Global Use and Future Prospects of Waste-to-Energy Technologies

Overview

1. Global Waste-to-Energy Situation
2. Waste-to-Energy Market Tendencies in Europe
3. Waste-to-Energy Projects in Europe
5. MARTIN® Incineration Systems
6. Examples for Energy Optimised WtE Facilities
   - Brescia, Italy
   - Amsterdam, Netherlands
   - Mainz, Germany
   - Bilbao, Spain
   - Schwandorf, Germany
7. Latest Incineration System Improvements
   - Oxygen enriched combustion (SYNCOM / SYNCOM-Plus)
   - Infrared camera guided combustion control
8. Contacts
1. Global Waste-to-Energy Situation

- Market volume is growing in Europe and Asia
- Only minor activities in USA
- South- and Middle-American countries show increasing interest in WtE / Financing unclear
- No WtE activities in Africa and Australia
- Leading technologies are grate-based systems
- Local opposition against new facilities still existing
- NIMBY- and NIMTO-Effects

2. WtE Market Tendencies in Europe

- Market volume is growing in most European countries
- Strong markets are France, Germany and Italy
- European directives for waste treatment support WtE:
  - Disposal site directive 1999/31/EEC (landfilling)
    - Disposal of biologically decomposable waste must be reduced to 35% of the quantity of 1995 within 15 years
    - precondition of disposal is pretreatment of waste
    - result of disposal site directive is renunciation of direct landfilling and demand for pretreatment (incineration, sorting, ...)
  - EU directive 2000/76/EC on the incineration of waste
    - Strict emission guidelines caused considerable reduction of emissions from WtE
    - Use of heat generated became mandatory
  - EU directive 2003/33/EC on the disposal of waste
    - Clear guidelines for the disposal of waste and residues from WtE plants
- Landfill taxes in several countries (e.g. UK = 15 £/t → 35 £/t in 2011)
WtE Market Tendencies in Europe

- New members in EU have to follow European directives and will install WtE/waste treatment facilities (CZ, PL, SK, SLO, ..)
- Market is clearly dominated by grate-based systems
- Gasification- and Pyrolysis-Systems failed
- Fluidised bed systems are used only in few cases for special wastes or waste-fractions
- Price, tipping fee and reliability are key factors for clients
- Lobbying activities from vendors for mechanical/biological treatment systems against incineration plants are strong

Between 1995 and 1998 the European market for thermal waste treatment decreased by 46 %

- FGC retrofit in Germany
- New price level
- New government in Germany
- New regulation (TASI) → lower landfill fees
- Restructuring of companies
- New environmental regulations in France
- New ministry of environment in France
- New landfill regulations
New Incineration Capacity awarded 2000 - 2003 in Europe

Capacity of plants awarded in 2000 - 2003 in tpd (data published by ISWA)

Waste Incineration Capacities
Europe 2003

Total waste amount Mio. tpy
Incinerated amount Mio. tpy
Long term perspective in Europe very positive

Market share of thermal treatment will increase due to:

- Legislative regulations
- Lack of alternatives
- Increasing acceptance

Total yearly market volume will be > 3 billion Euro:

- New capacities to be installed
- Increasing demand for replacement of existing facilities
Main Competitors tendering
WTE - Plants in Europe 1995

- ABB / W+E
- Deutsche Babcock
- EVT
- Martin - "Family"
- ML / Lurgi
- Noell
- Siemens
- Steinmüller
- Thermoselect
- Vølund / Ansaldo
- Von Roll

11 competitors with strong presence in the market
11 competitors with occasional presence in the market

Main Competitors tendering
WTE - Plants in Europe 2004

- AE&E / Von Roll
- Alstom (only Germany/Austria)
- FISIA Babcock
- Lurgi Energie & Entsorgung
- Martin - "Family"
- Foster Wheeler
- Keppel / Seghers
- Lurgi Lentjes Service / LLS
- Stiefel (mainly Switzerland)
- Tiru (France only)
- Vincy (France only)
- Vølund (mainly Scandinavia)

5 competitors with strong presence in the market
7 competitors with occasional presence in the market
Price Development 1995 – 200X
Central Europe (A, CH, D, NL, S)

Definition:
\[ \text{total plant invest} / \text{total plant incineration capacity per year} \]

