The Role of Thermal Treatment in Integrated Waste Management Concepts

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1. Introduction

The management of waste, which plays an important role in environmental protection in the context of sustainable development of any market economy, has been subjected to significant changes in the European Union in recent decades. The overarching idea that economic activities must be based on more sustainable ecological principles is a growing consensus. Maintaining or improving living standards will not be achieved by a disadvantageous exploitation of nature, but through smarter production techniques. A smart technology
is defined here as a technique that uses less material and less energy for the production of goods and which causes the least possible pollution emissions. Today, it is indisputable that the success of efforts to ensure a prosperous and sustainable society depends on the use of smart technologies in all economic processes.

The economic benefits of resource-and environmentally-friendly activities outweigh any economic cost disadvantages by far. The annual increase in global population is currently over 100 million persons. That means that each year a dignified existence of 100 million people including their rights to natural resources must be ensured. The assumption is not exaggerated that in the near future, producers of both industrial and agricultural products that do not consider the sustainability factor in their choice of production processes risk to lose their competitiveness.

In relation to waste management, the considerations outlined above lead to a hierarchy of choices with a priority placed first, on waste prevention and second, on waste recycling.

Alone in the European Union, hundreds of thousands of different products are bought and sold, with new ones added daily. Worldwide, some 12 million chemical compounds are bought or sold. It is inevitable that, in spite of all prevention and recovery strategies, a significant proportion of goods consumed will become waste at the end of their useful life. This waste consists of a wide variety of different components, including heavy metals, plus a variety of organic materials such as polychlorinated biphenyls, dioxins, furans, etc. which individually or in combination produce negative effects on humans and nature, though their human toxicological classification is often not known. Therefore, it is one of the most important tasks of waste management to treat waste in such a way that its properties affect the environment no more than the naturally existing level of emissions present in the natural environment.

The principles of a resource-oriented, environmentally-sound, and sustainable economy can help to derive the main ethical principles for waste management as follows:

- State of the art used in the production of goods must also be used for an environmentally sound disposal of waste; the quality of waste disposal must be at the same technological level as the quality of production of goods.

- The current generation must solve its own waste problems completely, and not pass on an unacceptable legacy of pollution to their descendants who will have their own problems in a world which is becoming more and more complicated.

- Each state must solve its own waste problems, preferably within its own borders.

These statements lead to the requirement that waste management concepts must strive, first, to avoid waste creation and second, to recycle waste with the final output being only inert material.

Only thermal waste treatment can produce inert and emission-neutral residues, which can subsequently be easily landfilled without harming earth, water or air. Thermal treatment dramatically reduces the polluting potential of waste residues. In addition, it significantly reduces the need for landfill space and takes advantage of an existing alternative energy source that can be used as a substitute for non-renewable fossil fuels and thus also avoiding their related emissions.
2. Augsburg Waste recycling facilities model

2.1. General Overview

The waste recycling plants in Augsburg, Germany were put into operation in 1995. Due to the holistic approach to sustainability from the concept stage and due to the advanced technology integrated as well as the design, the plants are still a good example of a successful, modern waste management in an area with a high population density.

The facilities, built in an industrial area on a surface of 235,000 m², consist of combustion, composting, hospital waste incineration, separation, and slag processing. They have provided a reliable recycling and safe landfilling of the waste of approximately 1 million inhabitants for over fifteen years.

2.2. Task

The Augsburg Waste Association was founded in 1980 by the City of Augsburg and the counties Augsburg and Aichach-Friedberg. The Association, after completion of the necessary regional planning process for the reorganization of the city waste disposal called for a new waste management concept with a hierarchy of waste reduction, waste reuse, waste recycling and waste landfilling which fulfils the principles set out below:

- Maximized protection of the environment is top priority.
- Recovery of waste is the second priority.
- The thermal treatment of waste must be considered, including the use of recovered energy and including exhaust gas purification according to the state of the art.
- The treated residual waste must be landfilled in an environmentally-safe way.

2.3. Output data

As part of the solution, the relevant data and the results of surveys on waste generation in the planning area were analysed, the key waste quantities were forecasted and the relevant chemical and physical parameters were determined. This resulted in approximately 250,000 Mg/year of household and commercial waste, 22,100 Mg/year of street sweepings, 45,500 t/year of sewage sludge (normalized to 25 % dry substance in the counties and to 50 % dry substance in the city) and 135,000 Mg/year of construction waste, including excavation waste.

In terms of materials and energy recovery, realistic sales possibilities were calculated for:

- compost,
- marketable waste components (recyclables),
- energy as electricity and as steam,
- treated incineration slag.

Additionally, possible combined systems for waste recycling and waste disposal were identified.

The investigations indicated that in the associated area, about 20,000 Mg/year of waste compost could be sold to private consumers, landscaping companies, agricultural enterprises, and used for greening noise protection walls, for the reclamation of landfills, etc.
The marketing of waste paper, scrap glass, scrap metal and textiles appeared to be attainable given the existing industrial and commercial activities in the area. Polyethylene materials are marketable, but the recycling of mixed plastic was classified as unsafe. For the use of incineration slag in the construction of new roads, the potential was estimated to around 10,000 Mg/year. The possibility for energy sales in the form of electricity and of heat to the neighbouring industry was characterized as realistic.

