STEAG group

STEAG Energy Services GmbH

General View

Current Projects

• Essential Waste to Energy Projects
• Refuse Derived Fuels (RDF) to Energy
• Biomass to Energy
### Ownership Structure STEAG GmbH

#### Municipal Holding Company KSBG GmbH

<table>
<thead>
<tr>
<th>KSBG Kommunale Beteiligungsgesellschaft GmbH &amp; Co. KG</th>
</tr>
</thead>
</table>

Municipal Utilities

- **Stadwerke Duisburg**: 19%
- **Dortmunder Stadtwerke (DSW 21)**: 18%
- **Dortmunder Energie- und Wasserversorgung (DEW 21)**: 18%
- **Stadtwerke Bochum**: 18%
- **Stadtwerke Essen**: 15%
- **Energieversorgung Oberhausen**: 6%
- **Stadtwerke Dinslaken**: 6%

---

### STEAG GmbH

- 51% owned by KSBG GmbH
- 49% owned by Evonik Industries

#### Subsidiary Companies
STEAG – Operations full of energy

Planning – operation – supply – marketing – recycling

Project development, planning, operation and supply of power plants...

... in Germany and ...

... abroad

... on the basis of fossil...

... and renewable energy sources.

Marketing of electricity and district heat, and...

...recycling of power plant byproducts.

Key figures (as of Dec. 2010)

External sales 2,762 € m

Capital expenditure on fixed assets 163 € m

Employees 4,916
The Business Area Energy unites all energy activities

- STEAG GmbH
  - STEAG New Energies GmbH
  - STEAG Energy Services GmbH
  - STEAG Fernwärme GmbH
  - STEAG Power Minerals GmbH
  - STEAG Trading GmbH
  - RVG GmbH
    - STEAG-EVN Walsum 10 Kraftwerksgesellschaft mbH
  - Iskenderun Enerji Üretim ve Ticaret A.Ş.
    - Compania Electrica de Sochagota S.A.
      - STEAG State Power Inc.
STEAG group
STEAG Energy Services GmbH

General View

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- Essential Waste to Energy Projects
- Refuse Derived Fuels (RDF) to Energy
- Biomass to Energy
Thermal Treatment and Combustion Technologies

Thermal Treatment Plants

- Co-combustion in Coal Fired PP

Grate System
- Municipal Solid Waste
- Refuse Derived Fuel
- Biomass

Fluidized Bed System
- Refuse Derived Fuel
- Production Residues

Rotary Kiln
- Hazardous Waste
- Production Residues

Gasification
- Biomass
- Liquid/Gaseous Hazardous Waste
- Refuse Derived Fuel
- Liquid/Gaseous Production Residues

Waste Heat Boiler
- Municipal Solid Waste
- Refuse Derived Fuel

Pyrolyse
- Refuse Derived Fuel
Co-combustion in Coal Fired PP

- Power plants in theory have had high throughput capacity of 40 Mio t/a at max. 25% of thermal heat capacity (THC)

- Co-combustion of
  - Sewage sludge
  - Production residues
  - Pet coke (= „design fuel“)
  - Meat and bone meal (decreasing)
  - Refuse Derived Fuel (RDF)
  - Solid Recovered Fuel (SRF)
  - Biomass and Wood

- In reality only 3 to 10 % of the thermal heat capacity will utilized.

- Main selection criteria:
  - Logistics and handling (terms of payment and delivery)
  - Firing System (fouling boiler, corrosion, availability)
  - Flue gas cleaning (for example Mercury)
  - Residue utilization (ash with DIN EN 450)
  - No special credits or payments
Furnace Types

Grate Stoker

Pulverized Coal Combustion

Stationary Fluidized Bed Combustion

Circulating Fluidized Bed Combustion
Furnace Types / Special Typ

Air-cooled / Water-cooled
Moving Grate Combustion

Hazardous Waste
Rotary Kiln
Boiler Technology

Grate System

Municipal Solid Waste
- municipal location
  - Live steam parameters
    - 400°C
    - 40bar
    - Energy output
      - 18 % electricity with district heating
  - Energy output
    - 20 up to 30 % electricity with steam feed-in

