Waste wood processing as a basis for an improved fuel quality for biomass combustion plants

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Contents

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Waste wood - sources and quality classes

- Wood waste from the wood processing industry
- Demolition wood
- Door panels
- Door trims
- Panels
- Insulating wall panels- and soundproofing tiles
- Chipboards
- Impregnated timber
- Pallets
- Transport boxes
- Furniture
- Fibreboards
- Sleepers
- Poles
- Impregnated garden furniture

Quality classes

- Due to these different sources waste wood is an extremely inhomogeneous fuel

- Its chemical composition as well as its contents of impurities vary significantly depending on the local constraints

- European standards concerning the classification of waste wood do not exist yet, but they are under development
  - CEN TC 343 „Solid recovered biofuels“

- In Austria and Germany waste wood classification systems already exist

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Quality classes for waste wood according the Austrian "Branchenkonzept Holz"

Q1: chemically untreated wood

- Q1.1: wood chips (with/without bark)
- Q1.2: logging residues (cross-cut ends, rinds, etc.; with/without bark)
- Q1.3: sawdust, compressed wood
- Q1.4: wood dust

Q2: bark

Q3: binder containing and halogen free coated wood (fibreboards)

- Q3.1: non coated (residues, sawdust)
- Q3.2: coated (residues, sawdust)

Q4: surface treated wood (residues, sawdust)

Q5: creosoted timber

Q6: salt impregnated wood

Q7: halogen plastics containing wood composite materials

Development of a waste wood processing plant – aims and methodology

Aims

- Improvement of the fuel quality by selective precipitation of fractions which are crucial for the combustion process

Methodology

- Identification of parameters which are crucial for the operation of a combustion plant
- Determination of guiding values for the maximum concentrations of these elements in the fuel
- Size selective chemical analyses of waste wood
- Development, design and conception of a waste wood processing plant
- Test runs with the processing plant
- Combustion tests with non-processed and processed waste wood

Crucial parameters – definition of recommendations for guiding values

Basic data

- **Data and experiences gained from waste wood combustion test runs Sources:**
  - Institute for Resource Efficient and Sustainable Systems (RNS), Graz University of Technology, Austria
  - BIOS BIOENERGIESYSTEME GmbH, Graz
- **Fuel analyses taken from databases**
  - RNS
  - BIOS BIOENERGIESYSTEME GmbH
  - IEA Bioenergy Task 32, „Biomass Combustion and Co-firing“
- **Consideration of the EU guideline 2000/76/EG with respect to emission limits**

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Parameters which may affect the combustion behaviour – Overview

Combustion related problems which are directly influenced by the fuel composition:

- Gaseous emissions
  (NO_x, SO_2, HCl, PCDD/F)
- Particulate emissions
  (especially fine particulate emissions)
- Slagging in the furnace and deposit formation on boiler tubes
- Boiler tube corrosion
- Ash removal and ash utilisation

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Chemical composition of waste wood – crucial parameters (I)

Ash content

- combustion technology
- fly ash emissions
- slagging and ash deposit formation
- ash removal system, ash storage and logistics
- ash disposal and ash processing costs

range: **1.5 to 10 wt% (d.b.)**
target value: **<4 wt% (d.b.)**

Cl-content

- HCl- and PCDD/F-emissions, fine particle emissions
- flue gas cleaning technology applied
- boiler conception and boiler cleaning systems applied
- formation of hard deposits and corrosion

range: **300 to 4,000 mg/kg (d.b.)**
target value: **<1,000 mg/kg (d.b.)**

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Chemical composition of waste wood – crucial parameters (II)

S-content

- SO_x-emissions
- flue gas cleaning technology (dry sorption and aerosol precipitation)
- formation of hard deposits (salt melts)
- corrosion (in combination with chlorides)

range: **300 to 2,000 mg/kg (d.b.)**
target value: **<1,000 mg/kg (d.b.)**

Fe-, Al- and Si-contents

- slagging and formation of ash deposits
- grate and ash removal system
- ash content

range			*target value*
Fe: 250	**to**	**3,000 mg/kg (d.b.)**	**<500 mg/kg (d.b.)**
Al: 400	**to**	**5,000 mg/kg (d.b.)**	**<800 mg/kg (d.b.)**
Si: 1,500	**to**	**15,000 mg/kg (d.b.)**	**<4,000 mg/kg (d.b.)**

Chemical composition of waste wood – crucial parameters (III)

Na- and K-contents

- slagging and formation of ash deposits
- aerosol formation
- heat exchanger cleaning system
- corrosion (in connection with Cl)

range				*target value*
Na:	**200**	**to**	**3,000 mg/kg (d.b.)**	**< 500 mg/kg (d.b.)**
K:	**800**	**to**	**2,500 mg/kg (d.b.)**	**< 1,500 mg/kg (d.b.)**

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Chemical composition of waste wood – crucial parameters (IV)

- **heavy metals (Zn, Pb, Cd, Hg)**
  - heavy metal emissions (strict emissions limits prescribed by the waste incineration guideline for Pb, Hg)
  - aerosol formation (Zn, Pb)
  - ash deposits respectively slagging (Zn, Pb)
  - flue gas cleaning (efficient dust precipitators needed)
  - boiler cleaning system
  - corrosion (in connection with Cl)
  - ash disposal and ash utilisation (Zn, Pb, Cd)

	range				*target value*
Zn:	**200**	**to**	**1,200**	**mg/kg (d.b.)**	**<200 mg/kg (d.b.)**
Pb:	**50**	**to**	**400**	**mg/kg (d.b.)**	**<100 mg/kg (d.b.)**
Cd:	**0.3**	**to**	**3.0**	**mg/kg (d.b.)**	**<1.0 mg/kg (d.b.)**
Hg:	**<0.01**	**to**	**0.4**	**mg/kg (d.b.)**	**<0.3 mg/kg (d.b.)**

