Integrated Waste Treatment including Residue Utilization

Andreas Richter

Waste Treatment, Principles

Based on the existing guideline 89/369/EWG the main purpose of waste incineration plants was defined as listed below:

*Waste incineration plants are industrial premises which shall be designed for the main purpose of treatment of municipal waste incl. recovery systems for generated thermal energy.*

History Waste Incineration Plants:

- First discontinuous stoker-fired furnace for waste incineration 1876 in Manchester (GB) and 1894 in Hamburg (D). Development of continuous stoker-fired systems starting in 1920. Currently, worldwide more than 1.000 waste incineration plants with combustion grate, fluidized bed as well as rotary kiln technologies have been realized.

- Today, various companies in grate combustion, fluidized bed, rotary kiln, boiler design and fabrication technology as well as operators of complex environmental facilities build on 100 years of tradition in construction and operation of waste incineration plants.

- Due to development of environmental movement the term *waste incineration plant* was afflicted with overtones. Hence the term *Waste to Energy* was developed in the past to substitute the old definition and to rebrand WtE projects with positive *green* public image.

During the last 5 decades an intensive development in waste management was realized worldwide and implemented in European as well as local laws and guidelines like exemplary listed below:

- **EC** – Incineration Directive No. 2000/76/EC
- **D** – Ordinance on Environmentally compatible storage of waste from human settlement and on biological waste treatment facilities, (Abfallablagerungsverordnung – AbfAbIV)
- **D** – Technical guideline (TA) municipal waste (TASi)
- **D** – Federal control of pollution act (BImSchG)
- **A** – Federal immission control act (IG-L)

Typical WtE concepts:

- Pure waste incineration plants => for unsorted waste collection basically with grate combustion technology
- Waste incineration plants with upstream mechanical treatment facilities => for unsorted waste collection and local recycling market as well as cement kiln with combustion technologies for incineration of refuse-derived fuel (RDF) – high calorific value fraction
- Waste incineration plants with upstream mechanical and biological treatment facilities => basically for unsorted waste collection and local recycling market as well as existing local law for application of *renewable energy*
- Waste incineration plants with fuel pre-treatment facilities => for selective waste collection and additional fuel types (e.g. sewage sludge) basically with fluidized bed technology
Figure 1: Waste to Energy concepts

Flue Gas Cleaning Systems, Basics

Typical flue gas systems for waste incineration plants can be listed and split into the following systems:

- Conditioned dry absorption (CDA) and SNCR flue gas cleaning system, SNCR stage installed in the boiler section at the combustion chamber
- Conditioned dry absorption (CDA) and SCR flue gas cleaning system
- Conditioned dry absorption (CDA) and wet scrubbing and SCR flue gas cleaning system

Based on statistics, the design and realization for flue gas cleaning systems in WtE plants during the last years has been heavily influenced by semi dry flue gas cleaning systems. Due to this reason the author will focus on this system.

The conditioned dry absorption flue gas system in combination with SNCR system will have the following advantages compared to others:

- Emissions essentially below Federal control of pollution act (BImSchG)
- Less capital expenditures (CAPEX)
- Less operational expenditures (OPEX)
- System without sewage & waste water
- Low requirements to the structural building and civil construction
- Low requirements to fire protection system due to standard material, mostly steel structure
• Low-pressure dual fluid nozzles, principle of ultra-sonic atomization, with no moving parts
• Low consumption of atomizing agent (steam or compressed air)

**Flue Gas Cleaning Systems, Line Up**

- Conditioned dry absorption (CDA) and SNCR flue gas cleaning system

<table>
<thead>
<tr>
<th>Dust</th>
<th>SO$_2$/HCl/HF</th>
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<th>NO$_x$</th>
<th>PCDD/F</th>
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- Conditioned dry absorption (CDA) and SCR flue gas cleaning system

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- Conditioned dry absorption (CDA) and wet scrubbing and SCR flue gas cleaning system

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**Flue Gas Cleaning Systems, Typical design**

Figure 2: Conditioned dry absorption (CDA) and SNCR* flue gas cleaning system

* SNCR stage installed in the boiler section at the combustion chamber and not shown in figure above
Flue Gas Cleaning Systems, layout and construction

Figure 3: Conditioned dry absorption (CDA) and SNCR flue gas cleaning system – Typical arrangement (left), Design elements and pictures (right)

Flue Gas Cleaning Systems, Statistics

Figure 4: Statistic: Emission values for conditioned dry absorption (CDA) systems in WtE facilities
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- condenser
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Residue Utilization

Due to environmental movement, residue utilizations get highly important even for development and financing of public-private-partnership WtE project.

Multilateral institutes such as
- European Bank for Reconstruction and Development – EBRD
- International Finance Corporation – IFC (Member of World Bank Group)

shall evaluate technologies, material balance and further utilization of residues in WtE projects in detail and as basic for their internal due-diligence progress.

Hence integrated waste treatment incl. Concepts for residue utilizations get more and more important for project development, construction and operation.

Residue utilizations secure sustainability for waste treatment process as well as for long term operation period including residue application based on economizing handling with resources from mother nature.

