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1. Introduction

1.1. Goals of waste management

The main objective of waste management is to treat solid waste, wastewater and waste air in a sustainable way in order to protect human health and the environment from damage caused by harmful substances. With increasing amounts of waste, besides preventing or limiting the input of pollutants, saving resources has become more and more important.
On one hand, waste management should be material-efficient. An ideal waste management system produces only two categories of substances, i.e. re-usable material and material for final repository focusing on the principle of concentration of environment-harmful material and conversion of environmentally compatible material into an earth crust- or soil-like form [8].

On the other hand, a distinguishing feature of a sound waste management system is energy-efficiency. Thermal combustion (burning of waste in order to obtain energy) has become a very important factor for the choice of location of a so-called waste to energy (WtE) plant. The heat released during the thermal treatment of waste should be used efficiently to produce district heat, process heat and electricity.

1.2. State of the art

The term State of the art describes the state of the development of devices, techniques, processes, methods, etc., which have been established in the practical application. It is important to notice, that state of the art is not the theoretical best solution, but rather the technical answer to a problem that can in fact be put into practice. As Henry H. Suplee stated in his engineering manual for gas turbine in 1910: In the present state of the art this is all that can be done.¹

have become established in the practical application of measures to ensure the safety and the improvement of the health and safety of employees involved in the preparation and use of working substances and in the protection of employees and third parties from the risks involved in the operation of plant requiring monitoring.

The state of the art is clearly described by norms and industry standards. Official guidelines from the EU describe state of the art technology as Best Available Technology (BAT) [2]:

<table>
<thead>
<tr>
<th>B</th>
<th>best, in relation to techniques, means the most effective in achieving a high general level of protection of the environment as a whole</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>available techniques means those techniques developed on a scale which allows implementation in the relevant class of activity specified in the First Schedule to the EPA Act 1992, as amended, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced within the State, as long as they are reasonably accessible to the person carrying on the activity</td>
</tr>
<tr>
<td>B</td>
<td>techniques includes both the technology used and the way in which the installation is designed, built, managed, maintained, operated and decommissioned</td>
</tr>
</tbody>
</table>

Source: Environmental Protection Agency EPA (2015), http://www.epa.ie/licensing/info/bat/#.VYAMWp06k8Q & http://www.epa.ie/licensing/info/bref/#.VYALtZ06k8Q (Accessed online on 16.06.2015)

¹ This passage in the engineering manual by Henry Harrison Suplee (1856-post 1943) titled Gas Turbine: progress in the design and construction of turbines operated by gases of combustion is the earliest use of the term state of the art documented by the Oxford English Dictionary.
Waste Incineration Plants – State of the Art

The European IPPC\(^2\) Bureau (EIPPCB) organizes and co-ordinates the exchange of information between states and industries concerned on BAT as required by Article 13 of the Industrial Emissions Directive (IED). The EIPPCB also produces BAT reference documents BREF and so-called BAT conclusions [3]:

- BREF are documents drawn up for defined activities and describe in particular applied techniques, present emissions and techniques considered for the determination of best available techniques.
- The BAT conclusions is a document containing the parts of a BAT reference document laying down the conclusions on best available techniques.

Generally, one important aspect has to be considered when talking about state of the art technology, namely time. Regarding waste incineration technology, the average period from planning until startup of an incineration plant is about 6 to 10 years. During this time, standards and technologies may change. Consequently, certain technologies, mainly process measuring and control technology, are already few years old at the point of starting up the plant and will be in use for another 30 years whereas there would be available far more sophisticated technology.

Other technologies, for example the incineration grate or the flue gas cleaning system, are based on developments which have already been successfully applied over several centuries and which have been in operation for years. These proven technologies remain state of the art since innovation takes time to establish in the market. Although the basic principles of these technologies are fixed, still there is room for further innovation available, e.g.:

- water-cooled grate,
- flue gas recirculation,
- fuzzy logic,
- incineration control.