Chemical composition of waste wood – crucial parameters (V)

Particle size of the fuel

- too big pieces: blocking of the fuel feeding system
- too small particles (in grate fired systems):
  increased fuel particle and charcoal entrainment from the fuel bed
  - higher fly ash concentrations
  - higher deposit build up rates

target value: about 7 to 100 mm

Particle size selective chemical analyses of waste wood - methodology

1. **Sampling from waste wood (Q1 to Q4)**

2. **Screening**
   (3, 7, 13, 45 and 63 mm perforated sieves)

3. **Performance of wet chemical analyses of the different size classes**
   (moisture content, ash content, C, H, N, S, Cl, Si, Mg, K, Na, Al, Fe, Zn, Pb, Cd)

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Sieve analyses - fractions

>63 mm

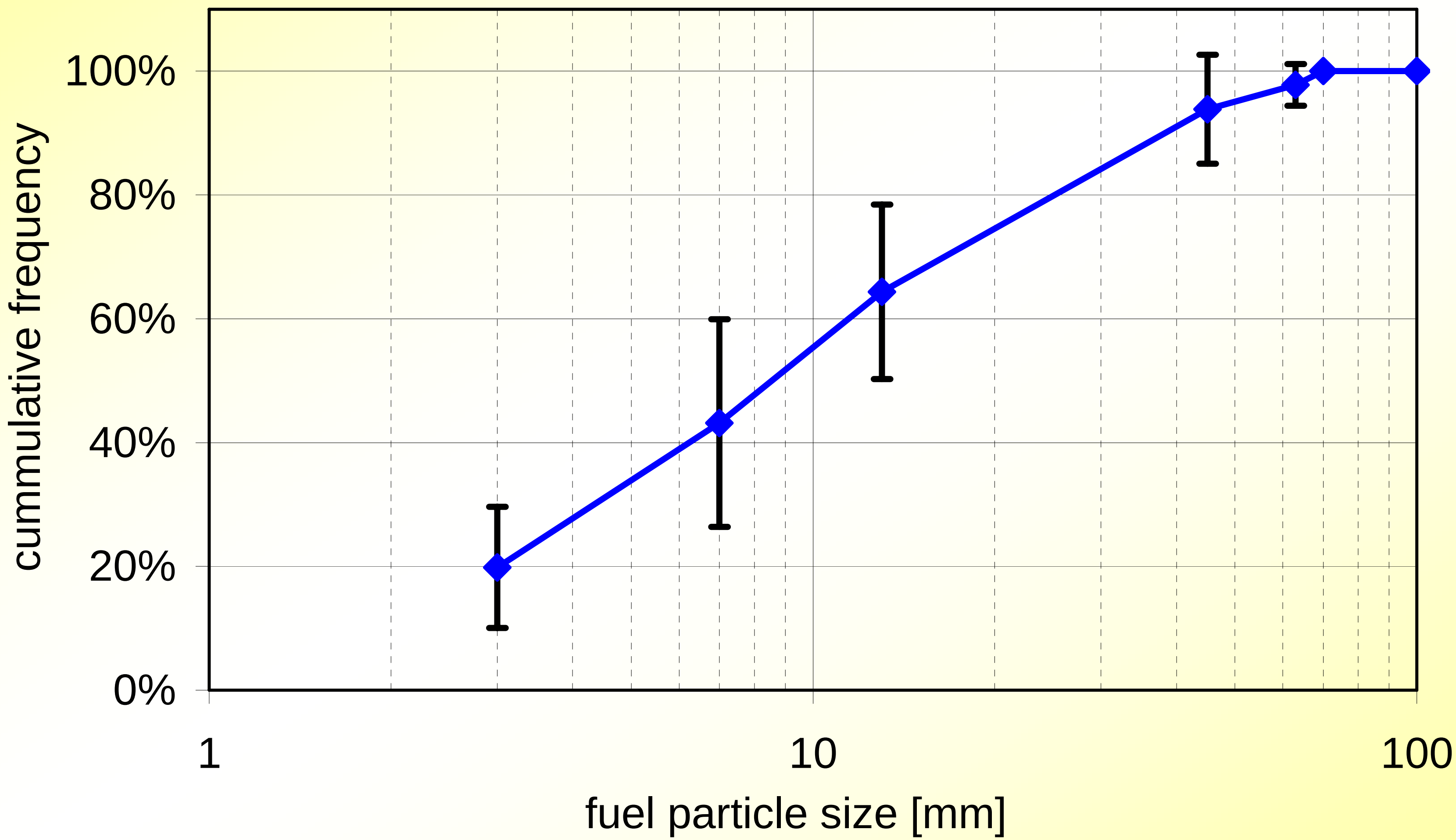
45 – 63 mm

13 – 45 mm

7 – 13 mm

3 – 7 mm

Particle size distribution of the waste wood investigated



Explanations: mean values and standard deviations from 8 sieve analyses

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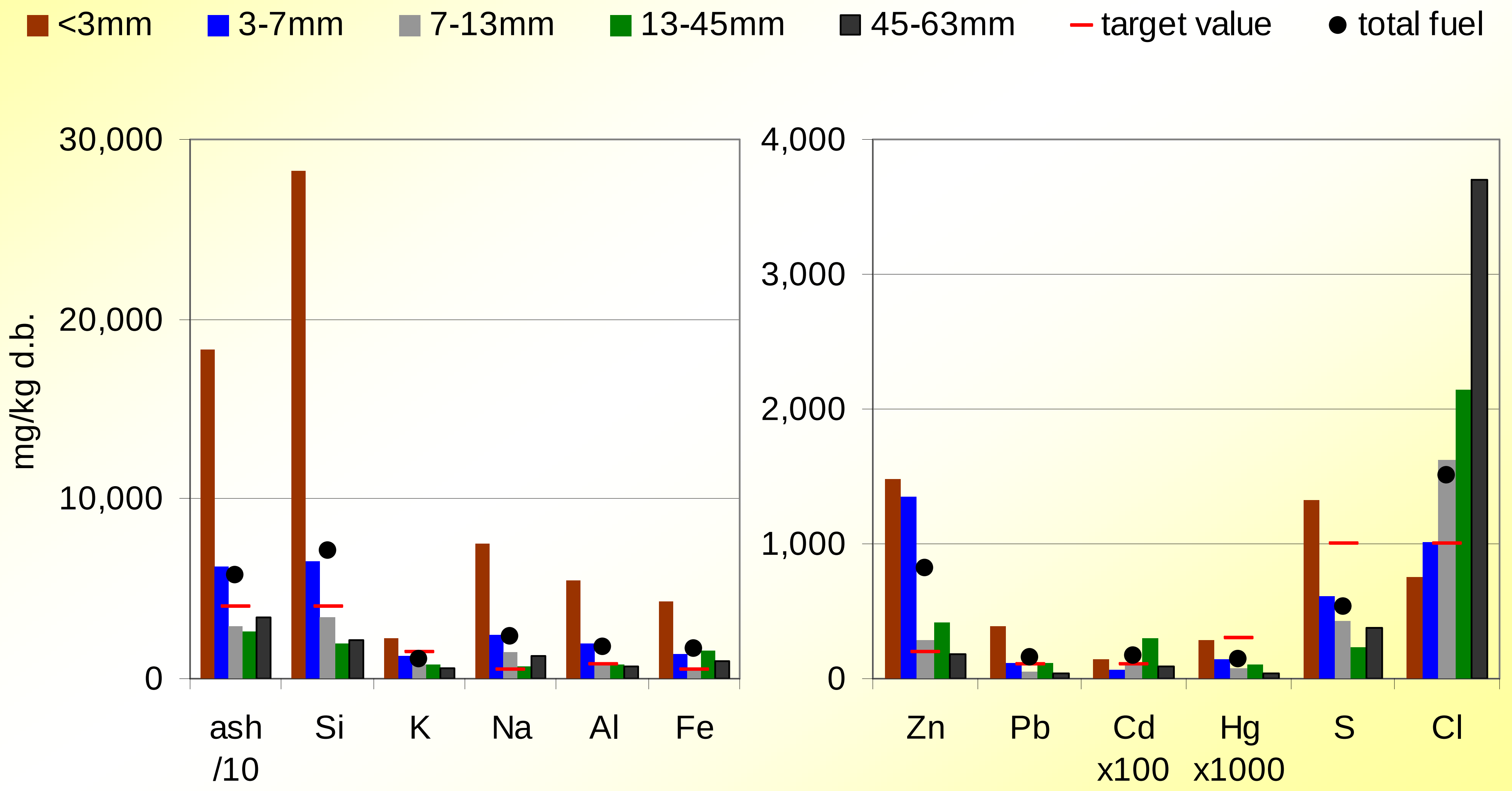
Results of wet chemical analyses of the single sieve fractions



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Sieve analyses – conclusions concerning the conception and design of a waste wood processing plant

- **Application of shredder which avoids the production of a high amount of undersized fuel particles.**
- **The highest concentration of all relevant elements with the exception of Cl and Cd is found in the smallest particle size investigated.**
- **By separation of the undersized particles a considerable portion of these elements can be discharged.**
- **As chlorine can not be discharged by particle size selective separation of different fractions an accurate receiving inspection is recommended.**
- **An iron- as well as a non-ferrous metal separation should also be included in the fuel processing concept.**

Waste wood processing plant

1 ... Fuel input
2 ... Shredder with 100 mm respectively 150 mm screen basket
3 ... Fe removal
4 ... Drum screen
5 ... Discharge of undersized particles
6 ... Non-ferrous metal removal
7 ... Processed fuel