Market Share by Suppliers in Europe 1995-2001

Total Market Volume
Plants started-up
1995 - 2001
= 73,335 tpd
Market Share by Suppliers in Europe 2000-2003

Total Market Volume Plants awarded 2000 - 2003 = 43,265 tpd

Market Share by Suppliers in Europe 2003

Total Market Volume Plants awarded 2003 = 12,510 tpd
3. Waste-to-Energy Projects in Europe

WtE Plant Marchwood/Great Britain

WtE Plant Chartres/France

Waste-to-Energy Projects in Europe: Germany

- Berlin (230,000 tpy; BOO; order to ALBA/MPS-System)
- Bremen (2 x 12 t/h; order to LLS)
- Buschhaus (1 x 25 t/h; awarded to ALSTOM)
- Frankfurt (4 x 20 t/h; awarded to Lurgi)
- Halle-Lochau (1 x 13.5 t/h; bidding procedure)
- Leuna (1 x 25 t/h; order to ALSTOM)
- Magdeburg (2 x 20 t/h; order to ALSTOM)
- Mainz (1 x 16.2 t/h; awarded to MARTIN)
- Neumünster (1 x 18 t/h; order to AE&E)
- Oberhausen (1 x 21 t/h; order to FISIA-Babcock)
- Solingen (1 x 8.5 t/h; order to ALSTOM)
- Stuttgart (2 x 20 t/h; order to ALSTOM)
- Zella-Mehlis (1 x 21.6 t/h; order to MARTIN)
- Several projects in earlier stages of development
Waste-to-Energy Projects in Europe: Austria and Switzerland

- **Austria:**
  - Arnoldstein (1 x 10.7 t/h; order to MARTIN)
  - Tirol (183,000 tpy; rfp expected 2005)
  - Vienna (230,000 tpy; rfp expected fall 2004)
  - Wels (1 x 24 t/h; order to MARTIN)

- **Switzerland:**
  - Lausanne (2 x 10 t/h; order to Von Roll)
  - Sion (1 x 8 t/h; order to Stiefel)
  - Tessin (2 x 13.4 t/h; order to MARTIN)
  - Trimmis (1 x 9.5 t/h; order to Stiefel)
  - Zurich (2 x 19.2 t/h; order to Martin)

Waste-to-Energy Projects in Europe: Belgium, Luxemburg and Netherlands

- **Belgium:**
  - Liège (2 x 21.3 t/h; bidding procedure)
  - Thumaide (1 x ? t/h; bidding procedure)

- **Luxemburg:**
  - Luxemburg (? t/h; rfp expected 2005)

- **Netherlands:**
  - Alkmaar (1 x 27.5 t/h; order to Von Roll)
  - Amsterdam (2 x 33.6 t/h; order to MARTIN)
  - Moerdijk (1 x 34.5 t/h; rfp expected 2005)
  - Twente (1 x 27.5 rfp expected 2005)
  - Wijster (2 x 27 t/h; bidding procedure)
Waste-to-Energy Projects in Europe:

**Scandinavia**

- **Finnland:**
  - Hämenlinna (1 x 16.25 t/h; rfp expected fall 2004)
  - Turku (1 x 16.3 t/h; bidding procedure)
  - Projects in earlier stages of develop. in Jakobstad and Helsinki

- **Norway:**
  - Oslo (1 x 10 t/h; rfp expected 2005)
  - Trondheim (1 x 15 t/h; order to Von Roll)

- **Sweden:**
  - Göteborg (1 x 11 t/h; rfp expected 2005)
  - Jönköping (1 x 22 t/h; order to Fisia Babcock)
  - Linköping (1 x 20 t/h; order to Vølund)
  - Malmö (1 x 25 t/h; rfp expected 2005)
  - Stockholm-Högdalen (1 x 34 t/h; order to Vølund)
  - Sundsvall (1 x 20 t/h; order to Vølund)
  - Timsfors (? t/h; rfp expected 2004)
  - Uppsala (1 x 26.4 t/h; order to Von Roll)