1.3. History of waste management

Table 1 summarizes the global development of waste management. With increasing settlement and civilization, waste became a ubiquitous source of irritation. Landfills were situated almost in the backyards and were often the origin of epidemic plagues. Self-ignition of waste in the discharges led to formation of smoke clouds near inhabited areas and thereby to associated health problems.

In 1874, the first plant with controlled combustion, a so-called incineration plant, was put into operation in Nottingham (UK). Construction of other plants followed and soon recovery of energy was integrated. In 1903, the first WtE plant with power-heat coupling was built in Denmark [7].

---

\(^2\) IPPC: Integrated Pollution Prevention and Control
Between 1920 and 1940, the construction of WtE plants stagnated in Europe, due to the world economic crisis and World War I. Meanwhile, in the USA and in Japan various small-scale WtE plants were built, which were still technically immature. Consequently, numerous problems were encountered including incomplete burnout and odour emissions.

The 1950s were characterized by worldwide economic growth and thus by construction of new WtE plants all over the world. In the years thereafter, a tremendous development within the field of incineration technology took place. Among other aspects, more durable materials were used and the combustion processes was optimized.

It was mainly in the 1970’s when the production of steam and electricity became increasingly important, what may be traced back to the economic growth and the increasing prosperity. Furthermore, the problem of air pollution through WtE plants has been recognized and regulations of air pollution in the following years brought the plants to a highly sophisticated standard what also enabled the operation of plants, which are situated within town limits in inhabited areas.

Due to the increasing market prices of basic materials, recovery of metals from the residuals of WtE plants became attractive. Nowadays not only do WtE plants dispose waste and recover the energy but they are also a mean for resource recovery either recycling before combustion or recovery after combustion out of slag or ash [8].

Table 2: Evolution of waste management

<table>
<thead>
<tr>
<th>History</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1900</td>
<td>• Disposal of waste in dumpsites/landfills causes epidemic plaques and space becomes rare with increasing population</td>
</tr>
<tr>
<td></td>
<td>• Self-ignition close to inhabited areas led to health complaints</td>
</tr>
<tr>
<td>1874</td>
<td>• First incineration plant The Destructor in Nottingham (UK)</td>
</tr>
<tr>
<td>1903</td>
<td>• First WtE plant with power-heat coupling and waste recycling in Fredriksberg (DNK)</td>
</tr>
<tr>
<td>1920s – 1940s</td>
<td>• Stagnation of WtE plant construction in Europe due to World War I and economic crises</td>
</tr>
<tr>
<td></td>
<td>• Various small-scale WtE plants in USA and Japan</td>
</tr>
<tr>
<td></td>
<td>• Problems with odour emissions, incomplete burn-out, heavy manual labour</td>
</tr>
<tr>
<td>1950s</td>
<td>• Increasing prosperity and economic growth</td>
</tr>
<tr>
<td></td>
<td>• Lack of space, uncontrolled fires in landfills</td>
</tr>
<tr>
<td></td>
<td>• New WtE plants in cities like Rotterdam, Sao Paulo, Paris, Zurich, Munich and others</td>
</tr>
<tr>
<td>1960s</td>
<td>• Innovative developments as high-temperature resistant grate elements, optimization of combustion air supply, etc.</td>
</tr>
<tr>
<td></td>
<td>• Problems with corrosion, contamination, short time between overhauls</td>
</tr>
<tr>
<td>1970s</td>
<td>• Global energy crisis leads to increasing production of steam and electricity</td>
</tr>
<tr>
<td></td>
<td>• High air pollution with dioxin and heavy metals</td>
</tr>
<tr>
<td>1980/1990s</td>
<td>• Higher emission standards</td>
</tr>
<tr>
<td></td>
<td>• Removal of dust, HCl, SO₂, NO, and dioxine</td>
</tr>
<tr>
<td>2000s</td>
<td>• Recovery of ferrous + non-ferrous metals like Fe, Ni, Cu, Al, ...</td>
</tr>
<tr>
<td>&gt; 2015</td>
<td>• Recovery of strategic metals</td>
</tr>
<tr>
<td></td>
<td>• Dry slag and ash extraction</td>
</tr>
</tbody>
</table>
Taking the lead with environmentally friendly Energy from Waste.

