Thermal Production of Fertilizer from Organic Waste

Rainer Heiniger

1. The Organisation: From the Beginning till Today

In 1966 several municipalities in the eastern part of Switzerland - in the area between Zurich and St. Gallen – formed an organisation with the purpose of building a waste incineration plant and to operate it. The wastes from the participating municipalities were deposited in various landfills during the first ten years – that means until the commissioning of the waste incineration plant in Bazenheid in 1976. Due to the amalgamation of the neighbour communities the organisation *waste recycling Bazenheid (ZAB)* was founded in 1982. In 1984 the waste incineration plant was expanded with a third grate line. By the end of the 90ties the plant was constantly increased to meet the demands of the Swiss environmental protection legislation and was adapted and improved so that energy could be utilized (heat and electricity).

Figure 1:

Position of the organisation of ZAB in eastern part Switzerland

To complement the three existing incineration lines (combustion grates), a fluidized bed line for the thermal recycling of municipal and industrial sludge was taken into operation in 2008. During this conversion a flue gas purification with a catalytic dioxin removal was also installed for all four lines. Herewith the plant in Bazenheid meets the requirements of 17.BImschV (German Federal Pollution Control Ordinance).

In spring 2011, the organisation agreed to a further project to optimize energy use. In the years 2012/2013 a new 40-bar turbine will be integrated and two old boilers will be stocked up from 20 to 40 bars. Herewith the greatest potential for energy production as well as the best cost-benefit ratio will be achieved – the current electricity production of 30 GWh could then almost be doubled – to 55 GWh – with the same amount of waste.

Figure 2:

Waste incineration plant Bazenheid – a modern system

In addition to the garbage and sludge incinerator plant the organisation also has other infrastructures, which are used for collecting and sorting of waste: An own refuse vehicle fleet, several decentralized waste collection centers as well as a sorting and shredding plant. Since 1995, the residues of waste of the incineration plant Bazenheid were deposited in its own landfill.

Figure 3:

Vehicle for the collection of combustible municipal waste

The refuse bag tax was introduced for municipal waste (household waste) in all municipalities of the Federation at the beginning of the 90ties. Hereby a great increase of the amount of separately collected valuable raw materials such as glass, paper and scrap metal was achieved.

Over the years, the local authorities association for waste treatment of Bazenheid developed to a modern enterprise for waste recycling. Its primary task is to collect household, industrial and commercial waste and sludge from municipal and industrial wastewater in the region and to recycle or to convert the materials to energy.

In addition to collecting and recycling of combustible waste the ZAB organises separate collections of paper, cardboard, glass, aluminum and tin cans, scrap metal and waste oil in the municipalities. Today the organisation provides its primary services for 38 municipalities with over 170,000 inhabitants, and for over 4,000 enterprises and companies.

Various tasks and services of the ZAB are fulfilled in close cooperation with public or private partners. The company itself employs 45 employees. This in manufacturing, logistics, maintenance, administration and consulting functions.

2. Why a Fluidized Bed Line?

Since the beginning of the century the ZAB has been checking strategies and future scenarios – this taking into account various factors, such as:

- Future market environment;
- New legal basic conditions;
- Economy;
- Environment and technology.

2006 the delegates of the organisation received a concept, which should allow developing a new opportunity: The thermal treatment of sewage sludge in a separate line.

Already since 1996 ZAB has been responsible for transporting and recycling of sewage sludge in the local communities. ZAB did this job by purchasing the necessary services.

Figure 4:

Sewage sludge accumulates in municipal wastewater treatment plants

The majority of the sludge was dried after dewatering and then used in cement works as a substitute to fuel. A small portion was still used in agriculture as fertilizer. However already in 2003, it was stipulated by the Swiss legislation, that after the 1st October 2008 all sewage sludge had to be treated thermally. The new concept of the ZAB stipulated to set up and operate a fluidized bed line. The capacities of the incinerators for municipal waste and for sewage sludge were defined together with partners from an other municipal solid waste incinerator in the neighborhood and from the plants for sludge drying. As result the disposal of sewage sludge could be offered 40 % cheaper to the 110 municipalities of the two associations.

The fluidized bed combustion is the best available technology worldwide in the field of thermal treatment for sewage sludge. It is a proven modern technology. The fluidized bed line in Bazenheid is designed for thermal treatment of 30,000 to 40,000 tons of sludge each year with an average of 30 percent of dry content. The corresponding energy for the combustion is delivered by 20,000 to 40,000 tons of appropriate medium to high caloric waste. The facility has been in operation since autumn 2008.