**France**

- Argenteuil (1 x 16.5 t/h; order to Von Roll)
- Avignon (1 x 8 t/h; bidding procedure)
- Bourgoin Jallieu (2 x 11 t/h; order to CNIM/MARTIN)
- Chalon-en-Champagne (1 x 15 t/h; order to CNIM/MARTIN)
- Clermont-Ferrand (1 x 22.3 t/h + 1 x 9 t/h; bidding procedure)
- Créteil (1 x 15 t/h; bidding procedure)
- Dunkerque (1 x 8.5 t/h; awarded to Vincy)
- Marseille (2 x 22 t/h; bidding procedure)
- Nîmes (1 x 7.5 t/h; bidding procedure)
- Ocréal-Lunel (1 x 14 t/h; bidding procedure)
- Poitier (1 x 12 t/h; awarded to Von Roll)
- Saint-Omer (2 x 8.5 t/h; bidding procedure)
- Vesoul (2 x 5.5 t/h; bidding procedure)
- Several projects in earlier stages of development (Tours, Lunel, Macon, Paris, Périgueux, …)
Waste-to-Energy Projects in Europe: Greece, Portugal and Spain

- **Greece / Crete:**
  - Several projects in earlier stages of development (Athens, Heraklion, ...)

- **Portugal:**
  - Acores (2 x 8.5 t/h; rfp expected 2004)
  - Coimbra (2 x 24.7 t/h; rfp expected 2004)

- **Spain:**
  - Mallorca (2 x 23 t/h; bidding procedure)
  - San Bartolomé de Meruelo (1 x 12 t/h; order to Lurgi)
  - San Pere de Torello (1 x 12.8 t/h; feasibility study)
  - San Sebastian (3 x 15 t/h; rfp expected 2004)

Waste-to-Energy Projects in Europe: Great Britain and Ireland

- **Great Britain:**
  - Cornwall (150,000 tpy; rfp expected 2005)
  - East-Sussex (220,000 tpy; rfp expected 2005)
  - Guernsey (1 x 10 t/h; awarded to Lurgi / rebidding likely)
  - Jersey (150,000 tpy; rfp expected 2005)
  - Lakeside-Grundon (1 x 27 t/h; bidding procedure)
  - London-Bexley (670,000 tpy; bidding procedure)
  - Newhaven (2 x 15 t/h; bidding procedure)
  - Sheffield (1 x 28 t/h; order to MES/MARTIN)

- **Ireland:**
  - Dublin (2 x 25.7 t/h; bidding procedure, ppp intended)
**Waste-to-Energy Projects in Europe:**

**Italy**
- Acerra/Naples (3 x 27 t/h; order to FISIA/Babcock)
- Augusta (2 x 32.3 t/h; bidding procedure)
- Brindisi (1 x 15.2 t/h; budgetary proposal)
- Casteltermini (2 x 21.6 t/h; bidding procedure)
- Foggia (2 x 15.2 t/h; budgetary proposal)
- Messina (3 x 18 t/h; awarded to Technip/MARTIN)
- Palermo (3 x 20 t/h; order to Actelios/Von Roll)
- Ravenna (1 x 15 t/h; budgetary proposal)
- Reggio Emilia (2 x 4.2 t/h; budgetary proposal)
- Rimini (1 x 18.5 t/h; budgetary proposal)
- Santa Maria la Fossa (2 x 27 t/h; order to FISIA/Babcock)
- Sondrio (1 x 11.4 t/h; budgetary proposal)
- Projects in earlier stages of development: Alessandria, Catania, Chilivani, Ferrara, Firenze, Forli, Genova, Greve in Chianti, Modena, Roma, Torino, Trento)

**East European Countries**
- **Albania:**
  - Calabria (feasibility study)
- **Croatia:**
  - Zagreb (feasibility study)
- **Czech Republic:**
  - Brno (2 x 14 t/h; bidding procedure)
  - Ostrava (2 x 7.5 t/h; rfp expected 2005)
- **Poland:**
  - Several projects in early stages of development
- **Russia:**
  - Moscow (2 X 24 t/h; awarded to LLS)
- **Slovenia:**
  - Llubljana (feasibility study)
4. WtE Market Tendencies in Asia

- Good market volumes in China, Japan, Korea and Taiwan
- Largest market still Japan
- Biggest growth rate in China
- Singapore and Taiwan close to saturation
- Beginning of promising planning-activities in HongKong, Malaysia and Thailand
- Other South-East Asian countries still „waiting“ (e.g. Indonesia, Philippines, …)
- No incineration projects in South-Asia (India, Pakistan, …)