Refuse Derived Fuel
- industrial zone
  - Live steam parameters
    - 450 °C up to 525 °C
    - 40 up to 90 bar
    - Energy output
      - 20 up to 30 % electricity with steam feed-in

Biomass / Wood
- industrial zone
  - Live steam parameters
    - 450 °C up to 525 °C
    - 40 up to 90 bar
    - Energy output
      - 20 up to 30 % electricity with steam feed-in
Municipal Waste Incineration Plants with Moving Grate
throughput: 20 Mg/h at approx. 52.1 MW \textsubscript{th}

<table>
<thead>
<tr>
<th>Year</th>
<th>Grate Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>5 m</td>
</tr>
<tr>
<td>1990</td>
<td>4.4 m</td>
</tr>
<tr>
<td>1995</td>
<td>6.3 m</td>
</tr>
<tr>
<td>2000</td>
<td>6.3 m</td>
</tr>
</tbody>
</table>

Quelle: EuPla 2000
Grate Typ
Waste and Biomass to Energy plant

Operating pressure: 90 bar
Operating steam temperature: 500 °C
Steam mass flow: 126.5 Mg/h
Boiler Technology

Municipal Solid Waste
- Municipal location
- Industrial zone power plant
  - Live steam parameters
    - 400°C
    - 40 bar
  - Energy output
    - 18% electricity
    - With district heating
  - Energy output
    - 20% up to 30% electricity
    - With steam feed-in

Refuse Derived Fuel
- Industrial zone
  - Live steam parameters
    - 450°C up to 525°C
    - 40 up to 90 bar
  - Energy output
    - 20% up to 30% electricity
    - With steam feed-in

Biomass / Wood
- Industrial zone
  - Live steam parameters
    - 450°C up to 525°C
    - 40 up to 90 bar
  - Energy output
    - 20% up to 30% electricity
    - With steam feed-in
Comparison of CFBC Boiler Layout

Alstom
Lurgi
Foster Wheeler
Kvaerner
Live steam parameters and corrosion mechanisms

Municipal Solid Waste
Refuse Derived Fuel
Biomass / Wood

Live steam parameters
450 °C up to 525 °C
40 up to 90 bar
Energy output
20 up to 30 % electricity with reheater
35 %
Main Steam Conditions and Fuel Quality

VGB Forschungsprojekt Nummer 302, Untersuchung von Biomasse- und Altholzheizkraftwerken im Leistungsbereich von 5 bis 20 MWel zur Verbesserung der Wirtschaftlichkeit (Teil I)
Reason for Stagnant Condition Periods

- Fouling heat recovery section: 16 namings
- Corrosion / Erosion: 7 namings, 1 additional
- Fouling furnace, first pass: 6 namings, 1 additional
- Grate, fluidized bed: 4 namings, 3 additional
- Fuel through put: 3 namings, 2 additional
- Ash handling: 4 namings
- Cleaning equipment: 3 namings
- Other subjects: 2 namings, 1 additional

Number of namings limiting continuous operating period.
Chlorine Induced Active Oxidation Corrosion Mechanism

**Modell der Korrosionsvorgänge unter Belägen [Born, 2004]**

- **Boiler super heater tube** (T = 400…550°C)

  - Flue gas: NaCl, KCl, HCl, O₂, SO₂
  - Vapor diffusion of flue gas components
  - Fouling of ashes and aerosols mixture
  - Fly ash fouling
  - Pastery Fe₃O₄
  - Molten salt (if necessary carbon within)

- **Reactions**
  - 2NaCl + SO₂ + O₂ ⇌ Na₂SO₄ + Cl₂
  - 3FeCl₂ + 2O₂ ⇌ Fe₃O₄ + 3Cl₂

