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Combustion properties and environmental performance during small scale combustion of pelletized hardwood raw material of aspen

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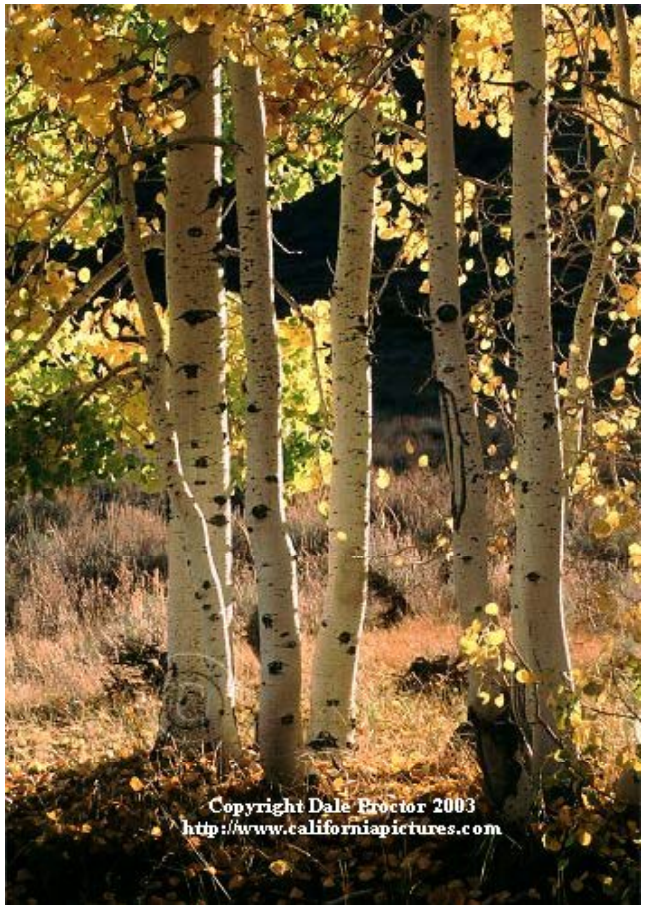
Outline

- Background
- Potential of hardwood raw material
  - InterReg Nord project report
- Combustion evaluation study - objectives
- Experimental procedures
- Results
- Conclusions

Background

- Limited availiability of traditional softwood raw material for fuel pellets production in Scandinavia
- New biomass assortments needs to be introduce on the market
- Hardwood (e g birch and aspen) might be a potential feedstock for fuel pellets
- Potential to use whole trees from thinning have been discussed



Potential of white hardwood in northern Scandinavia and the St Petersburg region –
Report from an InterReg project

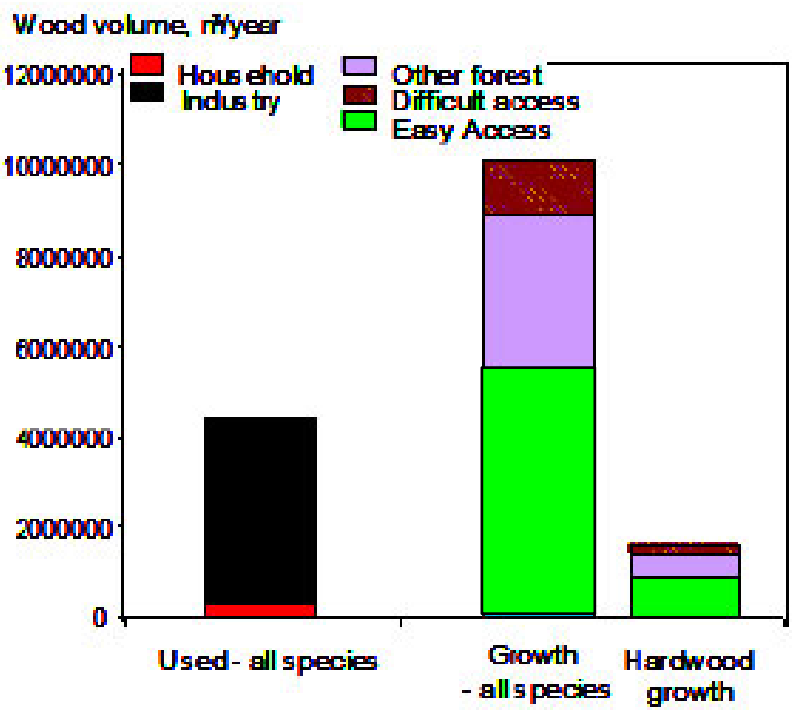
Lundmark A. Glommers Miljöenergi AB, 2007
" Inventory and analysis of commercial use of white hardwood"
Project CCI 2000 CB 16 0 PC 021 within Interreg IIIA Nord