2.4. Optimization of the variants

With the goal of determining the mass flow rates and the associated costs, a total of thirteen different variants were worked out which at the end could be merged down to five combined variants. These five combined variants were technically and economically feasible and satisfied the criteria listed below:

- High-volume reduction to reduce the need for landfill space;
- High-coverage of marketable recyclables;
- Production of quality compost;
- Substitution of fossil fuels;
- Reduction of exhaust emissions in the planning area;
- Promotion of household recycling activities;
- Flexible-concept which can be easily adapted to changing future conditions.

2.5. Augsburg Waste recycling concept model

Taking into account the most relevant aspects for the time after erecting the plants, the best combined variant could be chosen as follows:

- Collection of the recyclable waste in the city of Augsburg using multi-component bins;
- Collection of recyclables in the counties in containers;
- Collection of the waste of selected businesses at source;
- Establishment of a separation plant for the collected recyclables;
- Construction of a composting plant for biological treatment of organic household waste together with garden waste and with minimally-polluted sewage sludges;
- Creation of a thermal waste treatment plant with a proven filter system;
- Drying and incineration of sewage sludge from the city of Augsburg in the waste incineration plant;
- Thermal treatment of hospital waste.

2.5.1. Thermal power plant for waste

The thermal power plant for waste has the task to incinerate non-recyclable household wastes and all the residues from the separation plant and composting plant. It is also an indispensable component of the waste disposal concept in terms of ensuring disposal security throughout the planning area in that it destroys hazardous and poisonous organic waste components by oxidizing them.
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The delivery of residual waste from households and industry, as well as the combustible residues from the sorting and composting plants takes place over twelve straight unloading docks into the deep bunker of the thermal power plant.

The unloading hall and the waste bunkers are held under a slightly negative air pressure in order to prevent the escape of odours, which could cause nuisance in the surrounding area.

Bulky waste is shipped separately and arrives in the bunker after crushing in a pair of scissors. Sewage sludge from the counties come first into a silo from where they are fed to the fluidized bed drying. The dried sludge, with a dry matter content of which approximately 90-95% is in granular form, can be stored in the bunker and is sent together with other waste onto the grate.

The crane control cabin is located above the bunker. Two independent bunker cranes mix and blend the waste in the bunker and then transfer it into three hoppers.

Infectious waste is burned in two separate, cyclically operating units. The resulting slag is discharged together with the waste slag, and the waste gases are transferred into the combustion chamber.

The thermal power plant has three lines equipped with a grate, combustion chamber, downstream steam boilers, five-stage flue gas cleaning system, and chimney. There is also a separate plant to treat the process water.

A high priority was given to the design of the combustion chamber and to the effectiveness of the flue gas cleaning system. For flue gases in the secondary incineration chamber, a residence time of at least two seconds at temperatures above 850 degrees Celsius is required.

The flue gas cleaning consists of the electrostatic filter, a hydrochloric acid plus sulphuric acid wet washing stage, a wet electrostatic precipitator (60 degrees Celsius), a catalytic NOx-reduction in the medium temperature (260 degrees Celsius) and an activated carbon fibre filter.

Wastewater from the hydrochloric acid stage is neutralized and concentrated in the evaporation plant; the effluent from the sulphuric acid stage goes directly into the wet slag bunker.

The pollutant content of the flue gas should be as much as possible below the current limits of the German Technical Instructions on Air Pollution Prevention and the emissions should be in accordance with paragraph 2.6.1.1 of the Clean Air Act to be classified as a de minimis case.

The energy produced is converted either into steam, hot water or electrical current, depending on the wishes of the energy end-user. Two steam turbines are available with a rated output of 17.6 MW.

Residues produced during the thermal treatment such as slag, ash and flue dust are discharged separately and transferred to a container station. The slag contains scrap iron and nonferrous metals, which are separated, crushed and sieved into different sizes during the recovery process.

The entire process is monitored and controlled around the clock, every day of the year.

2.5.2. Hospital waste incineration

Infectious and pathological waste from hospitals, doctors’ offices, etc. is incinerated in two separate, discontinuous operated furnaces. In the first chamber, waste is incinerated under sub-stoichiometric conditions at about 850 degrees Celsius. The resulting solids are burned and the smouldering and burning gases are transported into the thermal waste power furnace.
2.5.3. Slag treatment

The incineration slag is screened, shredded and converted into several granule sizes and materials. Unburned coarse metal scrap is manually separated. After that, magnetic and electrical systems are used to separate ferrous and non-ferrous metals. The screening results in three different size categories. The slag can be used in the construction of roads, for filling cavities in extinct mines, etc.

2.5.4. Composting

The composting plant is built in a fully covered hall. There, organic waste and structural material such as shrub and tree trimming residues are processed. Bulky contaminants are removed through a sieve-drum. The composting process takes place in two upward pressure air-ventilated flat heaps. The exhaust air from the delivery-and the composting hall is used as pressure air for the heaps.

The compost material is automatically shifted once a week and moistened if necessary.

