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ITAD e.V.

"Waste-to-Energy – an essential part of the circular economy "

ITAD
Interessengemeinschaft der Thermischen Abfallbehandlungsanlagen in Deutschland e.V.
about ITAD

- German Association of Waste-to-Energy Plants
- represents almost 80 Municipal Solid Waste Incinerators (MSWI) and Refuse Derived Fuel Incinerators (RDFI) with round about 24 Mio. t annual treatment capacity
- Members: Private, Public and PPP
Waste-to-Energy –

History, tasks and aims
History

• Bible: Incineration of waste in open fire 1,000 b.c. (Jerusalem)

• Waste incineration was already common in the Roman Empire

• After downfall of the Roman Empire waste incineration falls into oblivion

  ⇒ Pestilence and cholera in the middle ages

• Collection of municipal waste in the cities in the 16th century (landfilling outside the cities)

• First waste incinerator named 'Destructor' in Nottingham 1874

• Waste incineration in Germany started end of 19th century

Hamburg 1894
Tasks and aims

- Sanitation
- Volume reduction
- Long run elimination of pollutants from cycle of materials
- Minimisation of emissions
- Efficient use of the energy content of waste
- Contribution to climate protection (substitution of fossil fuels)
- Contribution to sustainable waste management (recovery of metals from bottom ash and reuse of bottom ash as secondary raw material)
Waste-to-Energy
How does it work?
General principle

Waste Delivery and storage

Incineration, steam generating

Energy Recovery

Flue Gas Cleaning
Incineration

Feed Hopper

Combustion Chamber

Grate

Waste Storage

Bottom Ash Collection for recovery (metals and construction material)
Incineration

- Feed Hopper
- Grate
- Waste Storage
- Bottom Ash Collection for recovery (metals and construction material)
Incineration

Waste Storage

Grate

Combustion Chamber

Bottom Ash Collection for recovery (metals and construction material)
Incineration

Feed Hopper

Waste Storage

Combustion Chamber

Grate

Bottom Ash Collection

for recovery (metals and construction material)
**Incineration**

**Waste input (examples):**
- Municipal solid waste and similar commercial waste
- Bulky waste from households
- Demolition and construction waste (non mineral)
- Non recyclable packaging waste
- Sorting residues from commercial waste
- Calorific residues from MBT and composting plants (impurities)

**Not acceptable:**
- soil, concrete, asbestos, sand, stones, free-flowing sludges etc.
- Bulky metal waste (fridges, cars, washer)
- Self-igniting, explosive or highly flammable waste
- Radioactive or infectious waste

*Avoid non-combustible waste and very wet waste (wet organic) – input NCV ideally not below 6.000 kJ/kg*
Incineration and Energy Recovery

- **Incineration Chamber**
  - T > 1000 °C
  - Approx. 1 h

- **Boiler drum**
- **Superheater (40 bar/400°C)**
- **Economizer**
- **Incineration Chamber**
- **Turbine and electric generator**
- **De-Asher (water)**

- **Primary combustion air**
  - (4.000 -6.000 m³/t_{waste})

- **Heat**
  - (e.g. district heating, steam for industrial use)

- **Power**
Incineration:

• **Grate Combustion** is the most proven and widely applied method to treat residual waste and recover its energy.

• Organic compounds contained in residual waste are **safely destroyed**.

• Bottom ash left after incineration can be recovered, e.g. for road construction

• **Metals** embedded in residual waste **can be recovered** from the bottom ash, thus complementing the efforts done upstream in the waste hierarchy.
Energy Recovery:

• An Energy-from-Waste plant can recover more than 90 % of the energy embedded in the waste

• Electricity generated from residual waste is available 24 hours a day. This means that the renewable part of waste constitutes a non-intermittent supply of green energy

• The heat recovered by a plant can be used, for instance, for district heating and cooling, industrial processes, water desalination and many other purposes
Flue Gas Cleaning* I

(*)Air Pollution Controll - APC

Fabric Filter (for particles, dioxins, heavy metals)

Scrubber (for acid gases, such as HCl and SO₂)

Cleaned Gas (mostly water vapour and CO₂)

Fly ash storage (for disposal)
Flue Gas Cleaning II

- Electrical Precipitator
- Spray Dryer
- Wet scrubber (HCl and SO₂)
- DeNox and Cat
- Activated Carbon Reactor

Fly ash
Salts
Plaster
Activated Carbon
1. Feed hopper
2. Grate (water cooled)
3. De-Asher
4. Vibration conveyor
5. Grate fine waste
6. Magnetic separator
7. Primary combustion air fan
8. Secondary combustion air fan
9. Boiler
10. Boiler drum
11. Economizer 3
12. Recirculation economizer
13. Economizer 1+2
14. Bypass DeNOx
15. Air
16. DeNOx catalyst
17. Cooler
18. Fly ash conveyor
19. Fly ash pneumatic conveyor
20. Fabric filter
21. Fly ash silo
## Emissions