Glommers Miljöenergi AB, Arvidsjaur municipal, Norut Teknologi and *WICNWR St Petersburg* have analysed possible ways of utilising aspen

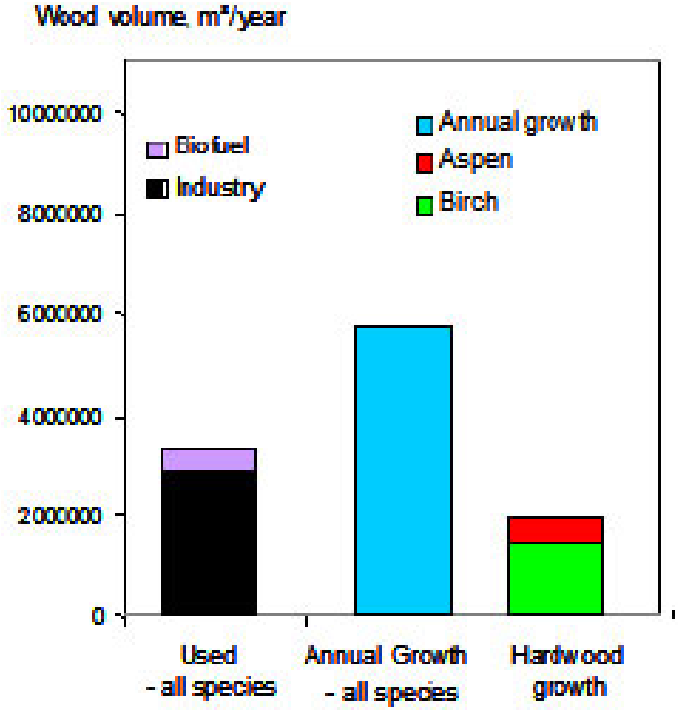
- In northern Sweden most of the available white hardwood (birch) is already used by the paper mill industry and production of matches (small amounts of aspen)
- Leningrad Oblast in Russia has a significant amount of white hardwood, including birch and aspen, today used commercially to a limited extent
- Aspen is to little or no extent used as a fuel *("aspen has little value as a heating fuel")* and **a goal of the project was to evaluate aspen raw material as a possible heating fuel used as pellets**

Significant potential for increased utilisation of forest based resources, including hardwood, in northern Sweden and Russia

Norbottens län, Sweden



Leningrad Oblast, Russia



- Also other regions in Russia have significant hardwood resources
- Lack of forest roads in some areas in Russia → redused accessibility

Combustion evaluation study of aspen pellets

Overall ojective

- Study the combustion properties and emission performance during combustion of pelletized hardwood raw material in typical residential appliances

Specific objectivs

- Determine:

  i) combustion performance (ash formation, accessibility and slagging tendencies)
  ii) environmental performance (emissions of gases and particles) in present residential appliances
  iii) combustion characteristics (total conversion time/reactivity) of single pellets

Experimental procedure

Raw material and fuel pellets

- Unbarked aspen trees including branches and twigs cutted in northen Sweden

  Similar quality as Russian aspen (Prof. Iwan Westerlund, SLU Umeå)