Our life is based on energy. Since there is only a limited availability of fossil fuels, thermal utilisation of waste as a resource is becoming more and more important. As Germany's leading company in the production of environmentally friendly energy from thermal waste utilisation, it is our responsibility to take the lead. With Energy from Waste plants that are both technically and environmentally state-of-the-art. With the best qualified and highly committed employees. With sustainable customer relations in the spirit of a partnership. And, of course, with environmentally friendly Energy from Waste.
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Our solutions are part of a multi-channel approach to master the processing cycles of municipal and industrial waste management.

CNIM’s main environment activities:
- design, construction and commissioning of waste-to-energy plants,
- operation,
- flue-gas cleaning (LAB subsidiary).

The CNIM Group
Designs and manufactures high-tech turnkey industrial equipments and solutions. Provides unique research and expert services in the environment, energy, defense and industry sectors.
- Consolidated revenues: € 790.8 million (67.5% from exports)
- 2,900 employees, with 46% engineers

CNIM has delivered more than 280 household waste-to-energy lines and 400 flue-gas cleaning installations.

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2. Drivers of waste incineration system development

Overview
A WtE plant is embedded in a complex system which is influenced by various factors, so called drivers, and cannot be considered separately.
In the following chapters, the emphasis is placed on the four main groups:
- Politics,
- Legal aspects,
- Market,
- Public opinion.

2.1. Politics
Primarily, the main function of incineration was to reduce the volume of waste and to bring it in a suitable form for final depository while meeting the emission standards. Along with the discussion on climate protection and reduction of greenhouse gases (GHG) there has been growing awareness for the waste’s recoverable energy potential and recycling of materials.

The European Union’s approach to waste management is based on the waste hierarchy which sets the following priority order when shaping waste policy and managing waste at the operational level [4]:
1. To reduce the amount of waste generated,
2. To maximize recycling and re-use,
3. To limit incineration to non-recyclable materials,
4. To phase out landfilling to non-recyclable and non-recoverable waste,
5. To ensure full implementation of the waste policy targets in all member states.

2.2. Legal aspects
The development of waste management law has followed a number of different paths around the world. Specific national laws and regulations regarding disposal and/or incineration strongly influence the technology and design and thus as well the costs of a WtE plant [5].
- Prohibition of landfill disposal
  In Europe, landfill disposal of untreated waste has strongly declined over the past years due to strict regulation. Countries like Austria, Belgium, Denmark, Netherlands, Norway and Sweden all have less than 3 percent of landfill disposal and Germany and Switzerland even zero landfill disposal. The European average of landfill disposal is currently around 34 percent, while on average 42 percent of waste is
recycled or composted and the remaining 24 percent is treated in WtE plants [1]. Landfills are still the most commonly practiced form of waste management. Currently, worldwide nearly 80 percent of global waste is sent to landfills with a significant amount lacking proper design or containment.

It is obvious that landfill bans have been a key factor to foster the development and dissemination of WtE plants.

- **Minimizing Emissions**
  Raising awareness for the relation between hazardous emissions and human health as well as impacts on the environment have led to incentives for stricter emission regulations. Therefore, limit values for emissions have been tightened along with the technical developments of flue gas cleaning and wastewater treatment. Over time, more substances have been considered harmful such as dioxins/furans. In addition, measuring instruments are becoming more accurate and allow stricter and more precise controls. Nowadays, state of the art WtE plants emit far less pollutants than the ambient air in a city on average contains.

- **Resource recovery**
  Recovering resources from waste, respectively from slag, is becoming more and more important. In various WtE plants, several ferrous and non-ferrous metals are already recovered from slag because of its material value (market as driver). Other materials, mainly heavy metals cannot yet be recovered economically. Some countries have therefore introduced regulations for recovery rates of certain types of heavy metals in order to save natural resources.