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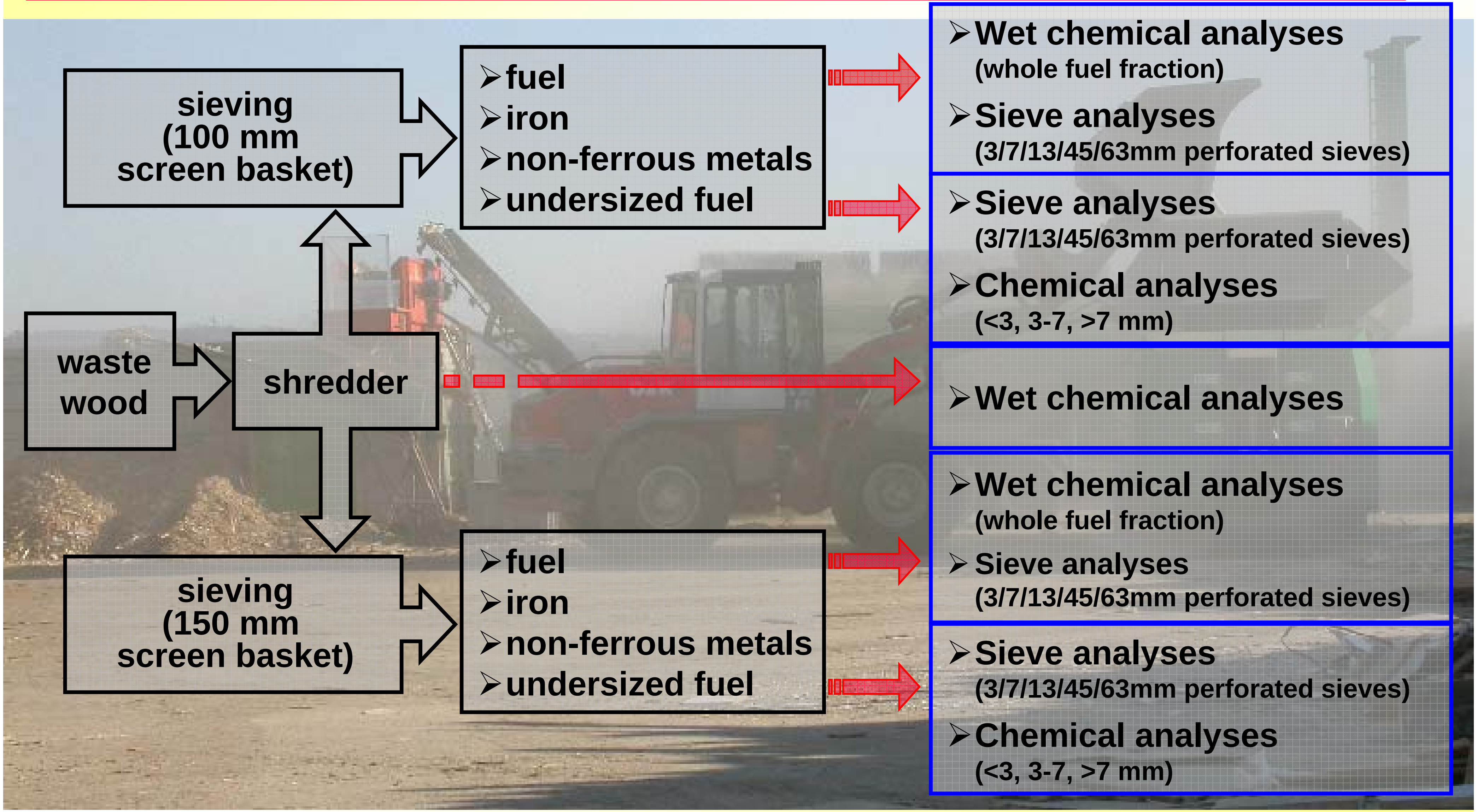
Test runs with the waste wood processing plant – methodology



Test runs with the waste wood processing plant – input material

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Test runs with the waste wood processing plant – processed fuel

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Test runs with the waste wood processing plant – processed fuel

Disadvantage
- **Oversized fuel pieces**
- **Poor metal precipitation**

Advantage
- **Small amount of undersized fuel particles**

Disadvantage
- **Higher amount of undersized particles**

Advantage
- **Reduced amount of oversized pieces**
- **Improved metal separation**