In Bazenheid there is a fluidized bed line, which has the following core elements:

- Oven with fixed fluidized-bed (Company Ebara); with sand bed temperatures of 600 to 650 °C, post-combustion at 850 to 900 °C in the Oven head;
- Boiler (Company Ebara/SES) with production of steam 40 bar/400 °C;
- Economizer (Company Ebara/SES) for preheating the feed water;
- Electrostatic precipitators (Company Elex) for the deposition of fly ash (phosphorous);
- Two-stage wet scrubber (Company Rauschert).

3. Legal Basic Conditions

Waste as a Raw Material – ZAB as an Energy Producer

Waste was regarded as something objectionable in our society for a long time. It therefore had to be removed. In the past few years this view and the handling of waste has fundamentally changed. Waste has increasingly become a valuable raw material that can be recycled or used for energy production.

The optimization of energy production from waste incineration plants has gained on importance in the last 5 years, due to the energetic and climatic policies. The 30 municipal solid waste incineration plants in Switzerland burn about 3.5 million tons of waste annually. Virtually all plants are now using the resulting energy to generate electricity and heat. The efficiency of the plants is very different. According to the federal energy law [1] half of the energy from waste incineration plants is considered as renewable, since it comes from biomass.

In the energy regulation [2] significantly extended or renewed biomass energy systems (including garbage, sludge and other combustion plants) can benefit form cost-covering feed-in tariffs for the produced electricity. This however only takes place when a certain energy efficiency is achieved. With the fluidized bed project as well as with the in May 2011 approved project *Optimization of energy use* (installation of a 40-bar-turbine, converting of two grid lines) ZAB fulfilled the conditions requested by the state for the funding purpose – this will be from 2013. The credit duration period is 20 years from the commissioning of the new turbine. For both projects ZAB will spend approximately 80 million Euro.

Ensure the Disposal of Sewage Sludge

To ensure the disposal of sewage sludge by a second disposal way, the Canton of St. Gallen developed a concept [3] together with the various regions in 1994.

In connection with the change of the ordinance on chemical substances of the 28th March 2003 [4] it was compulsory to treat the sludge thermally by 1st October 2008. Until then, the sludge could have been used for agriculture. In the catchment area of the ZAB and it's partner organisations approximately 60,000 tons of municipal and industrial sludge with an average of 30 % dry content are produced each year. Together with the partners up to 100,000 tons of dewatered sewage sludge can be processed yearly. Hereby the safety of disposal is also ensured. With the realization of the fluidized bed line, the price for the thermal treatment of the dewatered municipal sludge was reduced significantly. For all 110 municipalities, the price including transport and treatment is around 92 Euro – this unit price also includes a balancing out of transportation costs. Before 2008 the price was around 130 Euro per metric ton of dewatered sludge.

Phosphorus Recovery

Phosphorus compounds are essential for humans, animals and plants. Phosphorus is becoming scarcer and is neither a renewable nor a replaceable resource. The natural resources are scarce. In connection to resources the current phosphorus management in Switzerland is today not optimally designed.

Due to the fact that Switzerland does not own phosphorus deposits and has to import phosphorus, the recovery of phosphorus will be required with the coming revision of the Technical Ordinance on waste [5]). After a transition period of several years, this prescription will apply to wastes, which are rich in phosphorus as sewage sludge, vegetable and animal wastes.

For this reason, in future the holders of phosphorus rich wastes are obliged to recover the phosphorus or to allow subsequent recovery. The latter means that this waste has to be thermally treated in special incinerators (mineralization). The resulting ash will be stored in a separate disposal area for possible recovery.

Figure 5:

Phosphorus fertilizer from sewage sludge ash

The direct disposal of phosphorus rich waste in cement plants or even in traditional waste incineration plants will herewith no longer be possible in Switzerland in a couple of years.

For the allowance of phosphorus containing fertilizers, which are produced from waste, the requirements in the ordinance on marketing of fertilizers [6] and appendix 2.6 of the Chemical Risk Reduction Ordinance [7] which contain the by law transition for the application of sewage sludge in agriculture, are applied.

A future fertilizer from the ash of sewage sludge incinerators must therefore in future be guided by the following quality requirements.

Table 1: Quality requirements for a future fertilizer from the ash of sewage sludge incinerators

Toxic Matter	Recycling Fertilizer Limit Value in Gram pro Ton Dry Matter	Change Determination for Sewage Sludge Limit Value in Gram pro Ton Dry Matter
Lead (Pb)	120	500
Cadmium (Cd)	1	5
Chrom (Cr)	–	500
Cobalt (Co)	–	60
Copper (Cu)	100	600
Molybdenum(Mo)	–	20
Nickel (Ni)	30	80
Mercury (Hg)	1	5
Zinc (Zn)	400	2,000

ZAB will apply for the allowance of a recycling fertilizer, which is produced by thermal treatment of organic waste by the Swiss authorities, as soon as the feasibility can be demonstrated (see Chapter 4).