### 2.3. Market

The market environment has a major influence on the plant technology. It is important to notice that the market is volatile and changes faster than the legal situation. As mentioned previously, the average period from the planning until the startup of an incineration plant is up to 10 years. Thereby, assumptions that are made during the planning phase might be wrong, which influences the design of a WtE plant. When talking about market influences, the following aspects are to be considered:

- **Electricity market**
  The live steam is typically used to generate power in order to increase the income of energy production.

- **District heat and process steam demand**
  If there is a demand for, the live steam is used to deliver district heat or process steam. Nowadays, recovering the energy value embedded in waste most effectively is one of the biggest influences on the design and location of a WtE plant.

- **Operating costs**
  The costs for operating materials, operating personnel, maintenance, transport, disposal for residues, fees and taxes, etc. need to be taken into account.
2.4. Public opinion

As stated in [9] *The government, local authorities and industry must continue to work together to erase the public’s out of date view of incineration as dirty and polluting, and to demonstrate how WtE is an important option in helping to reach targets for landfill diversion and renewable energy generation. An open, transparent and proactive approach by developers with their stakeholders remains the best way of overcoming the genuinely-held concerns of a sceptical public.*

Realizing a project successfully therefore requires a high degree of stakeholder’s management. Not only have the needs of the builders to be met, but also those of various other stakeholders, e.g.:

- Builders, investors (Typically cooperation associations operating on behalf of the public sector),
- Government and local authorities,
- Environmental offices,
- Health and safety associations,
- Industry,
- NGO’s,
- Local residents.

The different stakeholders may be divided in four sections according to their interest of the project and their power. As outlined in Figure 1, there are specific strategies to approach those different groups of stakeholders:

\[
\begin{array}{|c|c|}
\hline
\text{Stakeholder Map} & \text{Keep Satisfied} \\
\hline
\text{High Power} & \bullet \text{Leverage existing meetings} \\
& \bullet \text{Presentations} \\
& \bullet \text{Organisational briefings} \\
\hline
\text{Low Power} & \bullet \text{No specific communications} \\
& \bullet \text{Monitor messages from this group} \\
\hline
\text{Monitor} & \text{Manage Closely} \\
\hline
& \bullet \text{Personal briefings} \\
& \bullet \text{Workshops} \\
& \bullet \text{Risk & Issue awareness} \\
& \bullet \text{Presentations} \\
\hline
\text{Keep Informed} & \text{Keep Satisfied} \\
\hline
& \bullet \text{Newsletters} \\
& \bullet \text{Posters} \\
& \bullet \text{Flyers} \\
& \bullet \text{Website} \\
& \bullet \text{Programme email address} \\
\hline
\end{array}
\]

Figure 1:

Interaction with stakeholders

3. WtE as engineered product

As outlined in the previous chapters, drivers strongly influence the design and layout of a WtE plant. Therefore, every WtE plant is a unique facility with specific boundary conditions. Depending on different influencing factors, also called drivers, the layout and technology of a plant differs. In other words, there is no single state of the art WtE plant. In fact, the specific state of the art technology depends on the individual drivers.

A WtE plant definitely cannot be considered a mass product, but rather an *engineered product*. Consequently, technical solutions from existing plants can only be adopted in other plants to a certain degree as the dimensioning and engineering of the various system components is individually adapted to the prevailing conditions.

The engineering of a WtE plant also includes non-technical aspects as coordination with authorities, spatial planning, environmental impact assessment, risk management, project tracking of costs and deadlines, public relation work, etc.

Therefore, the collaboration and coordination between the different stakeholders is essential.

4. Technologies examples

In the following chapters, four plants are outlined each with different drivers influencing the plant’s design and technology.

4.1. WtE plant Lausanne (Switzerland)

![Figure 2: WtE plant Lausanne](image)

<table>
<thead>
<tr>
<th>Table 3: Key values WtE plant Lausanne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
</tr>
<tr>
<td>End of construction</td>
</tr>
<tr>
<td>Investment</td>
</tr>
<tr>
<td>Firing technology</td>
</tr>
<tr>
<td>Treatment capacity</td>
</tr>
<tr>
<td>Incineration lines</td>
</tr>
<tr>
<td>Turbine/generator</td>
</tr>
<tr>
<td>District heating (max)</td>
</tr>
</tbody>
</table>

**Main driver**
- Market: High district heat demand

**Plant concept**
- 2 new incineration lines
- Grate furnace and waste heat boiler
- Thermal plant with steam turbine/generator and supply of district steam
- Flue gas treatment with electrostatic precipitator, wet scrubber, precipitation of calcium sulphate, DeNOx-system (SCR-process) incl. oxidation of dioxins and furans
- Waste water treatment facility.

