Aalto University
School of Engineering

Waste Management and Recycling

Thermal treatment of Waste

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Why waste is thermally treated?

- **To reduce the landfilling of waste**
  - Especially the amount of biodegradable waste that causes harmful environmental effects like methane (greenhouse gas) and odor emissions
- **To increase the utilization rate of waste**
  - In energy production (electricity and heat)
  - Partly CO2 neutral energy (50-60 % of the energy content origins from bio based materials)
  - Considered as domestic fuel
  - Metal recovery (collected from bottom ash)
  - Bottom ash mineral matter utilization in construction works
- **To reduce the volume and mass of waste**
  - The volume of bottom ash and fly ash is app. 20% of original mass of the waste incinerated

Legislation related to thermal treatment

- **EU Directive on incineration of waste (2000/76/EY)**

And on National level

- **Degree on incineration of waste (362/2003), Jätteenpolttoasetus**
  - Regulates the incineration of municipal solid waste and hazardous waste in WtoE plants co-firing power plants (fluidized bed boilers) and rotary kilns (cement industry)
    - *Conditions of combustion (temperature)*
      - 850/1100 celsius after last combustion air feed
    - *Energy recovery*
      - Produced heat must be utilized as effectively as possible
    - *Flue gas emissions*
      - And the measurements of emissions (**NOx, CO, particles, TOC, HCl, HF, SO2, O2, temperature, pressure, steam pressure**, dioxides, furans, heavy metals)
    - *Impurities of waste waters*
    - *Loss of ignition in combustion products*

Waste or Fuel 1/2

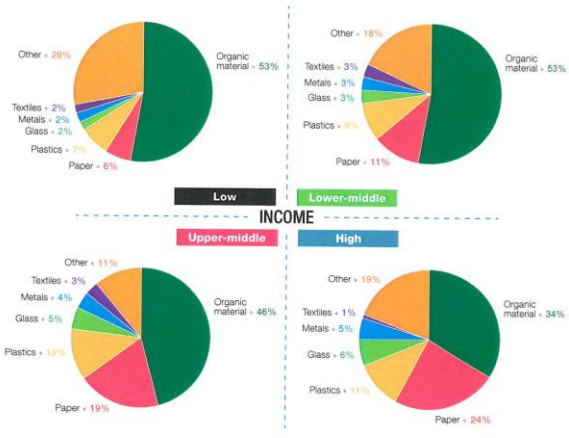
- **Content of MSW varies depending on origin of the waste**
- **Typically household waste contains 35-50 % kitchen waste (biowaste), 20-35 % paper products, 25-35 % plastics, metals, glass, textiles, dipers, even small amounts of hazardous waste**

As a fuel MSW is challenging because it's unhomogenity (composition, content and particle size)

The energy content is between 8-11 MJ/kg

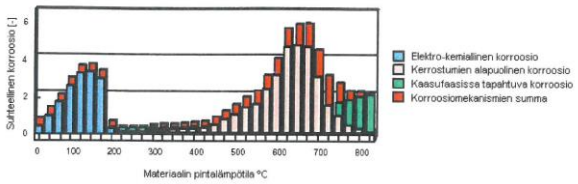
Chlorine content is high

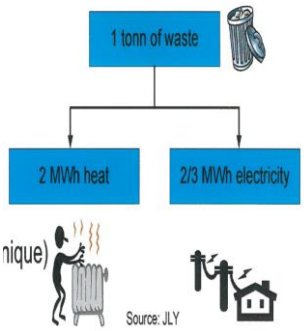
Ash content is high



Waste or Fuel 2/2

- **Due to quality of waste the energy utilization of it needs special technologies and materials or heavy pretreatment**
- **Forms of waste fuels are:**
  - Source separated municipal solid waste (no other pretreatment)
  - Fuels produced from waste by mechanical treatment (smaller particle size, less inert material or bio fractions, higher energy content than in MSW (Solid Recovered Fuel SRF, Refuse derived Fuel RDF, Recycled Fuel REF)
    - *Bag shredding*
    - *Size screening*
    - *Crushing*
    - *Mechanical separation of metals, stones, etc.*
    - *Coarse shredding*





Thermal treatment techniques 1/6

- **Grate firing**
  - The main waste incineration (Waste to Energy) technology
    - *No pretreatment except source separation needed*
    - *Can handle variety of waste types (MSW from households and industry, construction and demolition waste particle size up to 50-100 cm)*
    - *Steam values normally 40 bar/400 celsius*
      - Electricity production efficiency 25-35 % (relatively low due to low steam values)
    - *Robust technology*
    - *Effective flue gas cleaning processes needed*
      - Normally 3-5 stages
        - Particle removal (ESP or pack filter)
        - Catalyst (NOX removal)
        - Scrubbing (wet or dry)
        - Active carbon (for mercury and dioxides)
        - Polishing (particle and active carbon removal)
    - *Inert mainly in bottom ash, 90 % (mainly recyclable)*
    - *Boiler ash and fly ash less than 10% (hazardous waste)*

Långmossebergen-Waste to Energy plant

Dr Petri Kouvo, HSY Waste Management
16.9.2015

Steps toward high utilization rate of MSW

- **New Waste to Energy plant in use since spring 2014**

Location: City of Vantaa

Capacity: 340 000 tons/year (2-lines)

Fuel: Source separated municipal solid waste (mainly household waste or waste equal to household waste)

- Average HV 10,5 MJ/kg -> 930 GWh/a (116,6 MW)
- Plus natural gas of 650 GWh/a (91,8 MW)
- Electricity production 620 GWh/a (31 + 49=80,5 MW)
- Heat production 870 GWh/a (119,3 MW)
  - *Heat can be utilized in district heat production through the year*