In the past very stable and „government-controlled“ market volume (yearly contracted capacity ≈ 6,000 tpd)
- ≈ 80 % grate based plants, ≈ 20 % fluidized bed plants
- In the late 90's fluidized bed technology dropped dramatically due to high dioxin emissions
- New emission guidelines have been discussed and put in force (total dioxin output < 5 µg/ton of waste, strict limitations on leachable substances from solid residues)
- Incineration residues must be vitrified to meet regulations
- Development of gasification- and pyrolosis-technologies (market share ≈ 50 %)
- Very unstable market volumes
- New technologies (gasification, pyrolosis) show significant deficiencies in operational behavior
- Tendency: Gasification/Pyrolosis for small plants Grate technology for large plants
Waste-to-Energy Research and Technology Council
Fall Meeting Columbia University, Oct.7-8, 2004

WtE Plants ordered in Japan 1997-2003

Trend of Types of WtE Plants in Japan 2004 - 2007

Estimation by Japanese Industry May 2004
## Market Overview 2004

### Gasification Plants in Japan

<table>
<thead>
<tr>
<th>Situation</th>
<th>Fluidized bed</th>
<th>Shaft-Furnace</th>
<th>Rotary-Kiln</th>
<th>Other</th>
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### Gasification Plants in Japan (1) in Operation

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<tr>
<th>Plant Type No</th>
<th>Manufacturer</th>
<th>Prefecture</th>
<th>Plant Name</th>
<th>Capacity [ton/day]</th>
<th>Completion Date</th>
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### Gasification Plants in Japan (2)

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**Market Overview 2004**

### Gasification Plants in Japan (3)

<table>
<thead>
<tr>
<th>Type</th>
<th>No</th>
<th>Plant Manufacturer</th>
<th>Prefecture</th>
<th>Plant Name</th>
<th>Capacity [ton/day]</th>
<th>Completion Date</th>
</tr>
</thead>
</table>

- **Kiln**
- **Other**

**Waste-to-Energy Research and Technology Council**

**Fall Meeting Columbia University, Oct. 7 - 8, 2004**
Market Situation in China

- Economic growth toward Olympic Games in 2008
- In the near future largest market in Asia
- 20 WtE plants in operation
- More than 40 WtE plants under construction/planning
- Most projects are BOO/BOT projects
- Standard procedure: key components from overseas and other equipment from domestic resources
- Most plants are based on stoker systems
- Good market share for fluidized bed systems
- Heating values in rural areas difficult (< 5,000 kJ/kg)

WtE Plants in China (1)

<table>
<thead>
<tr>
<th>City/Province</th>
<th>Plant Name</th>
<th>Manufacturer</th>
<th>Capacity (ton/day)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>Changpin</td>
<td>Beijinnanuo</td>
<td>150</td>
<td>Chain</td>
</tr>
<tr>
<td></td>
<td>Gaoandun</td>
<td>Takuma</td>
<td>1200</td>
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<tr>
<td></td>
<td>Asuwei</td>
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<td>Pudong</td>
<td>Martin</td>
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<td>Stoker</td>
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<td>Jiangqiao</td>
<td>Steinmuller</td>
<td>1000</td>
<td>Stoker</td>
</tr>
<tr>
<td>Guangdong</td>
<td>Shenzhen</td>
<td>MHI/Martin</td>
<td>450</td>
<td>Stoker</td>
</tr>
<tr>
<td></td>
<td>Longgang</td>
<td>Richway</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yantian</td>
<td>Seghers</td>
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<td>Nanshan</td>
<td>Seghers</td>
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<td>Pinghu</td>
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<td>Laihuikeng</td>
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<td>Guangzhou Liang</td>
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<tr>
<td>Liyang</td>
<td>Shanghaiduoling</td>
<td>80</td>
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<tr>
<td>Suzhou</td>
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<td>Stoker</td>
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</table>
## WtE Plants in China (2)