4. Technical and Organisational Conditions for the Thermal Production of Fertilizer from Organic Waste

Technical Possibilities of the Fluidized Bed Line in Bazenheid

The main purpose of the fluidized bed line in Bazenheid is the mineralization of around 30,000 to 40,000 tons of dewatered sewage sludge with round 30 percent dry matter. In addition to municipal sewage sludge, sludge from the fermentation of meat-containing wastes is used today. The system is designed so that it can process up to 5 tons of sludge per hour at an annual operating time of 8,000 hours. On the contrary to the conventional mono-incineration plants - there are 14 plants in Switzerland - the thermal treatment of the sludge is herewith run without addition of primary energy (oil, gas).

Waste wood, waste from plastic and paper production or processing practices and processed commercial and industrial wastes are used as an energy source. All waste materials must meet the quality standards of ZAB in respect to size and impurities. The oven is designed for a thermal power of 21 MW. The sludge is injected into the sandbed at four supply points. The high calorific value wastes are pre-mixed by two plate conveyors and are fed in above the sandbed.

Figure 6:

View of the fluidized bed boiler and furnace line

Possibilities for Temporary Storage of Ash from the Fluidized Bed Line

In the currently ongoing revision of the technical ordinance on waste [5] the Swiss legislator assumes that phosphorus rich waste in mono-incineration plants should be treated thermally and the resulting ash should be used directly or after intermediate storage for phosphorus recovery.

About 15 km away from Bazenheid the ZAB has a landfill for the disposal of residues resulting from thermal treatment. They have this since 1995. Late 2010 the second expansion stage was taken into operation. It was laid out for the deposition of combustion residues. Also here the recovery of raw materials has top priority. With the metal recovery plant, around eight percent of iron, aluminum, copper and stainless steel resulting from the thermal treatment technology with the rust technique, is mechanically removed from the bottom ash of the incinerator and recycled into the material cycle.

The ash from the fluidized bed line in Bazenheid is separately stored from the bottom ash, so that it can always be taken out again and the contained phosphorus can be recovered as needed with the appropriate technology.

Figure 7:

Phosphorus ash is stored in their own landfill

Opportunities for Recovery of Phosphorus/Quality Requirements

In recent months, the ZAB intensively dealt with various methods for phosphorus recovery. For sewage sludge ash from incinerator plants, there are now, according to ZAB two promising approaches:

a) The sewage sludge ash is thermally treated with alkali chlorides and heavy metals are thus depleted (Ash Dec process). The remaining ash could be used as fertilizer. Prerequisite is the availability to plants which contain phosphate. The thermal treatment is complex and therefore more cost-intensive.

b) The sewage sludge ash is used directly as a fertilizer raw material. The ash is condi-tioned with acid however without thermal treatment. Hereby the phosphates are put into a soluble form and the desired phosphorus content. Thereafter the desired granulometry (RecoPhos process) is set. As there is no removal of heavy metals, the quality of sewage sludge ash is particularly important for the quality of the fertilizer with respect to the contents of heavy metals. In Germany, a functioning system used after the RecoPhos process already commercially makes fertilizer. The chemical and physical treatment is less complex and therefore less expensive than that of thermal processes.

What does this mean for the Operation of the fluidized Bed Line?

The quality of sludge from municipal wastewater treatment plants cannot be influenced by the ZAB. Only wastes whith a minimum content of heavy metals and – if possible – rich in phosphorus should be accepted as secondary fuel for the energy production. With the planned control of the input ashes can be produced, that are comparable to the quality of ashes coming from sewage sludge combustion. This year, the ZAB began examine with chemical analyses all the materials.

What Potential is Available for Fertilizer Raw Materials?

The amount of ashes at present is approximately 17 % during mineralization. With an annual volume of around 80,000 tons of sewage sludge and secondary fuels that go through the combustion, about 13,600 tons of fertilizer raw material will result. The amount of fertilizer that can be sold increases depending on the setting of the phosphate content. The commercial fertilizer in Switzerland has phosphate content (as P_2O_5) of 7 – 48 percent.

The possibilities for the recovery of phosphorus are not examined because of economical reasons but for the conservation of the resource phosphorus and also with respect to future regulatory requirements.

Feasibility Study of Phosphorus Recovery

For the thermal production of fertilizer from organic waste, the following requirements are essential:

- Mineralization of sewage sludge, respectively of alternative fuels;
- Storage and treatment of the ash (thermal or chemical);
- Reproducible composition of the ash;
- Setting a specific phosphorus content;
- Proof of availability to the plant;

- Approval of the treated ash as so called recycling fertilizer;
- Granulation and packaging of the ashes;
- Distribution and sale of fertilizer.

On the market there are several providers that offer various different treatment methods for sewage sludge ash. One of these suppliers, the German company RecoPhos, patented a process in the whole of Europe. In Germany RecoPhos successfully performed tests with sewage sludge ash to regulate the phosphorus content, to get an optimal the granulation and also to enhance the bio availability of phosphates to plants. RecoPhos received the approval for sewage sludge ash as a fertilizer in agriculture from the state administration.