Production and utilization of energy

The combustion grate is followed by a steam boiler with superheater and economiser. The produced superheated steam has a temperature of 400 °C and 40 bar. A steam turbine generates maximally 20 MW of electricity, out of which 3 MWel is used for covering own needs. The surplus of produced energy is fed into the public electrical grid. The turbine is equipped with two stages in between steam may be extracted. By using just a small part of the low-pressure turbine, enough electricity can be generated to run the plant and the rest of the steam is extracted after the high-pressure turbine in order to feed the district heating grid for adequate heating in the coldest weather.

If the plant is running at full electrical output and the waste heat is only used for water heating, the overall thermal efficiency is between 30 and 35 percent. In winter, when the demand for heat rises, thermal efficiency can reach over 80 percent. The overall average year-round thermal efficiency is just over 50 percent [2].

Specialities and challenges
- The plant is built into a hillside
- Waste is delivered by an underground railway
- Tight space conditions during construction

4.2. RDF plant Spremberg (Germany)

Main driver
- Market: High process heat demand of the neighboring paper mill

Plant concept
- New Refuse Derived Fuel (RDF) furnace line with grate furnace and boiler
- Semi-dry gas cleaning with fabric filter
- Steam turbine with air condenser and auxiliary condenser
• Auxiliary boilers to supply the paper mill with 11 bar steam in case of a downtime of the RDF furnace
• Civil construction and various secondary structures

<table>
<thead>
<tr>
<th>Table 4: Key values RDF plant Spremberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
</tr>
<tr>
<td>Start/end of construction</td>
</tr>
<tr>
<td>Investment</td>
</tr>
<tr>
<td>Firing technology</td>
</tr>
<tr>
<td>Treatment capacity</td>
</tr>
<tr>
<td>Incineration lines</td>
</tr>
<tr>
<td>Auxiliary boiler</td>
</tr>
<tr>
<td>Turbine/generator</td>
</tr>
<tr>
<td>Process steam</td>
</tr>
</tbody>
</table>

**Thermal system**

The RDF plant Spremberg is designed to supply the neighboring paper mill reliably, independent and continuously with medium-pressure steam. The two auxiliary boilers are kept warm in standby mode to supply the paper mill interruption-free during disturbance of the incineration lines. In the event of a sudden drop of the steam offtake to the paper mill, the excess steam is led to the auxiliary condenser without endangering the operation of the steam turbine. The condensate from the paper mill is treated in a cleaning-system before it is reused in the water-steam-cycle of the RDF plant.

**Specialities and challenges**

• Fault free interaction of RDF plant and paper mill
• Tight space conditions during construction (material delivery, crane location, etc.)
• The RDF plant had to be put up in a very short space of time partly under very cold and rough weather conditions
TONS OF ENERGY!

ENERGY GENERATION FROM RESIDUES: EFFICIENT & ECO-FRIENDLY.

Energy costs are continually rising. Making it all the more important for companies and municipalities to explore cheaper fuel alternatives for their energy supply.

We are experts in them: household and commercial waste, industrial residues and refuse derived fuels. And for many years now, we have been proving how they can be used in thermal recycling processes to produce useable energy for generating electricity, process steam and district heat.

For more information and references, visit: www.standardkessel-baumgarte.de
Thermal waste treatment plants are complex structures, the design of which differs in each individual case. The implementation of these plants requires a high level of competence in engineering and plant construction covering the whole range of services from planning and supply to start-up and maintenance.

Using our combustion technologies and cooperating with carefully selected and proven suppliers, we have accumulated a vast range of experience as a general contractor for the supply of entire turnkey plants.