<table>
<thead>
<tr>
<th>City/Province</th>
<th>Plant Name</th>
<th>Manufacturer</th>
<th>Capacity [ton/day]</th>
<th>Type</th>
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<td>Zhejiang</td>
<td>Wenzhou</td>
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<td>Wenzhou</td>
<td>Domestic</td>
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<tr>
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<td>Ningbo</td>
<td>Nossi-Knoeck</td>
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<td>Shaoxing</td>
<td>Wuzi Boiler</td>
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<td>Hangzhou</td>
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<td>Bingjiang</td>
<td>MHI/Martin</td>
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<td>Stoker</td>
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<td>Jiaying</td>
<td>Jingjiang Group</td>
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<td>Zhongkeyuan</td>
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<td>Fuzhou</td>
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<td>1000</td>
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<td>Shishi</td>
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<td>Putian</td>
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<td>Chenyangdongbei</td>
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<tr>
<td>Shandong</td>
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<td>Jingzhoujilin</td>
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<tr>
<td></td>
<td>Jinan</td>
<td></td>
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<tr>
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<td>Jinan</td>
<td>Shenzhenhnx</td>
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<td>Sichuan</td>
<td>Pengzhou</td>
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<td>Chengdu</td>
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<td>Takuma</td>
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<td>Fluidized Bed</td>
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</table>

Total: 41,535

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## WtE Plants in China (3)

<table>
<thead>
<tr>
<th>City/Province</th>
<th>Plant Name</th>
<th>Manufacturer</th>
<th>Capacity [ton/day]</th>
<th>Type</th>
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<tbody>
<tr>
<td>Heilongjiang</td>
<td>Haerbin</td>
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<td>Fluidized Bed</td>
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<tr>
<td></td>
<td>Heerbin</td>
<td>Ebara</td>
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<td>Fluidized Bed</td>
</tr>
<tr>
<td></td>
<td>Changchun</td>
<td>Richway</td>
<td>450</td>
<td>Fluidized Bed</td>
</tr>
<tr>
<td>Jilin</td>
<td>Taiyuan</td>
<td>Ebara</td>
<td>1000</td>
<td>Fluidized Bed</td>
</tr>
<tr>
<td></td>
<td>Yulin</td>
<td>Changshousanli</td>
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<td>Shandong</td>
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<td>450</td>
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<tr>
<td></td>
<td>Guilin</td>
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<td>600</td>
<td>Fluidized Bed</td>
</tr>
<tr>
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<td>Wuhu</td>
<td>Jinzhou Group</td>
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<td>Fluidized Bed</td>
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<tr>
<td>Hainan</td>
<td>Hainan</td>
<td>Shanghaiduoling</td>
<td>110</td>
<td>Fluidized Bed</td>
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<tr>
<td>Total</td>
<td></td>
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<td></td>
<td>41,535</td>
</tr>
</tbody>
</table>
Market Situation in Taiwan

- Nationwide waste management system initiated by Central Government
- MSW-production: 24,000 t/d in 2003
- Target: 100% Waste-to-Energy
- Waste-to-Energy plants:
  - In operation: 19 plants (20,400 t/d in total)
    - 1st plant in operation since 1992
  - Under construction: 7 plants (4,100 t/d in total)
  - Planned: 3 plants (850 t/d in total)
- Remaining market volume very small

Market Situation in Singapore

- Clean and green city policy
- MSW-Production: 7,200 t/d in 2003
- 100% Waste-to-Energy policy
- 5th WtE plant to be completed by 2008
Market Situation in Hong Kong

- EPD policy in early 1990’s:
  - New privatized landfill sites for 50 years

- New EPD policy in 1997:
  - Waste Reduction Program

- Landfill sites estimated life time:
  - 50 years → 20 years or less
  - No new sites available

- Program for new WtE plants initiated recently:
  - 1st WtE plant (3,000 t/d) to be in operation before 2010

MARTIN® - plants in 26 countries world-wide

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of plants (incl. extensions)</th>
<th>Number of units</th>
<th>Combustion capacity Mg / day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>332</td>
<td>648</td>
<td>185.798</td>
</tr>
<tr>
<td>Europe</td>
<td>189</td>
<td>318</td>
<td>95.693</td>
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<tr>
<td>North America</td>
<td>31</td>
<td>72</td>
<td>30.136</td>
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<td>Asia</td>
<td>110</td>
<td>254</td>
<td>59.368</td>
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<tr>
<td>South America</td>
<td>2</td>
<td>4</td>
<td>600</td>
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</table>

Status: 16.9.2003
MARTIN® - Cooperation-Partners worldwide

MES
Martin Engineering Systems, Ltd.
London
GREAT BRITAIN

COVANTA
Covanta Energy Group, Inc.
Fairfield, New Jersey
USA

MHI
Mitsubishi Heavy Industries, Ltd.
Tokyo and Yokohama
JAPAN

CNIM
Constructions Industrielles de la Méditerranée
Paris and La Seyne-sur-Mer
FRANCE

COOPERATION-
PARTNERS

TECHNIP
TECHNIP ITALY S.p.A.
Rome
ITALY

MARTIN® - License - Agreements

Chongqing
Chongqing Luneng Environment Co.