After successful experiments with small amounts of ash from the fluidized bed incinerator line in Bazenheid, it is planned to carry out experiments in Germany with around 50 tons of ash in September/October 2011.

The following activities have top priority:

- Production of ash by thermal treatment of municipal sewage sludge;
- Chemical analysis of the ash quality;
- Transfer of the ash as fertilizer raw material to Germany;
- Refinement of the ash to a phosphate fertilizer;
- Control analysis of treated ash after processing;
- Tests in connection with the homogeneity (based on phosphorus content), the granulation of the phosphate fertilizer produced in coarse, medium, fine, and the bio availability of phosphate;
- Return transport of the phosphate fertilizer to Switzerland;
- Examination of distribution and sales opportunities;
- Application for approval by the Swiss authorities.

5. Summary and Outlook

In the Swiss legislation – in the context of the revision of the Technical Ordinance on waste (currently in the works, [5]) – it is envisaged that after a transition period of several years, the phosphorus recovery will become duty. Included in the phosphorus rich wastes are sewage sludge, vegetable and animal wastes. This enables the owners of phosphorus rich waste to be able to obtain the phosphorus back or even to allow recovery at a later time.

With the fluidized bed line the ZAB has, since late 2008, a technology available, that is suitable for the mineralization of phosphorus-containing organic waste such as municipal sewage sludge and animal waste (for instance sludge from the fermentation of meat-containing waste). Unlike in conventional mono-incineration plants the thermal treatment of the sludge is operated without addition of primary energy (oil, gas). In future energy carriers that have low contents of heavy metals and are rich in phosphorus should be used as fuels (input control).

Already today, the phosphorus containing ash from the fluidized bed is stored in its own landfill in a separate compartment, so that the recovery of phosphorus at a later stage is possible.

In a feasibility study that is still planned for 2011, the ash from the fluidized bed line will be tested to see if there is an ability to use it as a fertilizer. The focus is on the RecoPhos process, in which the ash is treated in a wet chemical process so that the phosphates are brought into a soluble form and the desired phosphorus content and the desired granulating form can be adjusted. After the tests it will be determined, whether an application may be initiated by the Swiss authorities for the admission of the new phosphate fertilizer. The cooperation with the company RecoPhos is contractually regulated so that, if successful, an ash treatment plant could be installed at the site Bazenheid.

The ZAB is confident that within the next three to five years recycling fertilizer can be produced from sewage sludge ash in Switzerland. In the field of distribution and sale of fertilizers, the ZAB has partners, which have many years experience.

6. Literature

[1] Swiss Federal Council, Energy Law, SR 730.0, 26 June 1998 (as of 1 January 2011)

[2] Swiss Federal Council, Energy Regulation, SR 730.01, on 7 December 1998 (as of 1 August 2011)

[3] Office for the Environment and Energy of the canton of St. Gallen, sewage sludge Concept 94, 2011 revision (sludge disposal plan)

[4] Swiss Federal Council, Ordinance on environmentally hazardous substances, SR 814 013, modification of 26 March 2003

[5] Federal Office for Environment, TVA revision – standard approach, by May 2011

[6] Swiss Federal Council Regulation on the marketing of fertilizers, SR 916 171, dated 10 January 2001 (as at 1 July 2010)

[7] Swiss Federal Council, Ordinance on Risk Reduction for Use of certain particularly dangerous substances, preparations and articles (Annex 2.6), SR 814.81, 18 May 2005 (as of 1 December 2010)

Die Deutsche Bibliothek – CIP-Einheitsaufnahme

WASTE MANAGEMENT, Volume 2
Waste Management, Recycling, Composting, Fermentation,
Mechanical-Biological Treatment, Energy Recovery from Waste,
Sewage Sludge Treatment
Karl J. Thomé-Kozmiensky, Luciano Pelloni.
– Neuruppin: TK Verlag Karl Thomé-Kozmiensky, 2011
ISBN 978-3-935317-69-6

ISBN 978-3-935317-69-6 TK Verlag Karl Thomé-Kozmiensky

Verlag: TK Verlag Karl Thomé-Kozmiensky • Neuruppin 2011
Redaktion und Lektorat: Professor Dr.-Ing. habil. Dr. h. c. Karl J. Thomé-Kozmiensky,
Dr.-Ing. Stephanie Thiel, M. Sc. Elisabeth Thomé-Kozmiensky, Janin Burbott
Erfassung und Layout: Janin Burbott, Petra Dittmann, Sandra Peters,
Martina Ringgenberg, Ginette Teske
Druck: Mediengruppe Universal Grafische Betriebe München GmbH, München