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Limits 17. BlmschV</th>
<th>Operational data</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_{ges}$ (Total carbon) in mg/m$^3$</td>
<td>10</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>CO (carbon monoxide) in mg/m$^3$</td>
<td>50</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Cd/Tl (cadmium/thallium) in mg/m$^3$</td>
<td>0.05</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>HCl (hydrochloric acid) in mg/m$^3$</td>
<td>10</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Hg (mercury) in mg/m$^3$</td>
<td>0.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>NO$_2$ (nitrogen oxide) in mg/m$^3$</td>
<td>200</td>
<td>&lt;80</td>
</tr>
<tr>
<td>SO$_2$ (sulphur dioxide) in mg/m$^3$</td>
<td>50</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Dust in mg/m$^3$</td>
<td>10</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Particulate matter PM 10 in ng/m$^3$</td>
<td></td>
<td>&lt;5</td>
</tr>
<tr>
<td>PCDD/F (dioxin/furan) in ng/m$^3$</td>
<td>0.1</td>
<td>&lt;0.0015</td>
</tr>
</tbody>
</table>

### Percentage of ELV used on annual base [%]

![Percentage of ELV used on annual base](image)
Quick Facts...

Flue Gas:

- Emission limits for Waste-to-Energy plants are the most stringent of any combustion industry (Europe)
- Emissions are thus negligible compared to other sources
- “Dioxins emitted from Waste-to-Energy plants are not an issue”, stated the German Environment Ministry in 2005, then headed by Mr. Trittin from the Green Party
- The mandatory technology for heavy metal removal guarantees that almost all heavy metals (mercury) are removed from the eco-cycle
Residues

1000 kg waste

Combustion chamber

- Bottom ash 200-300 kg

Boiler

- Boiler ash 5-15 kg

Dry FGC

- Dust separator
  - Dust 10-30 kg

- Wet FGC
  - Salts 5-20 kg

Activated Carbon Reactor

- Clean flue gas

Semi-dry FGC

- Semi-dry FGC

- Solid APC residues 50-90 kg

- Dust separator

- Spent activated carbon

Solid APC residues 40-70 kg
Quick Facts...

Residues

- Safe disposal and recovery of APC residues and bottom ash in an environmentally sound way
- Separation and recovery of metals from bottom ashes
- Mineral part of bottom ash can be used as secondary raw material
- Only about 100 kg APC residues of 1,000 kg incinerated wasted are disposed on landfill or used in salt mines (recovery or landfill)
Economic key data

• Economic efficiency depends on
  – capacity (minimum ~ 50,000 t/a)
  – Technology installed
  – Infrastructural requirements:
    • Near to „waste production“
    • Logistic connection (truck, railway, ship)
    • Near to energy consumer (steam user e.g. desalination, district heating or cooling system)
  – Supply of waste
  – Operational availability
**Basic conditions**

**capacity** 100.000 t/a  
**NCV (Net-calorific-value)** 9.000 kJ kg  

**Investment costs**

The average investment cost per tonne of annual capacity (for a new plant, considering 15-20 years operation) ca.: 500 -650 € (Europe).

**Plant size and specific investment cost**

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Specific Investment Cost per Tonne</th>
<th>Total Investment Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.000 t/a</td>
<td>300-600 €</td>
<td>40.000.000 €</td>
</tr>
<tr>
<td>300.000 t/a</td>
<td>250-500 €</td>
<td>70.000.000 €</td>
</tr>
<tr>
<td>600.000 t/a</td>
<td>150-400 €</td>
<td>110.000.000 €</td>
</tr>
</tbody>
</table>

**Maintenance costs**

*Maintenance costs in % of investment costs: 3-5 %*

**Treatment cost ...???

**Employees** 40-60

**space requirement** (5 lines, each 150.000 t/a capacity) 40.000-80.000 m²

**NCV-dependence of capacity**

<table>
<thead>
<tr>
<th>NCV [kJ/kg]</th>
<th>Theor. Annual Capacity [t/a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.000</td>
<td>100.000</td>
</tr>
<tr>
<td>7.500</td>
<td>120.000</td>
</tr>
<tr>
<td>6.000</td>
<td>150.000</td>
</tr>
<tr>
<td>11.000</td>
<td>81.818</td>
</tr>
</tbody>
</table>
Energy Efficiency and Climate Protection Potential
Energy production [MWh]

- Steam exported
- Heat exported
- Power produced
- Power exported

### GHG savings

#### CO₂-burden WtE 2016

<table>
<thead>
<tr>
<th>waste fraction</th>
<th>Menge [t]</th>
<th>emission factor [t CO₂eq/ t waste]</th>
<th>emissions [t CO₂eq]</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal waste</td>
<td>12.340.000</td>
<td>0.315</td>
<td>3.887.100</td>
<td></td>
</tr>
<tr>
<td>Pre-treated waste</td>
<td>7.340.000</td>
<td>0.468</td>
<td>3.435.120</td>
<td></td>
</tr>
<tr>
<td>Other waste</td>
<td>3.960.000</td>
<td>0.446</td>
<td>1.766.160</td>
<td></td>
</tr>
<tr>
<td>Sum/avg.</td>
<td>23.640.000</td>
<td>0.384</td>
<td>9.088.000</td>
<td></td>
</tr>
</tbody>
</table>