In March 2015, we extended our product portfolio. As a plant manufacturer, we use the MARTIN dry digestion system (Thöni technology) to treat organic waste in numerous European countries as well as in Australia and New Zealand.

The Thöni dry digestion system has proven itself and is well established on the market. Biogas, compost and liquid fertilizers are separated from organic wastes and then returned to the substance cycle.
• Extremely high energy efficiency of approximately 85 percent due to the high process steam demand combined with high electricity generation (In Germany the required value for thermal power stations is 65 percent to receive state promotional funding).

4.3. WtE plant Silla 2 Milano (Italy)

Main drivers
• Legal aspects: High heating value (e.g. due to recycling rates)
• Market: High district heat demand
• Politics: Raising energy efficiency

Plant concept
• Optimization of an existing WtE plant in terms of performance and efficiency
• 3 incineration lines
• Thermal plant with steam turbine/generator, air condenser and coupling out of district heat
• Electrostatic precipitator, dry flue gas treatment system with fabric filter, bicarbonate injection and DeNOx-system (SNCR-process)

<table>
<thead>
<tr>
<th>Operator</th>
<th>A2A Ambiente S.r.l.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start/end of construction</td>
<td>Initial plant 1999 to 2003, optimization 2009 to 2014</td>
</tr>
<tr>
<td>Investment</td>
<td>195 Mio. EUR of which 30 Mio. EUR for optimization</td>
</tr>
<tr>
<td>Firing technology</td>
<td>Grate firing</td>
</tr>
<tr>
<td>Treatment capacity</td>
<td>580,000 t/y (Before optimization 500,000 t/y)</td>
</tr>
<tr>
<td>Incineration lines</td>
<td>3 x 86.3 t/h; 3 x 70.8 MWth (Before optimization 3 x 74.3 t/h; 3 x 61.5 MWth)</td>
</tr>
<tr>
<td>Turbine/generator</td>
<td>60 MW and 4.7 MWel; 8 MWel own consumption (Before optimization 45 MWel; 7 MWel own consumption)</td>
</tr>
<tr>
<td>District heating (max)</td>
<td>151 MWth (Before optimization 68 MWth)</td>
</tr>
</tbody>
</table>

Table 5: Key values WtE plant Silla 2 Milano
Optimization measures
In order to cope with the increasing heating value of the waste as well as to maximize the power output to the district heating system, the capacity of the combustion lines was enhanced. Due to the adaptations made, also the flue gas amount increased. Thereupon the permitted concentrations of harmful substances were lowered, ensuring that the emission loads and thereby the pollution of the environment do not increase. This was achieved by several modifications of the flue gas treatment plant (electrostatic precipitator, fabric filter, bicarbonate dosing, DeNOx catalyst, modifications of fans as well as air and flue gas ducts).

As a further measure, the thermal cycle was optimized. This comprised the heightening of the power of the existing district heating transfer station as well as the installation of a second district heating transfer station. Moreover, an additional steam turbine, in operation on demand, was installed between existing electric generator and condensing turbine. This enables an extraction of steam at high load of district heating as well as a most efficient power generation at low load of district heating. Furthermore, a new cooling circuit was installed for internal consumers.

Due to described measures, the total degree of efficiency of the plant went up from primary 57.4 percent to 84.3 percent.

Figure 7: Performance balance before optimization (left) and after optimization (right)

Specialities and challenges
- Large bunker and large incineration capacity
- Clutch-system on low pressure turbine
- Mechanical pretreatment
- Dry flue gas cleaning
4.4. WtE plant Bolzano (Italy)

Table 6: Key values WtE plant Bolzano

<table>
<thead>
<tr>
<th>Operator</th>
<th>Provincia autonoma di Bolzano</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start/end of construction</td>
<td>2004 to 2014</td>
</tr>
<tr>
<td>Investment</td>
<td>120 Mio. EUR</td>
</tr>
<tr>
<td>Firing technology</td>
<td>Grate firing</td>
</tr>
<tr>
<td>Treatment capacity</td>
<td>130,000 t/y</td>
</tr>
<tr>
<td>Incineration lines</td>
<td>1 x 16.3 t/h; 59 MW&lt;sub&gt;th&lt;/sub&gt;</td>
</tr>
<tr>
<td>Turbine/generator</td>
<td>15.7 MW&lt;sub&gt;el&lt;/sub&gt;</td>
</tr>
<tr>
<td>District heating</td>
<td>32 MW&lt;sub&gt;th&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Main drivers