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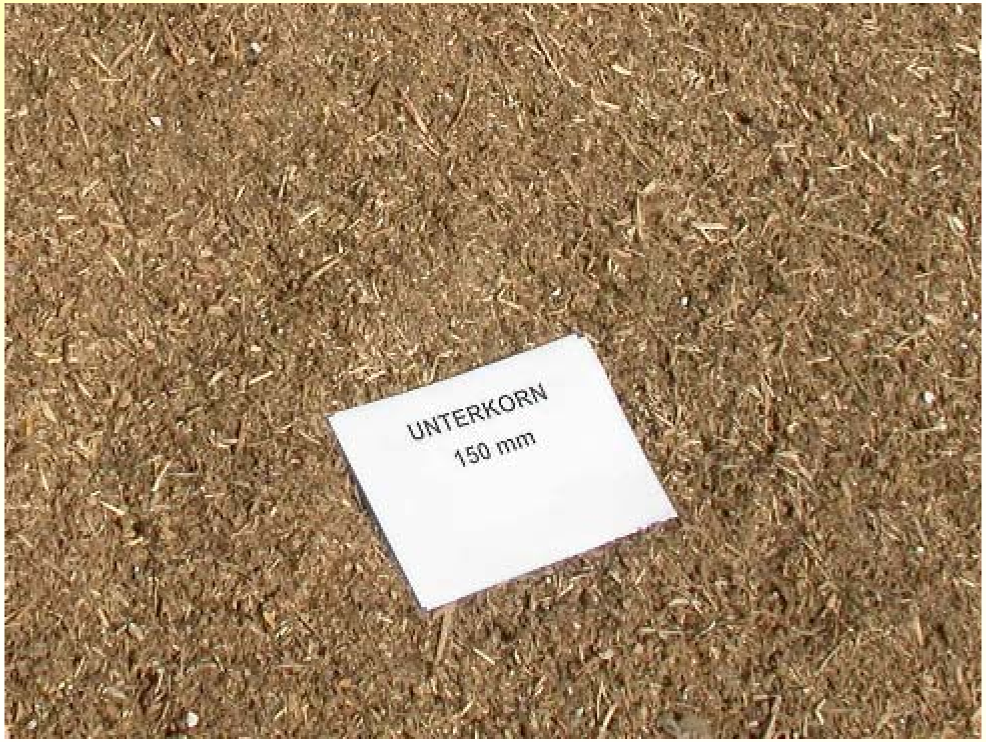
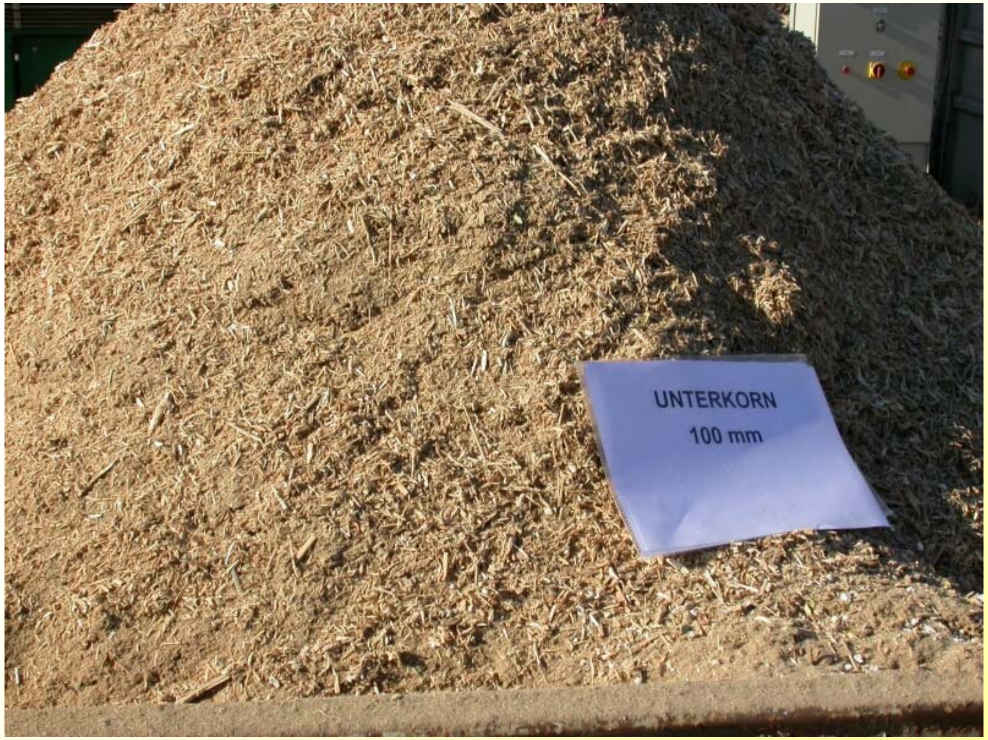
Test runs with the waste wood processing plant – undersized fuel fraction

150 mm screen basket



100 mm screen basket



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Test runs with the waste wood processing plant – Fe- and non-Fe-metal precipitation

Fe-precipitation

non-ferrous metal precipitation

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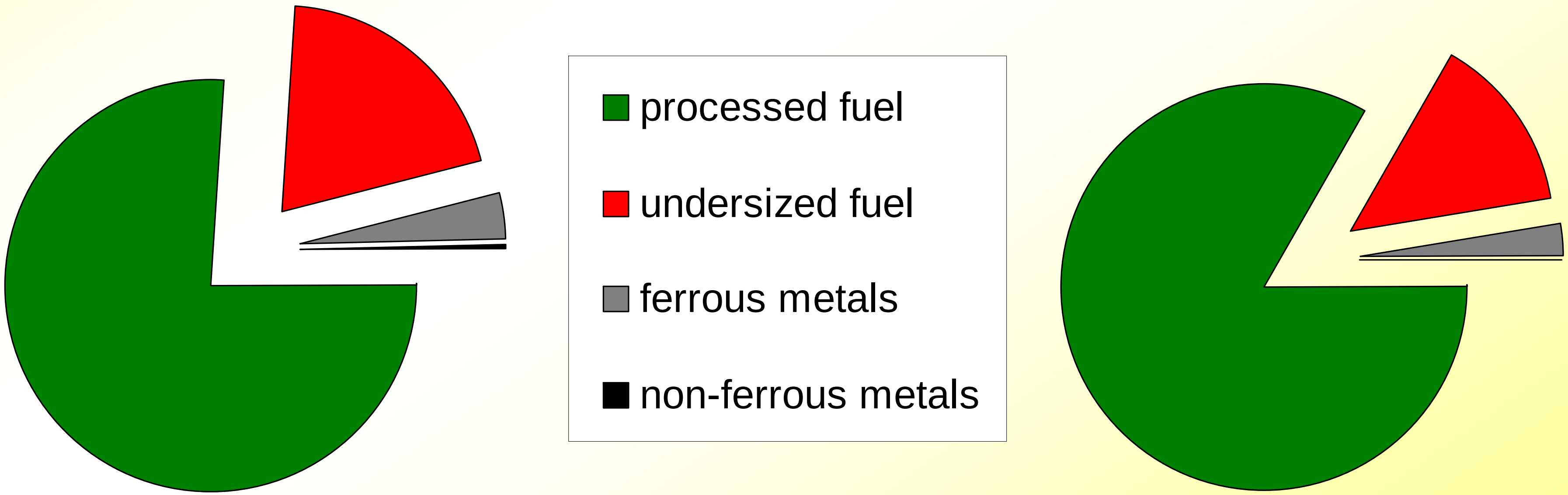
Mass balances of the waste wood processing plant