Samsung
Samsung Engineering & Construction Co. Ltd.

Shi
Sumitomo Heavy Industries, Ltd.

LICENSE-
PARTNERS

CHINA

Sungnam-Si
Republic of KOREA

Tokyo
JAPAN
Global market share of WtE plants using the MARTIN – Systems

≈ 33 %

5. MARTIN® Incineration Systems

Reverse Acting Grate
6. Examples For Energy – Optimised Plants

- Energy-optimised plants:
  - Brescia, Italy
  - Amsterdam, Netherlands
  - Mainz, Germany
  - Bilbao, Spain
  - Schwandorf, Germany
Optimised Conventional Type Facility - The Brescia Concept -

- Combustion with low excess air ($O_2 \approx 5-6\%$ by volume)
- Additional energy recovery from the cooling of the fluegas down to $130^\circ C$ (266 F)
- Dry FGC system without water injection
- High efficiency of plant components (e.g. variable frequency motor drives, no oversizing of drives, ...)
- High parameters for steam pressure and temperature:
  - Unit 1 + 2: 60 bar / 450°C
  - Unit 3: 73 bar / 480°C
- Inconel in upper furnace and second pass as well as on final superheater (unit 1 + 2)
### WtE Facility ASM Brescia

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal capacity</td>
<td>2 x 23 t/h</td>
<td>1 x 36 t/h</td>
</tr>
<tr>
<td>Nominal LHV</td>
<td>13,800 kJ/kg</td>
<td>10,000 kJ/kg</td>
</tr>
<tr>
<td>Heat input</td>
<td>88.3 MW(_{\text{thermal}})</td>
<td>100 MW(_{\text{thermal}})</td>
</tr>
<tr>
<td>Electrical output</td>
<td>334 GWh(_{\text{e}}) (2002)</td>
<td>--</td>
</tr>
<tr>
<td>Thermal output</td>
<td>261 GWh(_{\text{e}}) (2002)</td>
<td>--</td>
</tr>
<tr>
<td>Steam</td>
<td>61 bar, 450°C</td>
<td>73 bar, 480°C</td>
</tr>
<tr>
<td>District heating</td>
<td>16 bar, 130°C</td>
<td>16 bar, 130°C</td>
</tr>
<tr>
<td>Fuel</td>
<td>MSW, sewage sludge, biomass</td>
<td>Biomass, sewage sludge</td>
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### Energy Efficiency

<table>
<thead>
<tr>
<th>Plant</th>
<th>Brescia #1+2</th>
<th>Brescia # 3</th>
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<tbody>
<tr>
<td>Special feature</td>
<td>Conventional facility-Optimised for high efficiencies</td>
<td>Conventional facility-Optimised for high efficiencies</td>
</tr>
<tr>
<td>Fuel</td>
<td>MSW, sewage sludge, biomass</td>
<td>Biomass, sewage sludge</td>
</tr>
<tr>
<td>Steam pressure [bar]</td>
<td>61</td>
<td>73</td>
</tr>
<tr>
<td>Superheated Steam temperature [°C]</td>
<td>450</td>
<td>480</td>
</tr>
<tr>
<td>Gas temperature before flue gas cleaning [°C]</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Efficiency of electricity production [%]</td>
<td>27</td>
<td>29</td>
</tr>
</tbody>
</table>
Intermediate Superheating
- The Amsterdam Concept -

- Combustion with low excess air ($O_2 \approx 6\%$ by volume)
- Energy recovery by additional economiser after ESP
- High efficiency of plant components (e.g. variable frequency motor drives, no oversizing of drives, ...)
- High parameters for steam pressure and temperature:
  - $130\text{ bar / }440\degree\text{C}$
- Intermediate superheating system (power plant standard)
- Inconel in upper furnace and second pass
### Energy Efficiency