- **Chlorine cycle**
  - Iron cycle
Corrosion Diagram Waste to Energy Plant

- Corrosion possible
- Corrosion free from
- 17. BImSchV
- SH1
- SH2
- SH3
- Free from corrosion
- Additional zone in mind of Warnecke
Fuel composition and fouling structure on boiler tube

Figure 121  Simplified conceptual interactions among selected fouling elements in biomass.
Combustion Model
Centre Flow Combustion

Excess Fuel Zone

Burnout Zone

Oxygen Rich Zone

Solid Fuel

Release of Volatile
Chlorine Compounds
Alkaline chloride
Alkaline earth chloride
Heavy metal chloride

Drying
Gasification
Combustion
Char Combustion
Recirculation Zone

SA

Reaction with $SO_x$, $O_2$, if Efficient Turbulence and residence time

Ash

Release of Sulfur di- and trioxide and Alkaline
Combustion Model
Parallel Flow Combustion

Results Complete Burnout and Mixing of Reactants

Release of volatile Chlorine Compounds
Alkaline chloride
Alkaline earth chloride
Heavy metal chloride

Efficient turbulence, high temperature and adequate residence time

Release of sulfur di- and trioxide and reaction with volatiles

Excess Fuel Zone
Drying
Pyrolysis
Gasification
Combustion
Char Combustion
Ash
SL3
SA 2
SA 1
Solid Fuel

Oxygen Rich Zone
After Burn Zone

Excess Fuel Zone

Combustion Model
Parallel Flow Combustion
Alkali potential on fuel

Corrosions number II

Graph showing the relationship between alkali potential and chlorine content in fuel. The y-axis represents the chlorine content in fuel, and the x-axis represents the alkali potential. Different types of fuel are indicated by color-coded markers.

- Coal/Wood
- Plant residues
- Lahti

Equation:

\[ K_{\text{CK}} = \frac{2 \cdot [\text{NaCl} (\text{g}) + \text{KCl} (\text{g})]}{\text{SO}_2} \] [mol/mol]
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STEAG Energy Services GmbH

General View

Current Projects

• Essential Waste to Energy Projects
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**Waste to Energy**

**T.A. Lauta**  
Essential Plant Data

- Waste throughput: $225,000$ Mg/a
- Combustion units: $2$ unit’s
- Thermal heat throughput (per unit): $37.5$ MW$_{th}$
- Waste throughput (per unit): $15$ Mg/h
- Design calorific value (Hu): $9.0$ MJ/kg
- Calorific value range (Hu): $7 - 12$ MJ/kg
- Power output: ca. $20$ MW$_{el}$
- Plant power consumption: ca. $4$ MW$_{el}$
- Waste bunker capacity: ca. $11,000$ m$^3$
Thermal Waste to Energy Plant Lauta
STEAG group

STEAG Energy Services GmbH

Current Projects

- Essential Waste to Energy Projects
- Refuse Derived Fuels (RDF) to Energy
- Biomass to Energy
RDF to Energy, EVA Höchst, Infraserv Frankfurt

- Industriepark Höchst, Frankfurt
  Site for chemicals, pharmaceuticals and biotechnology
- RDF-ICFB Combustion with capacity of 700.000 t/a
- 3 times 94 MW (thermal)
- 80 MW (electricity)
- Japanese EPC
- trial operation at present
RDF / Waste Utilisation
Infraserv Frankfurt

1. Delivery
2. Delivery bunker
3. Boiler house
4. Flue gas treatment

- Closed delivery hall
- RDF in put
- Bubbling fluidized bed
- Boiler
- Cyclon
- Economizer
- Lime-spray drying
- Entrained flow reactor
- I-d fan, stack
- Fabric filter
- Reaction product
- Combustion air
- Bed material
- Fly ash
- Steam turbine and generator
- Electricity
- Steam
ICFB Combustion of Refuse derived fuel; Infraserv Frankfurt

