Thank you for the greetings from China!
Mengmeng and Jiaoqing are welcome in Germany!
Waste Incineration vs. Energy from Waste - then and now

Thomas Obermeier, Head of Business Development, EEW Energy from Waste GmbH

Ningbo, 29 June 2017
Agenda

1. History of waste incineration in Europe
   a) Waste quality
   b) First waste incineration plants in England
   c) First German waste incineration plant
   d) Alternative thermal treatment technologies

2. Current municipal waste treatment in Europe

3. Technical trends in Germany

4. Introduction of EEW

5. EEW’s reference plant in Delfzijl
Development of Waste Incineration in Europe

- 1000 BC: first biblical records
- 500 BC: Roman Empire
- 500 AC: Roman Empire
- 1500: Middle Ages
- 1600: Middle Ages
- 1700: Middle Ages
- 1874: First dependable incineration in England
- 1910: Closing of incineration plants
- 1914-1918: WWI
- 1939-1945: WWII
- 1950: Landfill
- 1950: EFW is standard
- 2000: Today
Quality of MSW and calorific value in 1910

Calorific Value:
c.a. 4 – 5 MJ/kg Waste

Above: Winter Sweepings Budapest, ca.1910
Below: Composition of sweepings Frederiksberg, ca.1910
Source: de Fodor 1911
Quality of MSW: Development of calorific value, EfW plant Brno (Czech Republic)
Development of waste incineration in England (1/2)

• Motivation for waste incineration in England: Sanitation due to health legislation in the mid-19th century

• Calorific value in England higher than in Continental Europe because of using hard coal instead of lignite for domestic heating → still carbon in ashes

• 1870 first experimental plant in Paddington → failed

• First plants with bad burnout and intense smoke generation → too low temperatures

• Tests with co-incineration with coal → not established

### Composition of municipal waste in London then and now

<table>
<thead>
<tr>
<th></th>
<th>c.1900</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash / Inert Material</td>
<td>47.0 %</td>
<td>7.3 %</td>
</tr>
<tr>
<td>Dust/ Particulates</td>
<td>9.8 %</td>
<td>5.5 %</td>
</tr>
<tr>
<td>Glass</td>
<td>0.4 %</td>
<td>8.1 %</td>
</tr>
<tr>
<td>Porcelain</td>
<td>1.7 %</td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>0.7 %</td>
<td>5.5 %</td>
</tr>
<tr>
<td>Paper</td>
<td>2.8 %</td>
<td></td>
</tr>
<tr>
<td>Straw, Biologicals/ Organics</td>
<td>13.1 %</td>
<td>33.7 %</td>
</tr>
<tr>
<td>Rags/ Textiles</td>
<td>0.4 %</td>
<td>2.5 %</td>
</tr>
<tr>
<td>Carbon</td>
<td>25.6 %</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>0.3 %</td>
<td></td>
</tr>
<tr>
<td>Coke</td>
<td>0.3 %</td>
<td></td>
</tr>
<tr>
<td>Plastics</td>
<td></td>
<td>7.2 %</td>
</tr>
<tr>
<td>Combustibles</td>
<td></td>
<td>5.9 %</td>
</tr>
</tbody>
</table>

Source: de Fodor 1911, M.E.L Research Limited 1999
Development of waste incineration in England (2/2)

• 1874/76 first reliable plants in Nottingham & Manchester:
  • Cell furnaces with inclined gap grate and arch (thermal radiation)
  • Front charging and de-slagging
  • Throughput: 8 – 10 Mg/d per furnace
  • 700 – 900°C operating temperature
  • Low dust and odour nuisance
  • Operational until 1903

• Afterwards rapid spread of technology (first in England):
  • Around 1900: over 210 waste incineration plants in England
  • 14 of them in London
First German incinerator in Hamburg Bullerdeich (1/3)

- 1893 start of construction
- 1894 – 1896 trial operation with two "Horsefall"-Twincell-furnaces
- 1st January 1896 operation started with 36 furnaces
First German incinerator in Hamburg Bullerdeich (2/3)

- 45,000 (1896) – 87,000 Mg (1914) annual throughput
- weighbridge, electrical cranes
- Top-charging and bottom de-slagging → only 1 worker for 3 furnaces
- Common forced draft for all cells, control via hatches
- Water-cooled stone slabs at the side walls, preheated combustion air
- 1.5 h combustion period
- Dust removal: low flow-speed in heating flue → massive dust emission
- Selling of the slag after cracking and sieving (roadmaking):
  Revenue: 2 Reichsmark (RM) per m³ !
- Metal deposition via magnet: Revenue 15 RM per Mg
- Utilization of ashes as filling for roof and wall gaps
- Power revenue: 6 R Pf/kWh
- Common rooms and lavatories for the staff
First German Incinerator in Hamburg Bullerdeich (3/3)
Alternative thermal treatment technologies (1/3)