<table>
<thead>
<tr>
<th>Plant</th>
<th>Brescia # 1+2</th>
<th>Brescia # 3</th>
<th>Amsterdam # 4 + 5</th>
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<tbody>
<tr>
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<td>Conventional facility</td>
<td>Conventional facility</td>
<td>Conventional facility</td>
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<td></td>
<td>Optimised for high efficiencies</td>
<td>Optimised for high efficiencies</td>
<td>Intermediate steam superheating</td>
</tr>
<tr>
<td>Fuel</td>
<td>MSW, sewage sludge, biomass</td>
<td>Biomass, sewage sludge</td>
<td>MSW</td>
</tr>
<tr>
<td>Steam pressure [bar]</td>
<td>61</td>
<td>73</td>
<td>130</td>
</tr>
<tr>
<td>Superheated Steam temperature [°C]</td>
<td>450</td>
<td>480</td>
<td>440</td>
</tr>
<tr>
<td>Gas temperature before flue gas cleaning [°C]</td>
<td>130</td>
<td>130</td>
<td>200</td>
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<tr>
<td>Efficiency of electricity production [%]</td>
<td>27</td>
<td>29</td>
<td>30</td>
</tr>
</tbody>
</table>
Combination of WtE / Gas Turbine
- The Mainz Concept -

Condensate from combined cycle turbine

40 bar / 400 °C superheated steam to combined cycle turbine

Low pressure steam for in-plant consumption

Turbine for in-plant consumption

Feedwater

Electricity for in-plant consumption

Energy Efficiency

<table>
<thead>
<tr>
<th>Plant</th>
<th>Brescia # 1+2</th>
<th>Brescia # 3</th>
<th>Amsterdam # 4 + 5</th>
<th>Mainz</th>
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<tbody>
<tr>
<td>Special feature</td>
<td>Conventional facility Optimised for high efficiencies</td>
<td>Conventional facility Optimised for high efficiencies</td>
<td>Conventional facility Intermediate steam superheating</td>
<td>Integration with combined cycle natural gas turbine</td>
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<tr>
<td>Fuel</td>
<td>MSW, sewage sludge, biomass</td>
<td>Biomass, sewage sludge</td>
<td>MSW</td>
<td>MSW, Natural Gas</td>
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<tr>
<td>Steam pressure [bar]</td>
<td>61</td>
<td>73</td>
<td>130</td>
<td>40</td>
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<tr>
<td>Superheated Steam temperature [°C]</td>
<td>450</td>
<td>480</td>
<td>440</td>
<td>400 / 555</td>
</tr>
<tr>
<td>Gas temperature before flue gas cleaning [°C]</td>
<td>130</td>
<td>130</td>
<td>200</td>
<td>200</td>
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<tr>
<td>Efficiency of electricity production [%]</td>
<td>27</td>
<td>29</td>
<td>30</td>
<td>≥ 40</td>
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</table>
WtE Facility Bilbao, Spain

Combined WtE / Natural Gas Turbine - CNIM Bilbao Concept -

Recette électrique (kWe vendu - kWh gas acheté) : 72%
Recette sur ordures : 28%

MODE A
"NOMINAL MODE"
- Net Power : 93.2 MWth
- Gross Heat Rate : 12935 MWth (42%)
- Real Decrease : 1377 MWth (45%)
- Net Heat Rate : 1157 MWth
- Availability : 7236 h/y
- Net Cutout Ratio : 42% (with Waste)
### Energy Efficiency

<table>
<thead>
<tr>
<th>Plant</th>
<th>Brescia #1+2</th>
<th>Brescia #3</th>
<th>Amsterdam #4 + 5</th>
<th>Mainz</th>
<th>Bilbao</th>
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<tbody>
<tr>
<td>Special feature</td>
<td>Conventional facility Optimised for high efficiencies</td>
<td>Conventional facility Optimised for high efficiencies</td>
<td>Conventional facility Intermediate steam superheating</td>
<td>Integration with combined cycle natural gas turbine</td>
<td>Integration with combined cycle natural gas turbine</td>
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<td>Fuel</td>
<td>MSW, sewage sludge, biomass</td>
<td>biomass, sewage sludge</td>
<td>MSW</td>
<td>MSW, natural gas</td>
<td>MSW, natural gas</td>
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<tr>
<td>Steam pressure [bar]</td>
<td>61</td>
<td>73</td>
<td>130</td>
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<td>100</td>
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<tr>
<td>Superheated Steam temperature [°C]</td>
<td>450</td>
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<td>440</td>
<td>400 / 555</td>
<td>540</td>
</tr>
<tr>
<td>Gas temperature before flue gas cleaning [°C]</td>
<td>130</td>
<td>130</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Efficiency of electricity production [%]</td>
<td>27</td>
<td>29</td>
<td>30</td>
<td>≥ 40</td>
<td>42</td>
</tr>
</tbody>
</table>