- Self-dried (to 15-16%) → Made into chips → Grinded (hammer mill)

  Grinding process required a little bit more time since the aspen wood is slightly softer than e g pine, spruce and birch

- Pelletized at the Biofuel Test Station in Glommersträsk

  (pellet press OGM 1.5)

700 kg of 8 mm aspen pellets produced that were equivalent to typical wood pellets made from softwood concerning bulk density, length, and fine fraction

Length: 12±5 mm
Bulk density: 645 kg/m^3
Pellet density: 1175±10 kg/m^3
Fines (<5.5 mm): <2%
Moisture content: 8.1%
Ash content: 1.0%

→ ***Aspen raw material shows acceptable properties for pelletizing***

Combustion tests in residential appliances

• 24 h combustion in two residential pellet burners in a Combifire boiler; *under-fed burner* (continous operation at nominal load 10 kW) and *over-fed burner* (intermitted operation 4.5 kW)

• Emission measurements;

CO and NO (electrical sensors)

SO_2 and HCl (FTIR)

TSP/PM_{tot} (standard filter sampling at 150 °C)

Particle size distribution (DLPI, 0.03-10 µm)

• After test runs;

Inspection of burners/boiler regaring *ash formation, slagging tendencies* and *unburned fraction* in ash

Chemical analysis of potential *slag* and *PM samples* by SEM/EDS (elemental composition)

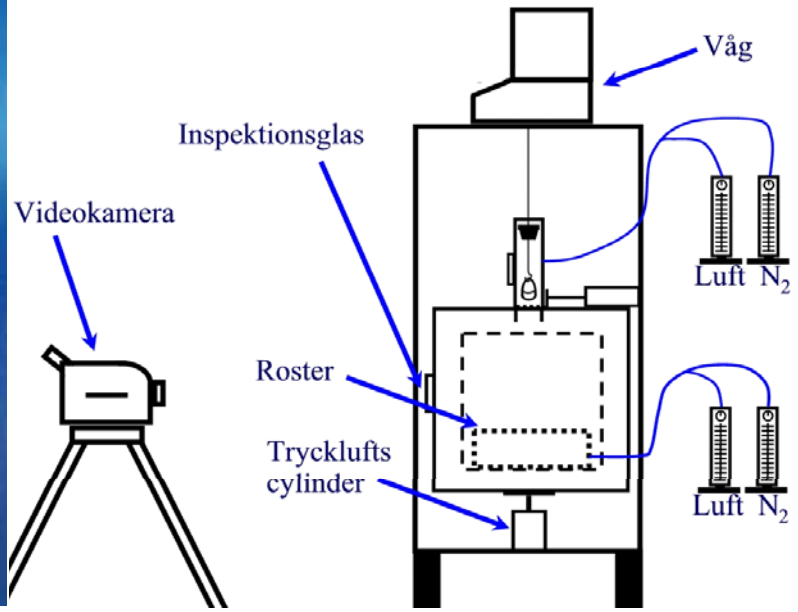
Single pellet combustion characteristics

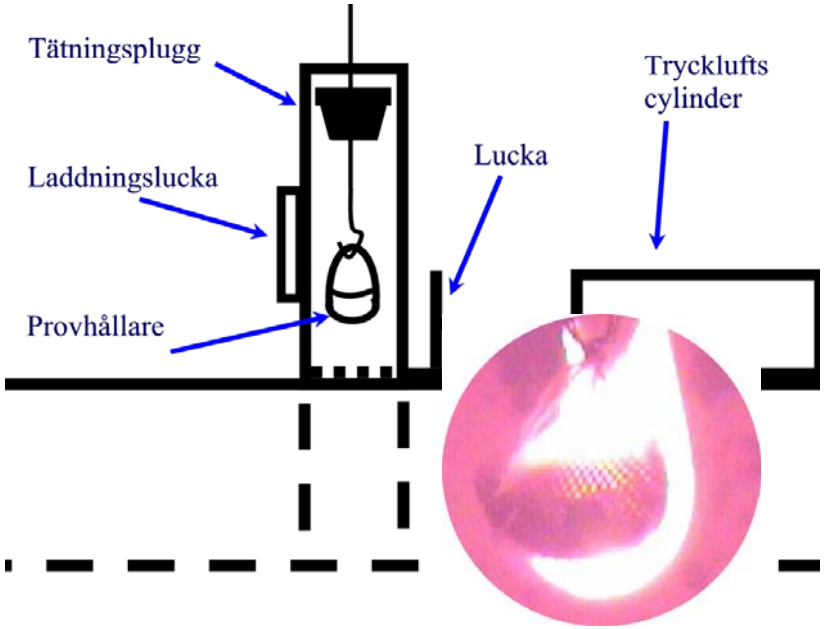
- Tests in an electrically heated laboratory furnace:

  - drying, pyrolysis and char conversion times
  - pellets shrinkage and weight reduction after pyrolysis
  - char yield and density

- 2 conditions: Low temp and O_2 (800ºC, 10% O_2)
  High temp and O_2 (1000ºC, 21% O_2)

- Pellets of aspen, mixed softwood (commercial pellets), spruce and pine
  Rather equal pellet densities, 3-4 replicates per fuel assortment





Results

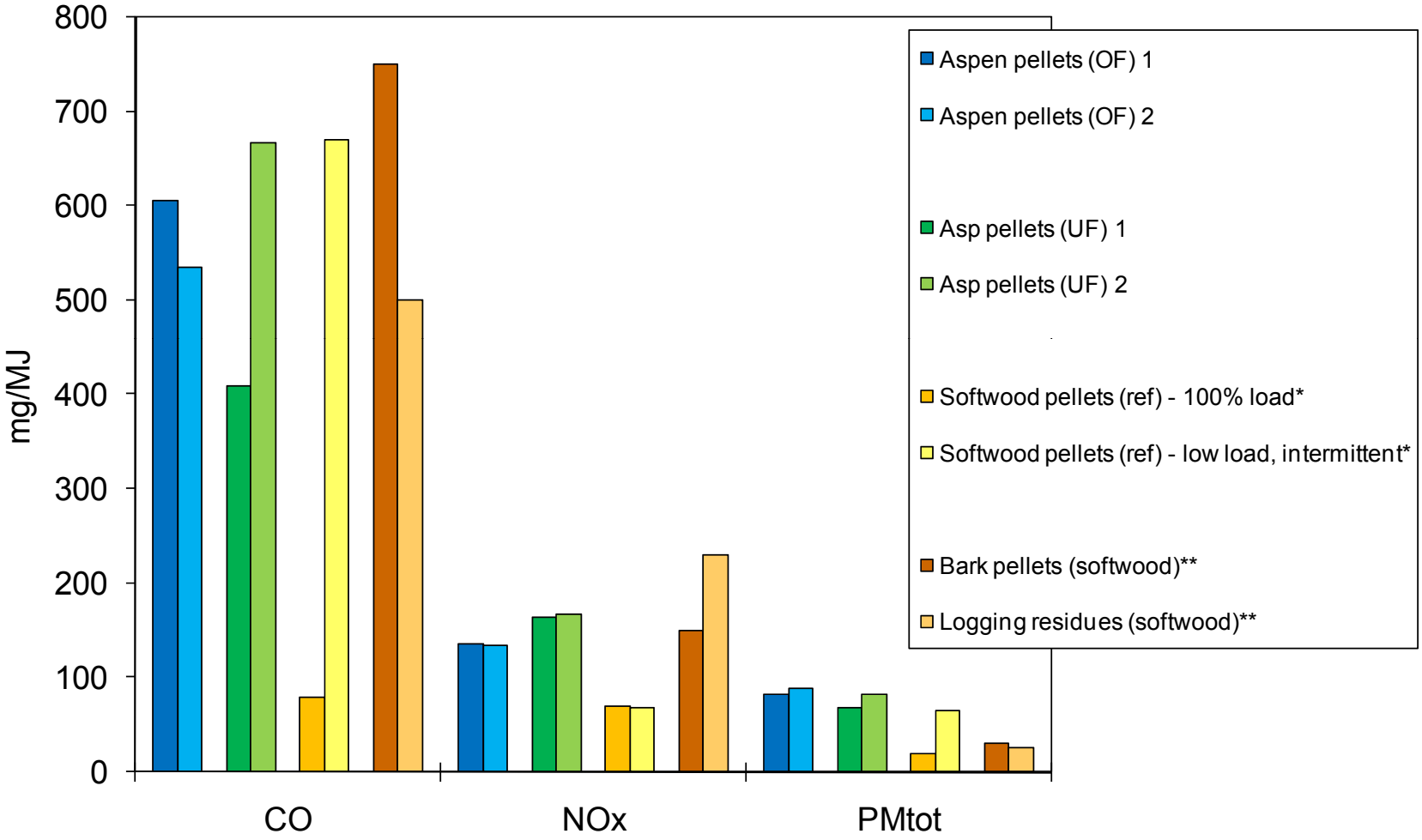
Combustion performance and ash related aspects