The composting period is approximately ten weeks. The raw compost reaches the fine screen, where more impurities are removed and two grain categories are produced. The material is then stored.

To avoid odour emissions, two fans extract approximately 200,000 m³ of air from the composting hall every hour and pass this into a biofilter consisting of chopped root wood or similar material.

2.5.5. Sorting

There are two lines for sorting the contents of the household multi-material component bins and containers. For the sorting of commercial waste only one line is available. The separation of cardboard, paper, textiles, plastics, ferrous and nonferrous metals, glass and wood is done mechanically and manually. The residues go into the bunker of the waste power plant. A baler provides an economical transportability of the sorted materials.

2.5.6. Goals

As previously mentioned, the goal of the Augsburg waste recycling model is to achieve a high and long term lasting flexibility without compromising in the environmental issues through organizational measures and through the combination of material and thermal recycling with composting.

2.6. Changes over time

Some years after the German reunification, the amount of valuable recyclable commercial waste declined sharply. New packaging regulations led to changes both in the detection system and in the sorting of recyclables. In 2000, the sewage sludge drying plant was taken out of operation and the existing waste collection area was extended through the establishment of long-term contracts with other counties such as Bavarian Danube-Ries, Ostallgäu and Dillingen. Since 1997, the steam produced in the thermal power plant has been fed into the district heating system of Stadtwerke Augsburg. In August 2009, the 2004 established AVA Re Sort GmbH responsible for the sorting plant was merged to the AVA Augsburg GmbH.

2.7. Operating Results

2.7.1. Waste collection

In order to achieve a very high rate of household waste recovery, a green bin is used for the collection of waste paper, a yellow bin or yellow bag for the collection of lightweight packaging material and a brown bin for the collection of organic waste. Additional residual household waste from households is collected in a gray bin.

In addition, large glass collection containers are placed in convenient locations throughout cities and towns. For small quantities of other recyclables, bulky waste, electronic waste, and small amounts of hazardous waste are collected separately at recycling centres.

The combining of the collection systems with the sorting plant and composting plant allow the recovery of nearly 120,000 Mg of marketable materials each year.

2.7.2. Thermal power plant

The thermal power plant bunker has a capacity of 10,000 m³ and a throughput of 3•10 Mg/h or of 210,000 Mg/a. The average calorific value of the waste is about 10,000 kJ/kg with a throughput of 3•10 Mg/h. Household waste, commercial waste similar to household waste, bulky waste, sorting residues, residues from the composting plant plus pathological and infectious waste from hospitals are incinerated. The steam output per line is 33 Mg/h.

100 million kWh per year electrical power, plus 40 million kWh of heating power are produced. Additionally, 930,000 kWh of solar electricity are produced. Slag amounts of approximately 70,000 Mg/a are produced. Annually about 8,000 Mg metals are obtained. The residues from flue gas cleaning including fly ash can be used together with the slag as filling material for a former salt mine (Bad Friedrich/Kochendorf, Germany).

Thanks to the multi-stage flue gas cleaning, the emissions for all load conditions and for all three incineration lines are under the maximum permissible limits for emissions set out in the 17th Federal pollution control regulation. The results of continuous and of discontinuous measurements, the annual averages of 2010 and the monthly mean values from January to April 2011 are listed for all three lines in the following table.

To record the emissions, the operator has developed a procedure for regular soil and vegetation surveys within the system, covering contaminant levels such as polycyclic aromatic hydrocarbons, polychlorinated dibenzodioxins and furans, and sulphur, chlorine, fluoride, cadmium, thallium, mercury, antimony, arsenic, lead, chromium, cobalt, copper, manganese, nickel, vanadium, zinc, tin, etc. Up to now, no noticeable negative changes were identified in soil and plant samples.
2.7.3. Composting

The composting plant designed with a capacity of 50,000 Mg/a produced a total amount of 270,000 Mg of compost in the last fifteen years, which is mainly used for producing special soils in the areas of horticulture and landscape design. It was also sold in bags of 45 l for both plant and soil improvement.

The composting process itself and the end-product approved for organic farming is entitled to carry the certification mark ‘compost’ of the Federal Quality Assurance Association; both the process and product are subject to constant controls. The goal to reach a constantly high quality is ensured.

3. Concluding remarks

For areas with a high population density, thermal waste treatment is a necessity. It has the capacity to produce inert landfillable residues, to reduce the space requirement for landfilling and to oxidize hazardous organic waste compounds into harmless molecules. Incineration
concentrates the inorganic pollutants of waste so that they can be separated and landfilled safely. The energy released during the process can be used in the form of either electrical power or heat. The recovery of energy by incinerating waste preserves fossil fuels and eliminates their associated emissions.

The daily practice of the Augsburg plants model, presented in this paper as an example of a good waste management concept, incinerated the two millionth Mg of waste already in late November 2004. For over fifteen years, it has provided impressive evidence that through an elaborate, integrated approach using intelligent techniques, waste management can reach a maximum level and most extensive recycling of waste in a large catchment area while fully ensuring safe disposal. In addition, the built-in flexibility allows the system to be adjusted to constantly changing factors.

4. Literature


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