- Internal Circulating Fluidised Bed Combustion with Combustion inside the Boiler
- Stable Technology – without moving parts inside the Furnace
- Wide range in respect of calourific value of fuel and waste
- Efficient in-bed heat-transfer
- Recycling of metals like iron, steal and non-ferrous metals
STEAG group

STEAG Energy Services GmbH

Current Projects

• Essential Waste to Energy Projects
• Refuse Derived Fuels (RDF) to Energy
• Biomass to Energy
## STEAG New Energies
### Biomass to Energy Plants

<table>
<thead>
<tr>
<th>Plant</th>
<th>Start up</th>
<th>Wood Fuel</th>
<th>Through put (Mg/a)</th>
<th>Power out put (MW&lt;sub&gt;e&lt;/sub&gt;)</th>
<th>District heating out put (MW&lt;sub&gt;th&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Großaitingen</td>
<td>2002</td>
<td>A I - A III</td>
<td>45.000</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Buchenbach</td>
<td>2002</td>
<td>A I – A II</td>
<td>30.000</td>
<td>1,2</td>
<td>3,3</td>
</tr>
<tr>
<td>Neufahrn</td>
<td>2003</td>
<td>A I - A III</td>
<td>45.000</td>
<td>5,3</td>
<td>10</td>
</tr>
<tr>
<td>Werl</td>
<td>2003</td>
<td>A I - A II</td>
<td>10.000</td>
<td>0,48</td>
<td>3,3</td>
</tr>
<tr>
<td>Buchen</td>
<td>2004</td>
<td>A I - A IV</td>
<td>60.000</td>
<td>7,1</td>
<td>10</td>
</tr>
<tr>
<td>Dresden</td>
<td>2004</td>
<td>A I - A IV</td>
<td>55.000</td>
<td>7,1</td>
<td>10</td>
</tr>
<tr>
<td>Neuwied</td>
<td>2004</td>
<td>A I - A IV</td>
<td>65.000</td>
<td>7,6</td>
<td>18</td>
</tr>
<tr>
<td>Traunreut</td>
<td>2004</td>
<td>A I - A III</td>
<td>50.000</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Ilmenau</td>
<td>2005</td>
<td>A I - A III</td>
<td>45.000</td>
<td>5,3</td>
<td>10</td>
</tr>
<tr>
<td>Lünen</td>
<td>2006</td>
<td>A I - A IV</td>
<td>140.000</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>Warndt</td>
<td>2009</td>
<td>Forest wood</td>
<td>40.000</td>
<td>1,8</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total amount</strong></td>
<td>-</td>
<td>A I - A IV</td>
<td>595.000</td>
<td>66</td>
<td>84</td>
</tr>
</tbody>
</table>
• **Grain Size Distribution:**
  High fuel fines increased fouling; risk of fuel segregation

• **Ash and Minerals:**
  All-important for abrasion of mechanical handling equipment, for high disposal cost and for high corrosion potential

• **Chlorine Content:**
  Risk of high temperature Chlorine corrosion; low ash softening temperature

• **Calorific Value:**
  Define the fuel amount and fuel cost

• **Air distribution and burn out phase:**
  Variable fuel will have variably burn out and different air distribution must be possible
Summary
Waste to Energy and Renewable Energies

• Energy from waste and biomass is state of the art, but technology of biomass to energy plants has to adapt to the different fuel qualities.

• Energy contracting and delivery for industry and real estate helps to environmental relief and reduction in energy costs.

• Fuel with different qualities leads, depending on fuel treatment extent and chemical composition, make changes at combustion system necessary.

• Control and regulate of the combustion and air distribution must be possible.

• High performance factors together with high plant availability rate shall be noted.
Take advantage of the potential of an interdisciplinary engineering company

STEAG Group specializes in the engineering and O&M management of waste and biomass plants, focusing on thermal energy generation facilities for municipal solid wastes, biomass, refuse-derived fuels and energy sources of the future.