• Relatively high fraction of unburned material in bottom (boiler) ash, i.e. 5 and 11% for the over- and under fed burner respectively

• No slagging tendencies and very ”fluffy” ash in both burners, only small pieces (~20 g) of porous ”cakes” in the over-fed burner

Emission – concentrations

(measured during continous operation)



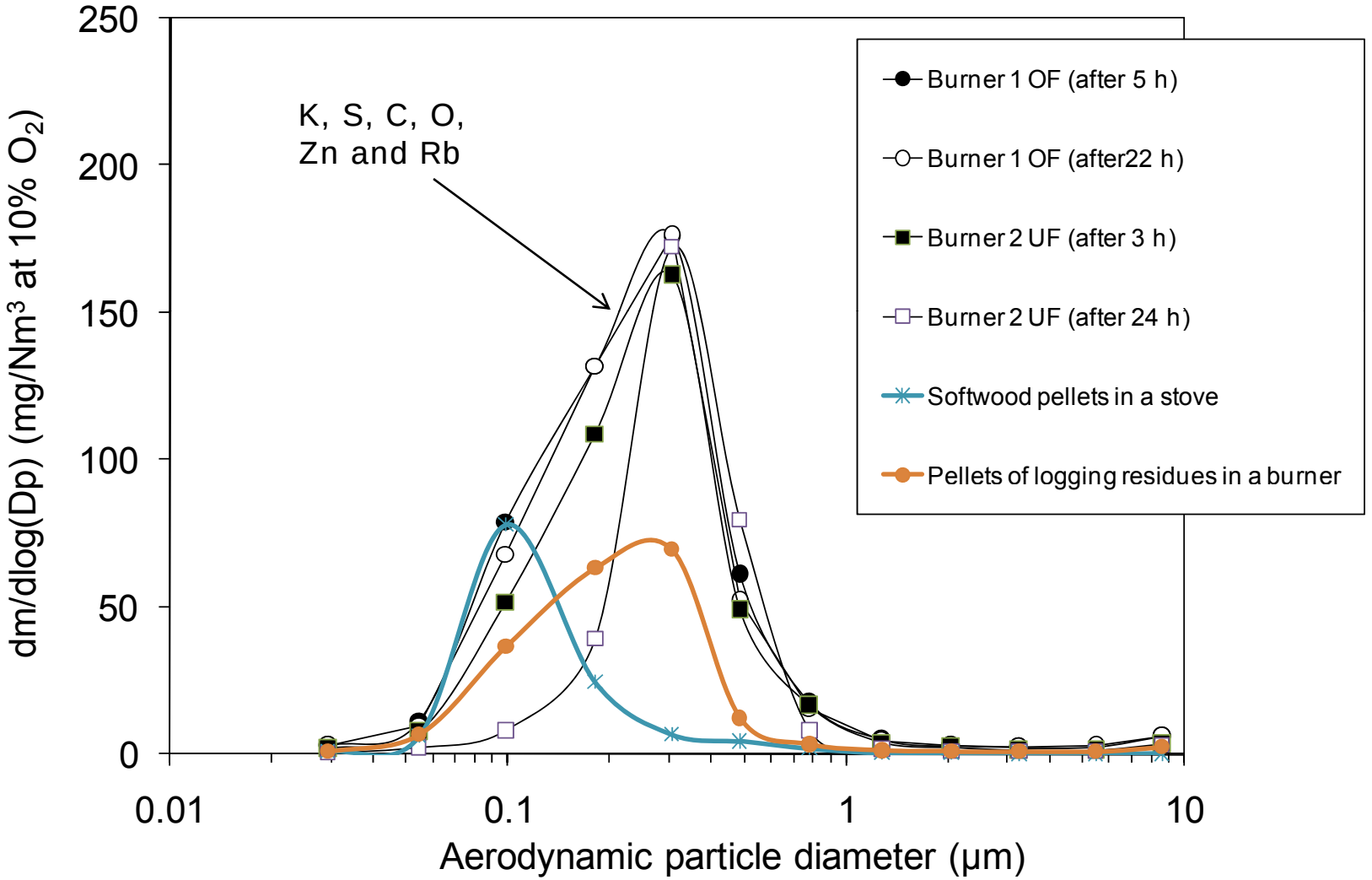
SO_2 <1 ppm

HCl (one burner) 2-4 mg/MJ

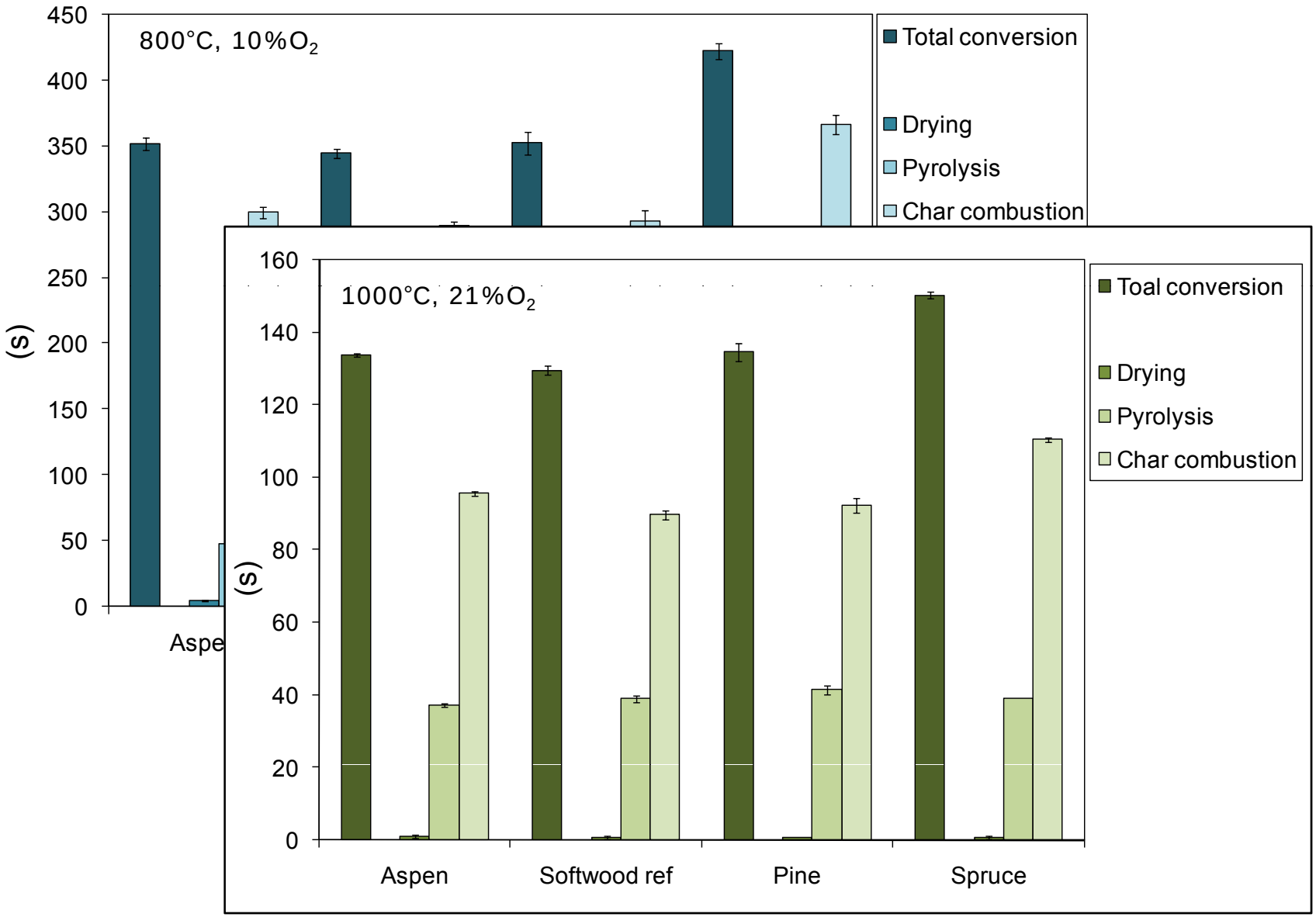
* Johansson et al. SP Report 2003