	100mm screen basket			150mm screen basket		
fuel	6,400	kg	76.0%	12,200	kg	83.2%
undersized fuel (<10mm)	1,700	kg	20.2%	2,100	kg	14.3%
iron metals	290	kg	3.4%	340	kg	2.3%
non-ferrous metals	30	kg	0.4%	20	kg	0.1%
Total	8,420	kg	100.0%	14,660	kg	100.0%



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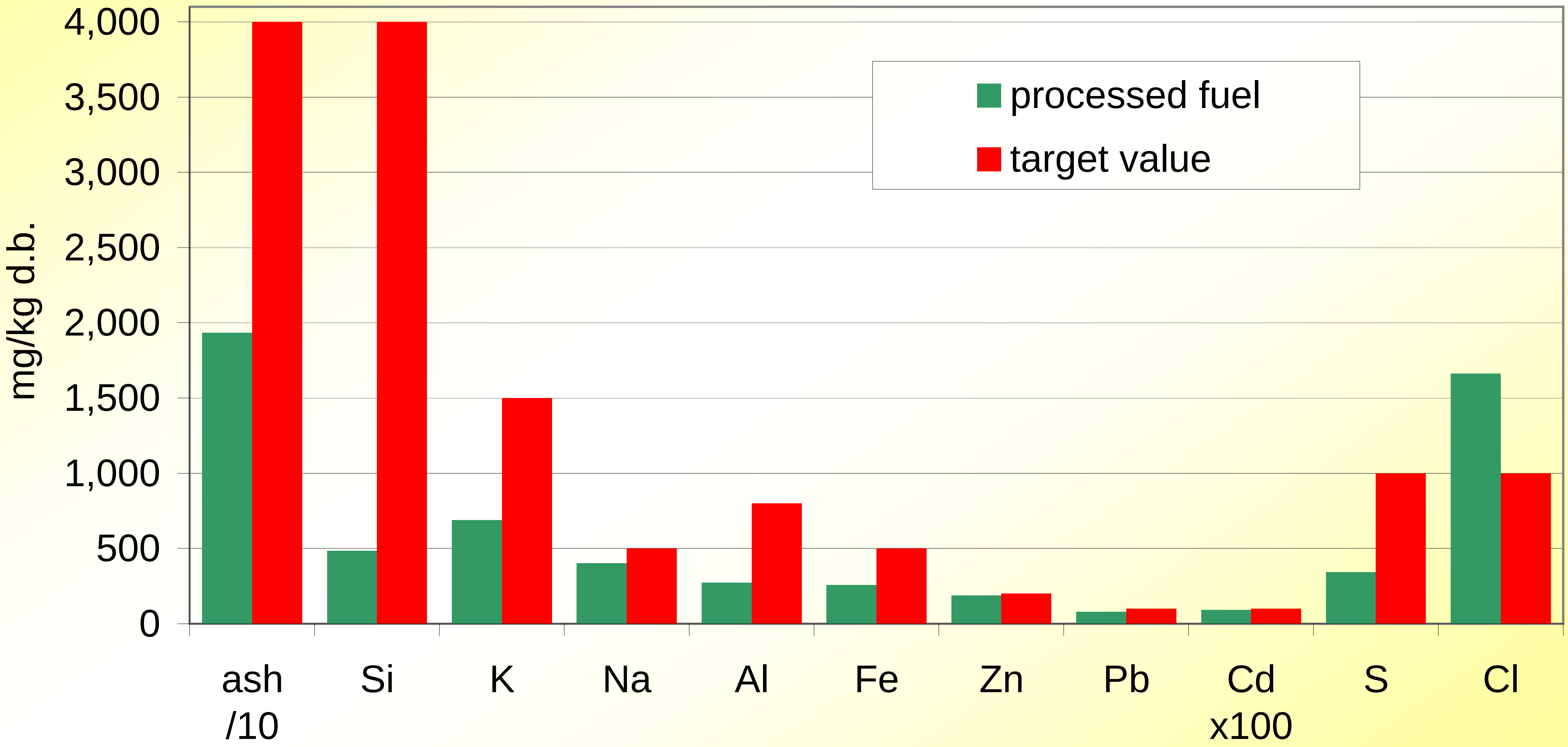
Results from wet chemical analyses of the processed fuel