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**WtE Facility Schwandorf, Germany**

![Image of WtE Facility Schwandorf, Germany](image-url)
7. Latest Incineration System Improvements

- Oxygen enriched combustion
  - SYNCOM
  - SYNCOM-Plus

- Infrared camera guided combustion control
Conventional Combustion Process

DIOXIN DESTRUCTION
ENERGY GENERATION
FLUE GAS CLEANING

Fuel bed temperature 950°C

Electricity production > 500 kWh/t of waste

Flue gas

Total dioxin output < 50 µg / t of waste

loss on ignition < 3%
Pb leaching < 0.2 mg/l

SYNCOM® Combustion Process

DIOXIN DESTRUCTION
ENERGY GENERATION
FLUE GAS CLEANING

Fuel bed temperature 1150 °C

Electricity production > 500 kWh/t of waste

Flue gas reduced by 35 %

Flue gas

Total dioxin output < 20 µg / t of waste

loss on ignition < 1%
Pb leaching < 0.05 mg/l
**SYNCOM® - Plus Combustion Process**

- **Dioxin Destruction**
  - IR camera
  - WASTE

- **Energy Generation**
  - Flue gas recirculation
  - Coke or AC
  - Boiler
  - Electricity production > 500 kWh/t of waste

- **Flue Gas Cleaning**
  - Lime
  - Flue gas reduced by 35%

- **Ash Sintering**
  - Fuel bed temperature 1150 °C
  - Loss on ignition < 1%
  - Pb leaching < 0.05 mg/l

- **Dioxin Destruction**
  - Total dioxin output < 20 µg/t of waste

- **Energy Generation**
  - Electricity production > 500 kWh/t of waste

- **Flue Gas Cleaning**
  - Flue gas reduced by 35%

- **Reduction in the amount of flue gas and fly ash**

<table>
<thead>
<tr>
<th>Flue gas flow (dry)</th>
<th>Fly ash input of waste</th>
<th>Dioxin input through waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Nm³/kg waste</td>
<td>3 Nm³/kg waste</td>
<td>70 µg 1-TEQ/t waste</td>
</tr>
<tr>
<td>20 µg 1-TEQ/t waste</td>
<td>3 Nm³/kg waste</td>
<td>30 µg 1-TEQ/t waste</td>
</tr>
<tr>
<td>70 µg 1-TEQ/t waste</td>
<td>30 µg 1-TEQ/t waste</td>
<td>10 µg 1-TEQ/t waste</td>
</tr>
</tbody>
</table>

**MARTIN GmbH**

Waste-to-Energy Research and Technology Council
Fall Meeting Columbia University, Oct. 7-8, 2004
Quality Bottom Ash
SYNCOM®- Plus Granulate

Loss on ignition in %
Lead leaching in mg/l x 10^1
Dioxin content in ng/kg

Conventional WTE
Syncom
SyncomPlus
Loss on ignition 2 % 1 % 0.1 %
Lead leaching 0.2 mg/l 0.05 mg/l 0.01 mg/l
Dioxin content 15 ng TEQ/kg 8 ng TEQ/kg 0.3 ng TEQ/kg

MARTIN® Incineration Systems
Combustion Control with Infrared - Camera

Boiler front wall
Right-hand boiler wall
Main combustion zone
Boiler rear wall
Heat reflected by boiler wall

Forschungszentrum Karlsruhe
INSPERCT II

Waste-to-Energy Research and Technology Council
Fall Meeting Columbia University, Oct. 7-8, 2004
8. Contacts

If you have any questions or for further information, please feel free to contact us at:

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