** ETPC, Umeå university, unpublished data

Emissions - particle size distribution and composition

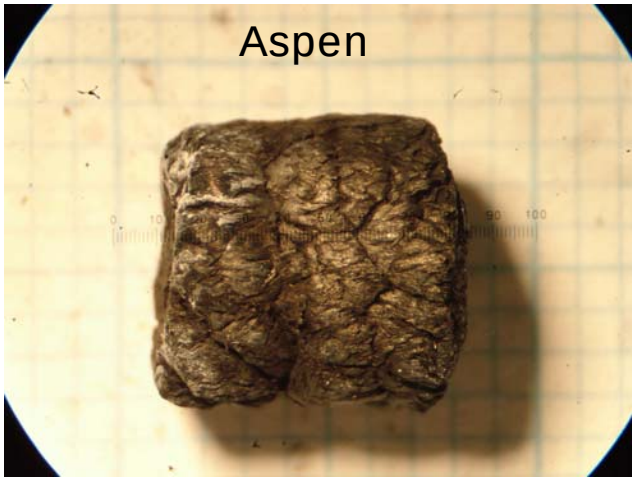


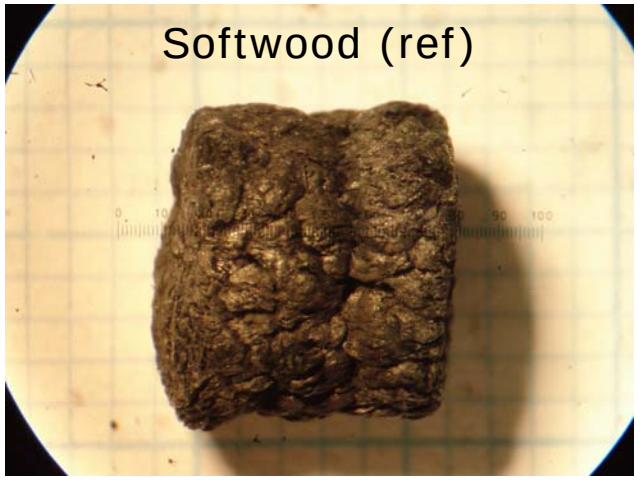
Single pellets combustion characteristics - conversion times