Residues from WtE facilities can be structured in the following categories:
- Boiler slag  =>  from the combustion chamber
- Boiler ash  =>  from downstream sections e.g. evaporator, superheater, economizer in the boiler
- Fly ash  =>  from flue gas cleaning systems

Residue Utilization, Quantities

Figure 5: Incineration residues, expected output balance*

* based on grate combustion technology and waste morphology for central Europe

Table 1: Incineration residues, output balance statistical records¹

<table>
<thead>
<tr>
<th>Country/City</th>
<th>therm. waste treatment</th>
<th>Boiler slag and ash</th>
<th>Fly ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vienna²</td>
<td>approx. 1,070,000</td>
<td>approx. 185,000</td>
<td>approx. 30,000</td>
</tr>
<tr>
<td>Austria</td>
<td>approx. 2,400,000³</td>
<td>approx. 528,000⁴</td>
<td>approx. 96,000⁴</td>
</tr>
<tr>
<td>Germany</td>
<td>approx. 26,800,000³</td>
<td>approx. 5,900,000⁴</td>
<td>approx. 1,070,000⁴</td>
</tr>
</tbody>
</table>

¹ partly based on internet research
² incl. quantities for hazardous waste incineration (rotary kiln) and sewage sludge incineration (FBC)
³ research VZ&Ä – 07/2011
⁴ Estimated values based on 22 % ratio for Boiler slag and ash and 4 % ratio for fly ash
Based on European as well as on local laws (e.g. Ordinance on Environmentally compatible storage of waste from human settlement and on biological waste treatment facilities, AbFAbIV for German), residues from thermal waste treatment must be stored based on morphology in different landfill categories.

- Boiler slag and ash shall be disposed in most of the cases on landfill classification III. After utilization, the material might be used as intermediate and cover layer for recultivation. In most of the regions in Central Europe adequate capacities for this landfill classification are available. Due to this fact, long term permitting process for new landfills as well as rising capacities in waste incineration, a view application in residue utilization have been installed in the last years. The actual expenditures for disposal boiler slag and ash are in a range between approx. 15 – 50 EUR/Mg.

- Depending on national & local legislation, waste morphology, incineration technology as well as local restrictions and permits, residue stabilization can be realized for further utilization and re-use of partial fractions.

- Fly ash from flue gas treatment systems is classified as hazardous material and must be stored in closed down salt mines. In Central Europe the available locations with official approvals and permits are limited. Due to fewer possibilities the expenditures for final disposal are quit high and in a range of approx. 120 – 180 EUR/Mg. Hence that fact and more or less expiring capacities additional solutions for further treatment of fly ash are under development.

Reference plants:

- For boiler slag and ash, STRABAG is operating the grate slag and ash treatment plant in Ville near Cologne/D since 2009.

- In Vienna the municipal department for waste collecting MA48 is operating since 1991 the mixing plant for residues from several waste and sewage sludge incineration plants in Vienna.

Figure 6: Residue Utilization, Reference Plant Ville/D
Here you will find our publications and research reports.
Material quantities:
The grate ash of the waste incineration plant in Cologne is transported from the incineration plant to the treatment plant in Ville by trucks. The stockpiling is outside without covering.

Plant Capacity: 100,000 Mg/a
Grate ash size: 0 – 1,000 mm
Fraction 0/6 mm: approx. 40 – 60 M.-%  
Fraction 6/16 mm: approx. 20 – 30 M.-%  
Fraction 16/45 mm: approx. 20 – 30 M.-% 
Fraction of not incinerated: < 5 M.-% 
Average amount of recyclables:
- Ferrous metal scrap:
  * ca. 5 M.-%,
    - with 3 – 4 M.-% fine scrap
    - 1 – 2 M.-% medium scrap,
    - 0,1 M.-% scrap
- Non Ferrous scrap
  * 1,5 – 2 M.-%

Main treatment facilities
- Bunker incl. feeding hopper, steel plate dosing conveyor, vibration conveyor
- Polygon screening drum
- Ferrous and Non Ferrous separation by magnetic separator and magnetic drum separator
- Mechanical separation by flop screen machine
- Wind sifter for removal light fraction
- Recirculation system for waste air, incl. ventilation system and chimney
Figure 8: Grate Ash Treatment Plant Cologne – Ville

Figure 9: Final products slag and ash, several fractions
Residue Utilization, Ref. Plant MA48 Vienna/Austria

Plant history:

- Professor Wruss and Professor Lukas develop a type of slurry containing slag, ash, bonding agents and water, so called *ash and slag concrete*. MA 48 starts to use the slurry for reinforcing side walls of the existing landfill Rautenweg in Vienna.
- In 1991 MA48 realized the construction of a single line mixing plant based on the adapted technology of a standard concrete mixing plant.
- In 1994/1995 MA48 realized the design and construction of a second line for slag and ash processing and mixing.
- Since 2008 a highly efficient ferrous and non ferrous separation system was implemented.