• Gasification: already 100 years ago heated reactors for generation of coal gas in Vienna, Stuttgart, Paris and Versailles
  → low gas yield, fluctuating composition, high dust content and high amount of residues (63 % of the input)
  → not economic

• Gasification plant San Jose, batch operation 200 Mg, gas generation for engines
  → explosion after 4 month of operation

• Today pyrolysis plays no significant role in Germany and Europe

• In the East Asian region (Japan) the technology was established (economic factors: higher gate fee, 400 EUR/t)

• Glazed slag which can be used directly for paving stone production
Alternative thermal treatment technologies (2/3)

- Due to the German energy crises in the seventies and eighties alternative thermal treatment technologies had been developed

**Carbonisation**

- **Siemens Schwel-Brennverfahren**: first pyrolysis, afterwards separation of residues and inert material (glass, stones, porcelaine), metals and carbons for high temperature combustion
  → Pilot plant: technical problems, leakage of torque tube and no public acceptance
  → Further developments in Japan

- **Thermoselect Gasifier**: first degasification of waste (Syngas for power generation), afterwards combustion in high temperature reactor with the addition of oxygen (1,200 - 2,000°C)
  Product: inert mineral granules

- Karlsruhe, Germany: plant closed in 2004 because of economic failure, insufficient throughput and technical risks
Alternative thermal treatment technologies (3/3)

- Waste-Pulverisation, admixing to combustibles → not efficient due to high percentage of ashes
  Hydrothermal Carbonization (HTC): only for biogenic substrates
- Oiling: Production of oil (diesel, heating oil) from specific types of waste (polyolefin)
  → pre-treatment necessary, no large-scale plant operational
- Plasma-Gasification
  - Plasma-Pyrolysis: conversion of high calorific value waste into gas and destruction of hazardous waste
  - Plasma-Gasification: generation of high CO- or H₂- syngas from waste
  → high quality of waste, glazed slag

Reasons for alternative waste treatment technologies:

- Promising high-quality products, enhanced product attributes or better efficiency of processes

BUT:

- Complex systems engineering, high requirements for waste pre-treatment, not economical
- Hardly any alternative procedure has reached steady operation in a large-scale plant over 1 - 2 years

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More than a quarter of the total MSW is still landfilled in the EU 28

Huge difference between the countries regarding waste treatment

In developed markets such as Germany recycling rate is very high as well as the portion of residual waste treated in EfW plants
**EfW plants: Technical trends in Germany**

**Actions for improving energy efficiency:**

- Further expansion of district heating network
- Refurbish and upgrade process technology
- Utilization of residual heat
- Reduction of parasitic load
- Improving flue gas treatment
- Optimizing existing capacities
- Optimizing boiler temperatures
- Miscellaneous

![Bar chart showing technical trends in Germany](chart)

EEW Energy from Waste – the leading pure-play EfW company in Europe

- 18 plants in Germany and neighbouring countries
- 1,050 employees
- Approx. 4,700,000 tonnes of thermal waste treatment capacity
- Approx. 3,900,000 megawatt hours of process steam and district heating produced
- Approx. 2,400,000 megawatt hours of power produced
- Power for the equivalent of 700,000 households
- More than 1,000,000 tonnes CO₂ savings
EEW’s 18 EfW plants in Europe
District heating in Europe

- More than 6,000 district heating systems in Europe in 2010
- Providing 620 TWh/y for district heating and low-temperature steam for industry
- Furthermore 220 TWh/y from industrial CHP plants for internal consumption
- Combined 840 TWh/y
Still potential for EfW plants to contribute to district heating in Europe

- 482 EfW plants generated 88 TWh heat in Europe 2014\(^1\),
- this equates to ~10\% of the total heat delivered through district heating systems (840 TWh/y)\(^2\).

→ Studies predict a potential of 200 TWh heat per year by 2050\(^3\) produced in EfW plants

→ Still opportunities for further development

→ In countries with low heating demand, steam can be supplied for industrial production (e.g. chemical, paper industry) and for cooling networks

Source: 1 CEWEP, 2 “Heat Roadmap 2”, Aalborg University Denmark, 2013, 3 “Warmth from Waste”, CEWEP 2014
EfW: Very low emissions due to enhanced FGT (1/3)

Bicarbonate  Baghouse filter 1  SCR  Ext. Eco  Lime hydrat/HOK  Baghouse filter 2

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**EfW: Very low emissions due to enhanced FGT (2/3)**

![Graphs showing emissions of SO₂, NOₓ, dust, and Hg](image)

- **SO₂ in mg/Nm³**
  - Legislative threshold: 50
  - Average¹: 6.9
  - EEW plant²: 0.37

- **NOₓ in mg/Nm³**
  - Legislative threshold: 200
  - Average¹: 97
  - EEW plant²: 48

- **Dust in mg/Nm³**
  - Legislative threshold: 10
  - Average¹: 0.49
  - EEW plant²: 0.06