- Legal aspects: High emission standards
- Public opinion: Architectural integration into landscape

Plant concept

- New WtE plant with 1 line with grate furnace and boiler
- Dry flue gas treatment system with two fabric filters, lime and bicarbonate injection, DeNOx-system (SCR-process)
- Thermal plant with steam turbine/generator, air condenser and coupling out of district heat
- Shredder and ball press integrated in waste bunker

Flue gas cleaning

The flue gas treatment plant of WtE Bolzano is characterized by a double-stage dry sorption. Downstream the steam boiler, the temperature of the flue gas is adjusted to about 190 °C by injecting and evaporating water. Afterwards, calcium hydroxide and activated carbon are evenly distributed into the flue gas stream and let to the first fabric filter. Immediately in the flue gas, particularly on the filter bags, acid pollutions react with the calcium hydroxide respectively heavy metals and PCDD/F are adsorbed on the activated carbon. Thus, the residues out of the first fabric filter consist of fly ash, the mainly reaction products CaCl₂, CaSO₃, CaF₂ plus partly loaded activated carbon.

In the second stage of dry sorption, a precipitation of pollutions takes place based on sodium bicarbonate (NaHCO₃), just analogue to the first stage: Injecting finely ground bicarbonate into a contact reactor upstream of the second fabric filter, it is intensively mixed with the flue gas. Additionally, activated carbon can also be injected to the second stage of flue gas treatment. The residues out of this stage consist of almost exclusively sodium salts, which can be recycled on the manufacturer’s site.
If the several sorbents are distributed to both stages of dry sorption in an appropriate manner, the specific advantages of them can be deliberately used. As an achievement, the efficiency of the flue gas treatment as well as the total amount of residues can be optimized.

**Specialities and challenges**

- Architectural integration into landscape to gain the acceptance of the citizens
- Maximum chimney height of 65 m due to the nearness to the airport
- Odour removal of bunker air in case of plant standstill
- Tight space conditions during construction (material delivery, crane location, etc.)
- High energy recovery
- High emission standards as shown in Table 7 below:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Unit</th>
<th>Local emission standards</th>
<th>Measured emission values</th>
</tr>
</thead>
<tbody>
<tr>
<td>dust</td>
<td>mg/m³</td>
<td>3</td>
<td>&lt; 1.5</td>
</tr>
<tr>
<td>TOC</td>
<td>mg/m³</td>
<td>10</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>HCl</td>
<td>mg/m³</td>
<td>2</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>SO₂</td>
<td>mg/m³</td>
<td>25</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>NOₓ</td>
<td>mg/m³</td>
<td>40</td>
<td>&lt; 40</td>
</tr>
<tr>
<td>Cd + Tl</td>
<td>mg/m³</td>
<td>0.025</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Hg</td>
<td>mg/m³</td>
<td>0.025</td>
<td>&lt; 0.0002</td>
</tr>
<tr>
<td>Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V</td>
<td>mg/m³</td>
<td>0.25</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>PCDD + PCDF</td>
<td>ng/m³</td>
<td>0.05</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

*Table 7: Emission standards WtE plant Bolzano*
5. Conclusion

State-of-the-art is not something static, but constantly evolving and developing. At the same time, innovation needs to be proved and well established. Innovative technical solutions can only be considered as state of the art after they have been successfully tested and used in the field for a certain time.

There is no state of the art WtE plant. In fact, the layout and the used technology depend on the given conditions of politics, legal aspects, market and also of the public opinion. These local aspects along with the individual needs and desires of the builder need to be considered for the general layout planning. To meet all these requirements, planners and engineers with an overall view and interdisciplinary know-how are essential for the success of a project.

6. References

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