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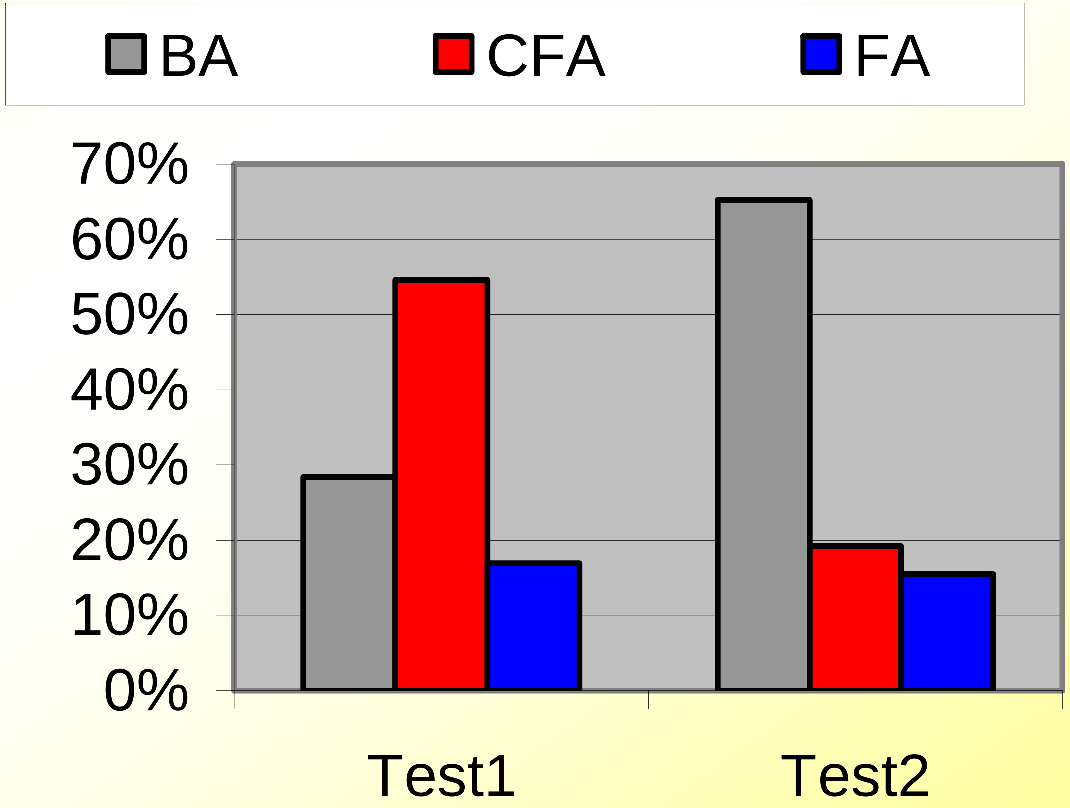
Combustion tests with processed and non-processed waste wood (I)

The total amount of ashes produced could be reduced to 50%

Ash distribution

Significant reduction of fly ash emissions (cyclone fly ash)

Consequently significant increase of the bottom ash



Explanations: Moving-grate fired furnace; nominal capacity 10 MW_{NCV}

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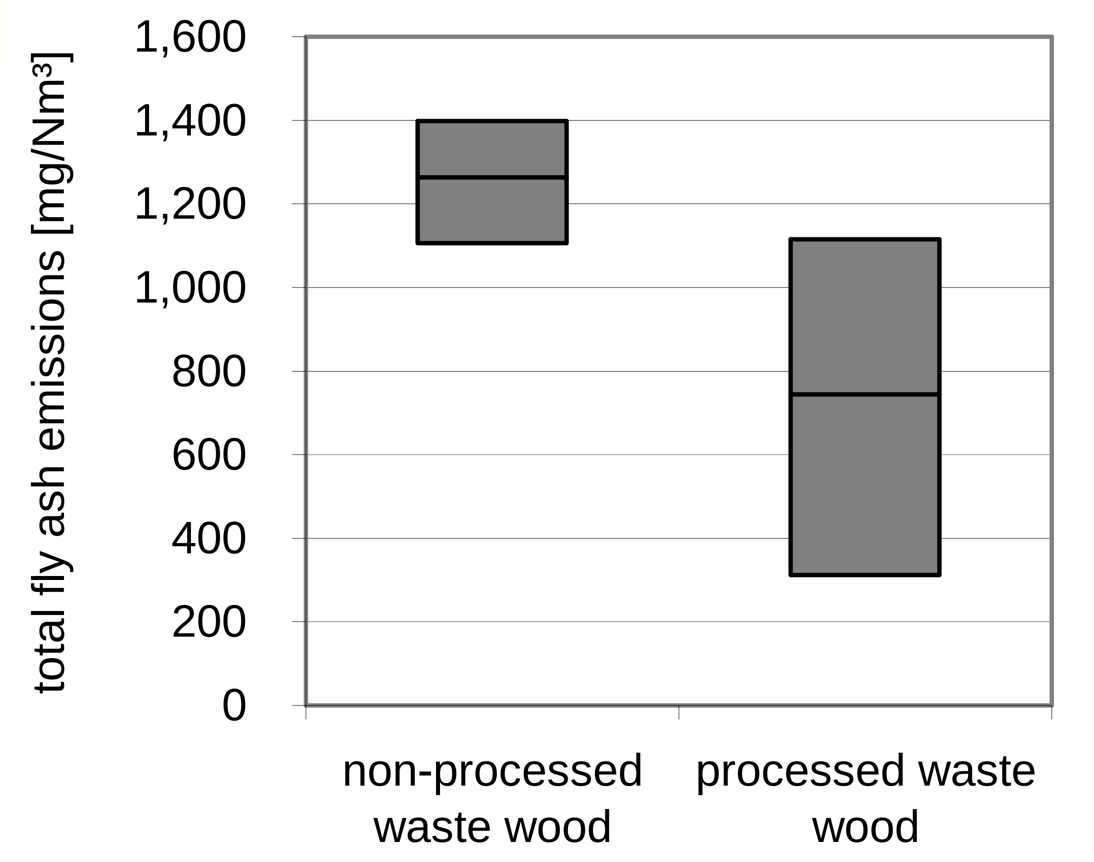
Combustion tests with processed and non-processed waste wood (II)

