste accepted through the plant. Biogas is mixed with landfill gas (which is produced at around 2,000 m^3/day, or 730,000 m^3/year) and burnt in 5 gas engines to produce electricity and heat. The five biogas engines and the pumping unit for the district heating scheme are contained in the buildings shown in Figure 11. The landfill site can be observed in the background in Figure 12.

Figure 11 Biogas utilisation building

Excluding the input from landfill gas, approximately 90% of the electricity produced is used to cover on-site requirements. The other 10% (or whatever excess there is) is sold to the grid. Considering only biogas from the anaerobic digesters, only 10% of the heat energy produced is required to cover all on-site requirements. The rest of the heat energy is utilised in a district heating scheme serving the nearby village of Ringsheim. The thermal oxidation exhaust gas treatment is one of the most energy intensive parts of the plant.

ENERGY PRODUCTION

Heat and electricity recovery from the biogas produced at the plant are shown in Table 1 and Table 2.

Table 1 Electricity balance from biogas produced on-site

Electricity production	13,578 MWh/a
Electricity use on-site	12,812 MWh/a
Excess electricity	766 MWh/a

(Translated from ZAK Ringsheim Promotional Information).

Table 2 Heat balance from biogas produced on-site

Heat production	18,828 MWh/a
Heat used on-site	8,646 MWh/a
Heat excess	10,183 MWh/a

(Translated from ZAK Ringsheim Promotional Information).

The concept also recovers all possible recyclates and recovers all possible energy from the waste. Only inerts such as stones and sand are landfilled, and it is hoped that a market or at least a beneficial use can be found for these.

EXHAUST GAS TREATMENT

Exhaust gases are pre-treated in an air-washing unit. After ‘washing’ exhaust gases are treated in biofilter (Figure 12) or a thermal oxidation unit (Figure 13) depending on the exhaust gas quality. Different exhaust gases are treated in different proportions in the different exhaust gas treatment facilities in order to fully meet the German Legislation in the most economical way. By having the choice of different exhaust air treatment units, the expensive thermal oxidation can be used sparingly, only when absolutely necessary.

Figure 12 Biofilter for exhaust gas treatment

Figure 13 Thermal oxidation unit for exhaust gas treatment

COSTS AND ECONOMICS

The total capital cost of the plant was €45 million (Gibis, Personal Communication, 2006). Operating cost per tonne of incoming waste is €70 (including finance). It is assumed that the incomes from the excess electricity and heat produced are included in this figure. As the plant is publicly owned, the gate fee charged is slightly above €70/tonne. The exact figure was not given. ZAK are confident that their 'concept' represents the best possible residual wastes solution given German Legislation, but accepts that it may be an elaborate and expensive option in other nations given the less strict Legislation.

VISUAL AND LOCAL IMPACT

The plant was built at the local landfill site, which was on the site of a hill and therefore visible, although well wooded, to the local town and motorway. The sections of the landfill site that had been restored were restored to a high quality, and turned into a public recreation area, with wooded areas and picnic facilities. The employees of the plant even keep animals on the restored landfill (Figure 14), horses, goats and donkeys including more exotic species to improve the area's image.

Figure 14 Restored landfill site

There are domestic houses within 10 metres of the edge of the restored landfill (also observable in Figure 14). The proximity of these residences exacerbated the importance of landscaping and odour minimisation. As for the MBT plant, despite being on the edge of a hill, it was well landscaped into the hillside with trees. No odours were detectable outside the plant, or even on the site outside the buildings, despite the warm (28^{o}C) and windless conditions. This was an original aim of the process, due to the proximity of residential housing. From this point of view the plant should meet its zero-odour objectives (if it maintains a similar standard).

CHALLENGES

It could be expected that any new plant would have teething problems that required sorting out during the first year or so of operation. At the time of the visit the plant had only been up and running for a period of 6 weeks, and if this plant was experiencing any particular teething problems, they were not revealed.

DISCUSSION AND CONCLUSIONS

The total throughput time of the plant is around 8 - 9 days. The time in the mechanical sorting is less than 1 day, time in the percolator is 2 days, AD retention time is 4 days, while simultaneously the solid fraction is biodried for approximately 5 days. Mechanical sorting of the biodried output is assumed to take a maximum of one day. This represents a very fast throughput of wastes, enabling the plant to treat 100,000 tpa of residual waste on a relatively small site (8,000 – 9,000 m^2 [Juniper, 2005]).

As ZAK is municipally owned, wastes contracts are not an issue. Given this scenario, decisions to make large investments in plants that will benefit the whole community environmentally and financially can be made more easily and with greater confidence.

If the company owning or running the plant was privately owned, the potential danger of losing wastes contracts would be a very important parameter, and could potentially limit investment and development.

In the percolators, the waste stream is mixed with cold water. If warm water or steam was to be used (as in the ISKA system) then a higher proportion of the organics could presumably be recovered from the solid to the liquid fraction. If more organics could be recovered, then more biogas could be produced. In any case there is usually an excess of heat energy in the form of steam, due to the difficulty of finding a use for all of the heat produced. The reason why cold water was used rather than hot water was that a certain proportion of the organics must be retained in the solid fraction to provide enough heat (as a by-product of its aerobic decomposition) in the subsequent biodrying stage of the process.

The housekeeping and odour control at the plant were impressive. The plant had only started up six weeks previously and therefore looked new and free from dust and grime, but if the same (or similar) levels of housekeeping and odour control are maintained, then no odour at all would be detected, even from a distance of only a few metres.

All in all the ZAK concept, should time to prove it to be reliable, is perhaps one of the best possible MBT plant designs with regards to landfill diversion and energy recovery. The high scoring of the plant in both of these key areas (landfill diversion and energy recovery) is primarily down to the fact that the solid fraction of the percolated waste is biodried and upgraded to SRF rather than landfilled. The percentage of the residual waste stream that is landfilled has been reduced to 15%. Only inert material is landfilled. It must be remembered that the residual waste stream consists of only those sections of the waste stream that are not recycled, re-used or disposed of as hazardous waste. In real terms therefore, the actual percentage of the waste stream being landfilled is considerably lower.

The ZAK management are confident that their ‘concept’ represents the best possible solution for residual wastes in Germany, and they expect that when the Legislation of other nations ‘catches up’ that their concept will become much more common throughout Europe. The plant compares well with other MBT options for residual waste processing in the following key areas;

- Energy.
- Landfill diversion.
- Odour minimisation.
- Total throughput time.

REFERENCES

Gibis, (Managing Director, ZAK Ringsheim MBT Plant), Personal Communication, 2006.

LIFE Program website, (www.ruk-online.de/life-ZAK-Kahlenberg/index.html), accessed August 2006.

ZAK (Zweckverband Abfallbehandlung Kahlenberg) Promotional Information, 2006.

Person G. (Engineer, ZAK Ringsheim), Personal Communication, 2006.