**Auxiliary fuels**

- Quelle: eigen
- 200.000

#### CO₂-credits

<table>
<thead>
<tr>
<th>energy</th>
<th>[MWh]</th>
<th>substitution factor [t CO₂eq/ MWh]</th>
<th>emissions [t CO₂eq]</th>
<th>remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>power prod.</td>
<td>10.310.000</td>
<td>0.806</td>
<td>8.309.860</td>
<td></td>
</tr>
<tr>
<td>steam exp.</td>
<td>12.020.000</td>
<td>0.360</td>
<td>4.327.200</td>
<td></td>
</tr>
<tr>
<td>heat exp.</td>
<td>9.200.000</td>
<td>0.296</td>
<td>2.723.200</td>
<td></td>
</tr>
<tr>
<td>Sum/avg.</td>
<td>30.530.000</td>
<td>0.503</td>
<td>15.360.000</td>
<td></td>
</tr>
</tbody>
</table>

**Credits from metal recycling** (ca. 24 kg/t Abfall)

- Quelle: EdDE, eigen
- 1.182.000

**Total GHG saving 2016**

- 7,25 mio t CO₂eq or 0,307 t CO₂/t waste
CO$_2$-saving costs

Costs to save 1 tonne CO$_2$:  

- Waste-to-Energy: 40€
- Wind on land: 70€
- Biomass: 90€
- Wind on sea: 120€
- Photo-voltaic: 140€

Sources: EZ, Regeling subsidiebedragen milieukwaliteit elektriciteitsproductie; VROM, personal communication; ECN, 2002, Duurzame Energie en Ruimte, M. Menkveld; analysis Deloitte
WtE-plants as alternative for MSW-landfills, avoiding methane emissions

Figure 3. Emissions of CO₂ equivalents contributing to climate change per tonne of waste managed (kg CO₂ eq per tonne of waste)
Quick Facts...

Energy efficiency and Climate Change Potential

- Energy-from-Waste is about 50% renewable energy
- Due to substitution of fossil fuel in the wider economy efficient WtE-plants save CO$_2$-emissions
- Most benefit from methane mitigation if replacing landfill
- CO$_2$-avoidance costs are low
- Possible benefits from ETS
The role of Waste-to-Energy in the Circular Economy
The vision
Reality...
Quick Facts on WtE and CE

- Thermal waste treatment is a cornerstone of waste management industry and an integral part of sustainable resource management.
- It acts as a pollutant sinks.
- It guarantees an environmentally sound and long-term disposal security.
- It is a sustainable contribution to resource efficiency through 'thermal recycling' - energy recovery as well as metal separation from slags and the production of high-quality granulates.
- The “resource waste” can only be used efficiently and sustainably if all treatment options - material recycling, energy recovery and landfill - are properly combined based on proper segregation of waste at source.
But how to establish?
Key issues

- Waste management
  - proper waste segregation (waste quality!), collection, transport

- Economics
  - reliable business model WtE
  - realistic conditions of operating contracts

- WtE Plant performance
  - Good operating performance
  - High environmental performance

- Environmental aspects and public perception
  - “Transparent” plant operation
  - Appropriate permitting and monitoring
Strategies

• Segregation of waste at source is essential for the waste quality towards the design criteria of the WtE plant.

• Establish pre-treatment if necessary to meet the MSWI input-quality.

• Avoid deterioration of long term capital investment for WtE strategy by financial support (e.g. appropriate Gate Fee Policy and contract conditions / service levels).

• Keep maintenance and replacement strategy on high level to ensure sustainable investment (25 years of operation).

• Establish transparent Emission Measurement Systems (CEMS) at all times and publish environmental performance.

• Regular and stringent monitoring of plant operation and performance by competent authority to increase public acceptance.

• Enhance communication amongst operators/contract partners and competent authority (“regular round tables”), but also with neighbourhood and “opponents” (NGO).

• Establishing specific national technical standards (comparable to European Best Available Techniques) for Waste-to Energy including monitoring and auditing routines.
Barriers

- High investment costs
- Missing energy users
- Public acceptance
- „God recycles, devil burns“ ideology
Barriers
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• Transparency from the start of the planning phase
• Active communication with neighbours, residents, local authorities
• Convince third party advocates
Barriers

- Transparency from the start of the planning phase
- Active communication with neighbours, residents, local authorities
- Convince third party advocates

*New WtE press officer*

...no negative impact through Waste-to-Energy

*Barrier: public acceptance*

Something went wrong if your perception is like that...
Happy end...?

Energy from Waste – clean and safe, that’s cool.
And good looking...
Thank you for your patience !!!

Any questions?