Plant substitutes one coal fired unit of Vantaa Energy Ltd

- Reduction of the use of coal in energy production app 30%
- Reduction of CO2 emission in energy production app. 20%

Technology: Grate fired combined WtoE and gas turbine process

Steam values: 90 bar/400 C° and 88 bar/515 C°

Total Energy efficiency 95 %

Thermal treatment techniques 2/6

Grate firing

1 waste feed hopper

2 waste extruder

3 waste bed and grate

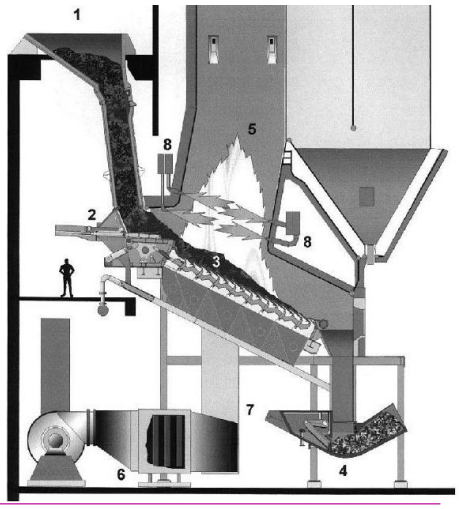
4 Bottom ash (coarse unburnt material)

5 Furnace

6 Combustion air blower

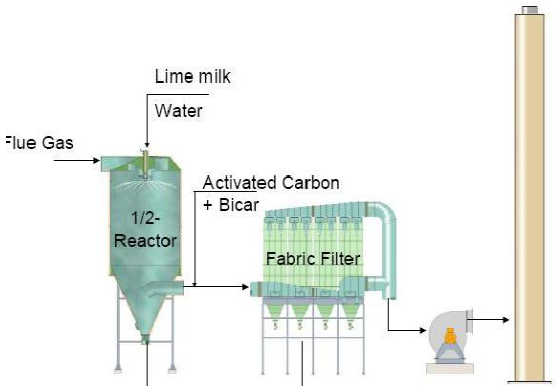
7 Combustion air duct

8 Gas burners

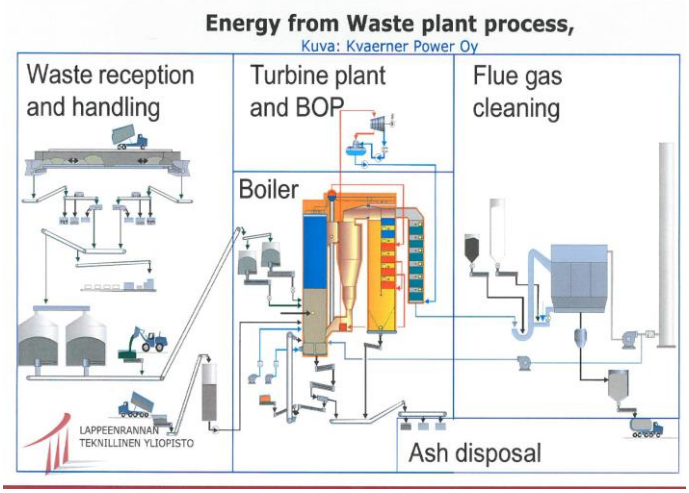


Thermal treatment techniques 3/6

- **Flue gas cleaning for acidic compounds SO2, HCl HF**
  - Wet or dry scrubbing
    - *Lime and water added*
- **Hg and dioxides**
  - Activated carbon
- **Fine particles**
  - Fabric filter (pack filter)



Thermal treatment techniques 4/6



Thermal treatment techniques 5/6

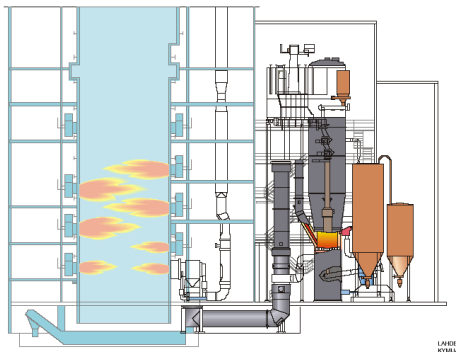
Waste based fuels co-firing in Fluidized bed boilers

- Pretreatment of waste is needed to remove inert material and fractions unsuitable for combustion
- Also particle size needs to be decreased (100 millimeters or lower)
  - Household waste contains high amounts of impurities that are harmful for combustion like chlorine -> risk of slagging and fouling
  - Normally better quality raw material (waste from commercial operators or industry) used for fuel production
    - *Problem: this kind of waste contains recyclables more than household waste*
- **Co-firing with wood based fuels limited due to Ca, Na and K salts formation (causes slagging and fouling and corrosion)**
- **Formation of fly ash amount high compared to grate firing**
- **Higher energy production efficiency than in grate firing**

Thermal treatment techniques 6/6

Waste based fuels gasification

- **Amount of references very limited**
- **Pretreatment of waste needed**
- **Product gas cleaning difficulties**
  - Gas contains particles, tars and complex compounds
- **One gasifier in Finland (Lahti, Kymijärvi)**



Bottom ash and fly ash treatment

Bottom ash is coarse unburned portion of MSW that includes:

- Stones, concrete, other minerals (glass)
- Metals: ferrous metals, stainless steel, copper, brass, zink
- And mineralized materials

- Ash is collected from boiler section and from ESP (electrostatic precipitator) or other dust removal device (air pollution control system)
  - *Ash is highly contaminated with heavy metal and is treated as hazardous waste*
  - *Ash mixed with stabilizing substances (cement) and water*
  - *Deposited at hazardous waste landfill area (special bottom layers and leakage management*

Bottom ash and fly ash treatment