- Project Development
- Project Planning and Engineering
- Permitting Management
- Project Management
- Site Supervision / Commissioning
- Plant Operation
- Plant Optimization
steag
Specific Boiler Design
Super Heater at high Flue Gas Zone

Schematic diagram of Maribo Sakskøbing CHP Plant showing position of superheater sections investigated. The arrows show the flow for the banks 2-7 in superheaters 2 and 3.

Corrosion Investigations at Maribo Sakskøbing
Combined Heat and Power Plant Part IV
Melanie Montgomery et.al. ; April 2007
RDF and Biomass to Energy Plants

- RDF
- Furnace
- Cyclone
- CFB Boiler
- Venturi Reactor
  - Ca(OH)2 + act. carbon
- Baghouse
- Stack
- Primary combustion air
- Bottom inerts
- Secondary air
- Fly ash
- Steam
Chlorine compounds at reducing and oxidizing conditions for the case Cl/Zn = 11. Remaining chlorine (80%–90%) was found in the flue gas mainly as hydrogen chloride.

When chlorine is present at lower concentrations than potassium, it reacts with potassium and forms solid potassium chloride which starts to volatilize at 500 °C. At 700 °C potassium chloride is completely volatilized and present in the flue gas.
Sulfur / Chlorine ratio

Corrosion number S/Cl Ratio

- S/Cl = 4
  - without corrosion

- S/Cl = 2
  - corrosion-endangered

Fuel german hard coal
Energy plant
Imported coal
Lahti
Infracor K4
Altholz
Ensdorf
Bexbach
BMK Lünen
Göttelb.
firs brushwood
cottonwood
oat
grop
Coal
Lahti
rapeseed
 imported coal

Sulfur / Chlorine ratio
Waste to Energy

Essential Waste to Energy Plants of STEAG-Group
with participation in build, finance and operation management

<table>
<thead>
<tr>
<th>Plant</th>
<th>Start up</th>
<th>Through put (Mg/a)</th>
<th>Performance STEAG-Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>RZR Herten</td>
<td>1982</td>
<td>250.000 (1)</td>
<td>design, operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>60.000 (2)</td>
<td></td>
</tr>
<tr>
<td>MHKW Burgkirchen</td>
<td>1994</td>
<td>200.000</td>
<td>design, operation</td>
</tr>
<tr>
<td>AVA Augsburg</td>
<td>1994</td>
<td>220.000</td>
<td>design, build, operation, finance</td>
</tr>
<tr>
<td>AEZ Kreis Wesel</td>
<td>1997</td>
<td>250.000</td>
<td>design, build, operation, finance</td>
</tr>
<tr>
<td>AVA Velsen</td>
<td>1997</td>
<td>210.000</td>
<td>operation</td>
</tr>
<tr>
<td>MHKW Pirmasens</td>
<td>1998</td>
<td>170.000</td>
<td>design, build, operation, finance</td>
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<tr>
<td>AHKW Neunkirchen (Neubau)</td>
<td>2001</td>
<td>120.000</td>
<td>design, build, operation, finance</td>
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<tr>
<td>MVA Madeira</td>
<td>2002</td>
<td>130.000</td>
<td>operation</td>
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<td>T.A. Lauta</td>
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<td>TREA Breisgau</td>
<td>2005</td>
<td>150.000</td>
<td>design, build, operation, finance</td>
</tr>
</tbody>
</table>

(1) municipal solid waste (2) hazardous waste
Waste derive wood fraction

- Municipal solid waste: 1%
- Valuable material recycling: 4%
- Industrial waste: 15%
- Bulky waste: 49%
- Construction & demolition waste: 30-100%
- Industrial residual wood: 100%

Wood part in waste stream

Wood waste
- Waste management

Wood waste outside
- Waste management

State-owned municipalities / waste disposal enterprise

Export

Treatment and sorting plant
- Utilization & recycling biomass to energy

Import

Disposal facility
- Waste disposal landfill
- Waste disposal waste to energy

Sort residues