From 1991 to 2007 approx. 2.7 Million Mg of slag & ash concrete have been treated and forwarded to the existing landfill *Rautenweg* as basic construction material for surrounding barrier.

Main benefits from slag & ash concrete:

- Significant reduction of eluate classification compared to un-compacted landfill material as pollutants are embedded in the cement matrix.
- Reduction of dust and odor emissions.
- Due to high compaction density (1.80 Mg/m³) steeper slope for constructing surrounding barrier, therefore increasing of landfill capacity.

Residue Utilization, Basics

Basically there exist 2 possibilities to impact residue conditions:

- Primary measure => optimization of main treatment process, which means incineration process, e.g. optimization of incineration conditions such as e.g. combustion temperature, air supply, etc.
- Secondary measure => optimization of downstream treatment process, which can be development of residue utilization process.

*Primary measures*

Optimization of primary measures is fluently executed by all of well known boiler suppliers worldwide and can be demonstrated in higher combustion rate, higher boiler efficiency, rising plant availability and less residue outcome.

*Secondary measures*

Optimization of secondary measures was focused in the past mainly on treatment of boiler slag & ash and recycling of ferrous and non ferrous fractions. Due to environmental movement, less disposal capacities and high disposal costs, development of utilization technologies and processes for fly ash from flue gas cleaning systems are getting more and more important in the last few years.
Residue Utilization, Categories

Due to low development and experience of further fly ash treatment systems the author will concentrate only on evaluation, visions & potentials in fly ash treatment for residues from waste to energy facilities.

In professional literature there were listed two different categories of residue treatment processes:

- Low-temperature treatment process
- High-temperature treatment process

High-temperature processes are defined with a minimum temperature running above 650 °C.

Low-Temperature processes are from theoretical point of definition below 650 °C, in practice less than 100 °C.

Residue Utilization, Categories

Low-temperature treatment process

This category can be split into further 3 subgroups.

![Diagram](image)

Figure 10: Low-temperature treatment process with three subgroups

For treatment of fly ash from waste incineration plants the subgroup Stabilization (utilization) will be the technology with highest potential in development and optimization.

This subgroup contains two main treatment processes:

- Stabilization (utilization) with cement
- Stabilization (utilization) with clay

Wet treatment of residues is executed within the process of flue gas cleaning system if executed as conditioned dry absorption (CDA) and wet scrubbing and SCR flue gas cleaning system. The 2 main treatment processes can be listed with

- Acid treatment
- Alkaline treatment
Chemical treatment is seldom and basically used for industrial applications and integration of heavy metals in form of carbonizing and immobilization of heavy metals.

**High-temperature treatment process**

This category can also be split in further 3 subgroups.

![Figure 11: High-temperature treatment process with three subgroups](image)

High temperature treatment processes have to implement high energy quantity in the treatment process to realize sintering or melt down process. All high-temperature processes will destroy organic pollutants.

If the process runs under reduced atmospheric conditions the recovery process for metals will be the main topic.

During treatment under oxidation atmospheric conditions the generation of optical, chemical and electrical special glasses or glass fibers will be the main topic.

The realization of energy input can be realized via

- Plasma method
- Electrical energy
- Fossil energy sources

**Summary**

*Integrated waste treatment including residue utilization* is not only a catchphrase, it shall be the maxim for further development in waste management for all kinds of waste types and local conditions and requirements.

Modern WtE – *Waste to Energy* projects, shall be understood as innovative turn key solutions to convert waste products in recyclables which substitute the limited natural resources such as fossil energy sources and secures sustainable preservation of Mother Nature.
As one of the first companies, LAB dedicated itself to the development of turn-key flue gas cleaning installations, in particular in the thermal waste management industry and quickly gained a good reputation due to its innovative technology and reliable components. Founded as a plant manufacturer for flue gas cleaning in 1953, the company with headquarters in Lyon, Stuttgart and La Seyne sur Mer, has been designing and manufacturing for more than 50 years components for flue gas cleaning and is in that area with over 300 reference plants one of the market leaders in Europe and worldwide. Today, LAB is a company of the Groupe CNIM with headquarters in Paris; in addition there are worldwide branch offices and affiliates.

LAB has a complete portfolio of own processes and offers for each individual project the relevant parameters adjusted to the most reasonable technology for the respective requirement, considering dry sorption with hydrated lime or bicarbonate as well as semi dry, wet type, multi stage or combined processes for the acid gas separation. Likewise, catalytic denitrification methods are designed and carried out. Principally, all processes are developed in our company and most of them are also patented, as, for example, the new VapoLAB process which significantly increases once more the performance, profitability and energy efficiency of dry sorption technology.

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LAB offers you from one single source qualified counselling, designing of individual components of flue gas cleaning, turn-key delivery and assembly, commissioning, documentation according to your instructions and training for your future operating staff.

An excerpt from LAB's current references:

- EBS HKW Rostock
- MKK Bremen
- EEW Delfzijl
- Twence Afvalverwerking
- SWD Düsseldorf
- Fortum Värme Högdalen
- IRU WTE Tallinn
- WTE Baku
- TRM Turin
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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

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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

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