Total fly ash emission at boiler outlet:

Reduction from an average of 1.263 mg/Nm³ to 745 mg/Nm³ in average

(reduction to 59% of the initial emission)



Explanations: Moving-grate fired furnace; nominal capacity 10 MW_{NCV}
emissions related to dry flue gas and 13 vol.% O_2

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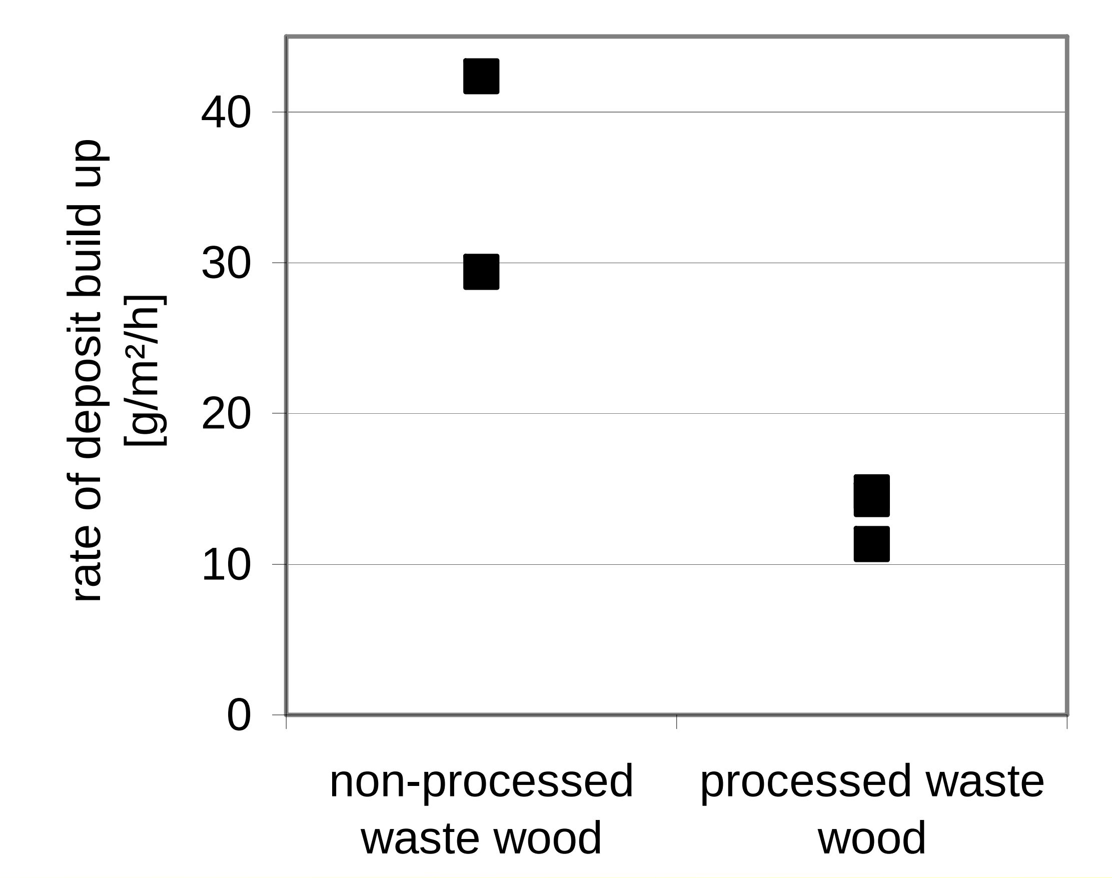
Combustion tests with processed and non-processed waste wood (III)

Deposit formation:

Reduction from
30 to 43 g/m²/h to in average
11,6 g/m²/h

The time between two plant shut downs for boiler cleaning could be increased from 2 to 3 months.



Explanations: Moving-grate fired furnace; nominal capacity 10 MW_{NCV}
measurement with and air cooled deposit probe; surface temperature of the sampling ring: 500°C

Conclusions (I)

- **By the application of a processing plant designed for waste wood the fuel quality can be improved significantly.**
- **Besides the precipitation of Fe and non-ferrous-metals the separation of undersized particles (<7 mm) is of special relevance.**
- **With the separation of this fraction the concentrations of almost all elements, which cause plant internal or emission related problems during combustion (Si, Fe, Al, K, Na, S, Zn, Pb), can be reduced significantly.**
- **Waste wood processing is therefore an intelligent and efficient primary measure to minimise problems in waste wood combustion plants.**

Conclusions (II)

- Only the Cl-concentrations could not be influenced with the waste wood processing plant developed.
- Regarding Cl mainly a correct reception inspection is of relevance.
- Advantages of the waste wood processing plant presented
  - Significant reduction of the ash content of the fuel
  - Therefore, reduction of the amount of ashes formed during combustion (reduced ash logistics and costs for ash disposal)
  - Reduction of ash deposit formation in the furnace and the boiler
  - Reduction of the fly ash emissions at boiler outlet
  - Longer operation periods between plant shut downs for cleaning
- Disadvantages of the waste wood processing plant presented
  - About 15 wt.% of the fuel are precipitated as undersized fraction.
  - Possibilities for utilisation: densification or combustion in waste incineration plants.

Thank you for your attention

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