- **Hg in mg/Nm³**
  - Legislative threshold: 0.03
  - Average¹: 0.0013
  - EEW plant²: 0.00012

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1) Average (not weighted) values of 188 EfW lines in Germany in 2014/2015; based on an evaluation determined by German EfW association ITAD

2) EfW plant Stapelfeld commissioned in 1979
Excellent operational track record as demonstrated by improving operational metrics

**EEW plant portfolio**

### Availability and OEE

#### Time availability (%) (1)

<table>
<thead>
<tr>
<th>Year</th>
<th>Availability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>88.6</td>
</tr>
<tr>
<td>2014</td>
<td>89.6</td>
</tr>
<tr>
<td>2015</td>
<td>90.1</td>
</tr>
<tr>
<td>2016</td>
<td>90.9</td>
</tr>
</tbody>
</table>

#### Work availability (%) (2)

<table>
<thead>
<tr>
<th>Year</th>
<th>Availability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>90.3</td>
</tr>
<tr>
<td>2014</td>
<td>93.1</td>
</tr>
<tr>
<td>2015</td>
<td>94.2</td>
</tr>
<tr>
<td>2016</td>
<td>95.7</td>
</tr>
</tbody>
</table>

#### OEE (Overall Equipment Efficiency)

<table>
<thead>
<tr>
<th>Year</th>
<th>OEE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>90.3</td>
</tr>
<tr>
<td>2014</td>
<td>93.1</td>
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<td>2015</td>
<td>94.2</td>
</tr>
<tr>
<td>2016</td>
<td>95.7</td>
</tr>
</tbody>
</table>

**Note:**

(1) Actual operating hours of plant divided by maximum possible operating hours (based on arithmetic group averages)
(2) Actual production of live steam during operating hours divided by maximum possible production of live steam (based on arithmetic group averages)
(3) 16 grate fired and 2 fluidised bed plants

Reduction of unplanned outages from 4.4% to 1.7%

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State of the art example: EEW’s energy from waste plant in Delfzijl (1/2)

a) Plant location
State of the art example: EEW’s energy from waste plant in Delfzijl (2/2)

**Plant highlights**
- Throughput around 380,000 t/a
- Operating since 6 years
- Strategically favourable location in a harbor enabling increasing amount of import volumes from the UK and Ireland
- Very high availability and energy efficiency levels
- Very low emission values
- 3rd line in construction

**Ownership and key trading relationships**

**Key technical data**

<p>| | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>2010</td>
</tr>
<tr>
<td>Original investment</td>
<td>€ 160m</td>
</tr>
<tr>
<td>Furnace type</td>
<td>Reciprocating-forward-moving grate</td>
</tr>
<tr>
<td>Lines</td>
<td>2</td>
</tr>
<tr>
<td>Thermal capacity (MW)</td>
<td>2 x 22</td>
</tr>
<tr>
<td>Power capacity (MW)</td>
<td>31</td>
</tr>
<tr>
<td>Steam capacity (t/h)</td>
<td>140</td>
</tr>
<tr>
<td>Design NCV (MJ/kg)</td>
<td>10</td>
</tr>
<tr>
<td>Range NCV (MJ/kg)</td>
<td>8 - 16</td>
</tr>
<tr>
<td>R1 factor (2015)</td>
<td>1.16</td>
</tr>
</tbody>
</table>

**Plant**

**Take the lead: Waste incineration vs. Energy from Waste - then and now**
Business case to expand EfW plant in Delfzijl

Increasing energy (mainly steam) demand by customers requires increase of steam production by expanding the plant with a third line (186ktpa)

Excellent conditions due to location in Chemical Park
- High demand on electrical and thermal energy
- Very good existing infrastructure (grid, gas, water, heating network)
- Strategically favourable location in a harbor connected to network of waterways
- Direct link to highway

Low capex due to existing infrastructure
- Property
- Bunker
- Condenser
- Switchgear building
- Steam network (for 23 bar)
→ Total capex: c. € 70m
Plant layout with extension

New FGT
New boiler
Expansion turbine building
Technical data for 3rd line

- Waste throughput: 25 t/h
- Steam output: 78.5 t/h
- HD steam-temp.: 400°C
- Flue gas-temp.: < 660°C
- Exhaust fumes-temp.
  - Boiler outlet: 240°C
- Exhaust fumes-temp.
  - Chimney: 140°C
- Availability: > 92%
- CO behind boiler: <25mg/Nm³
Expansion allows even to reduce specific emissions

→ EEW commits to lower emission thresholds despite expansion

Permitted thresholds for three lines plant

- Dust
- Hydrochloric acid
- Sulphur dioxide

Permitted thresholds for two lines plant
EEW guarantees full transparency

### Daily emission values on website

EEW Energy from Waste Hannover.

### Daily emission values displayed at site entrance

- Daily emission values are submitted online to the local control authorities
- Yearly emission values are published in the local newspapers
Many Thanks.

References:
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