Single pellets combustion characteristics – char properties

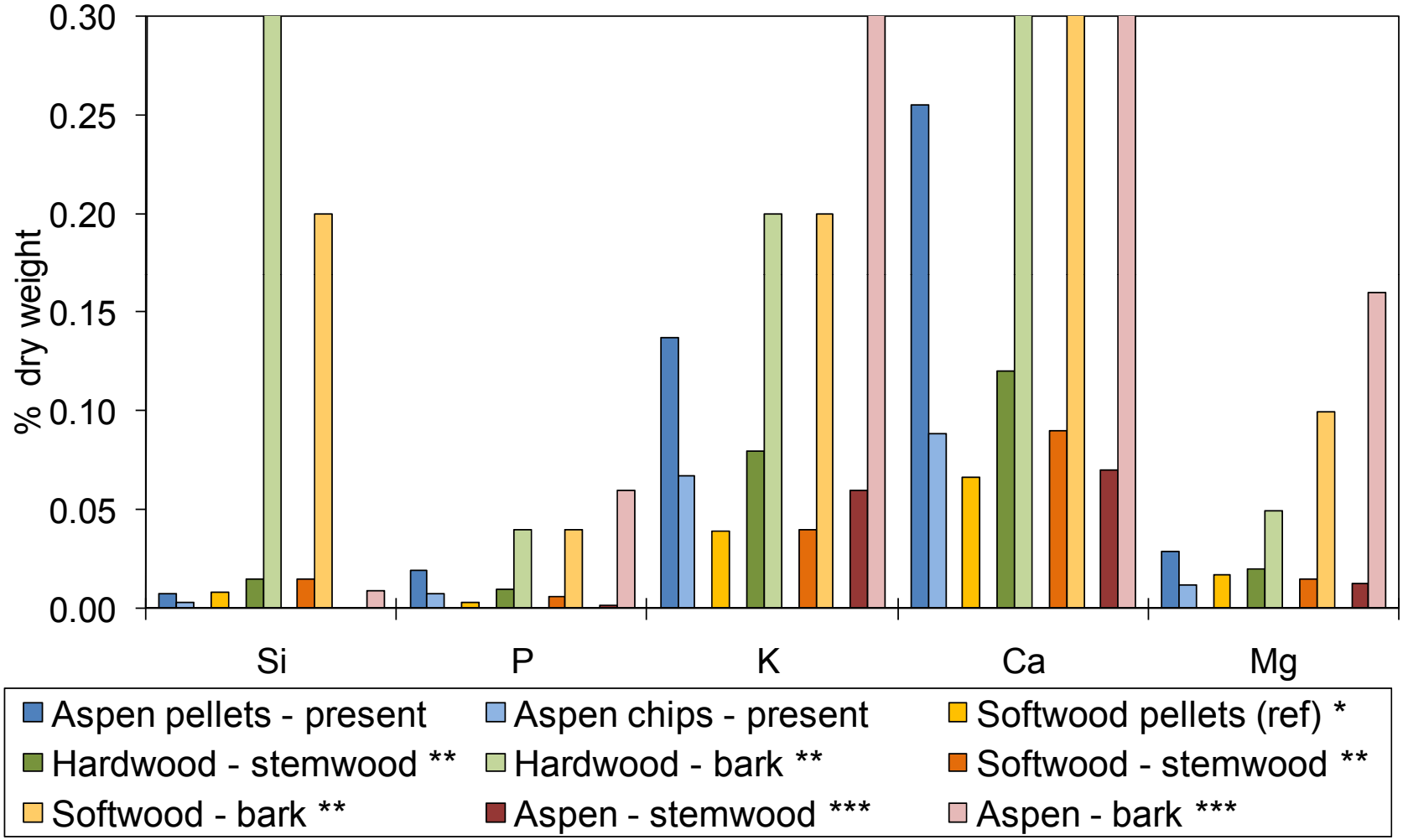
Char residues (1000°C, 21%O_2)





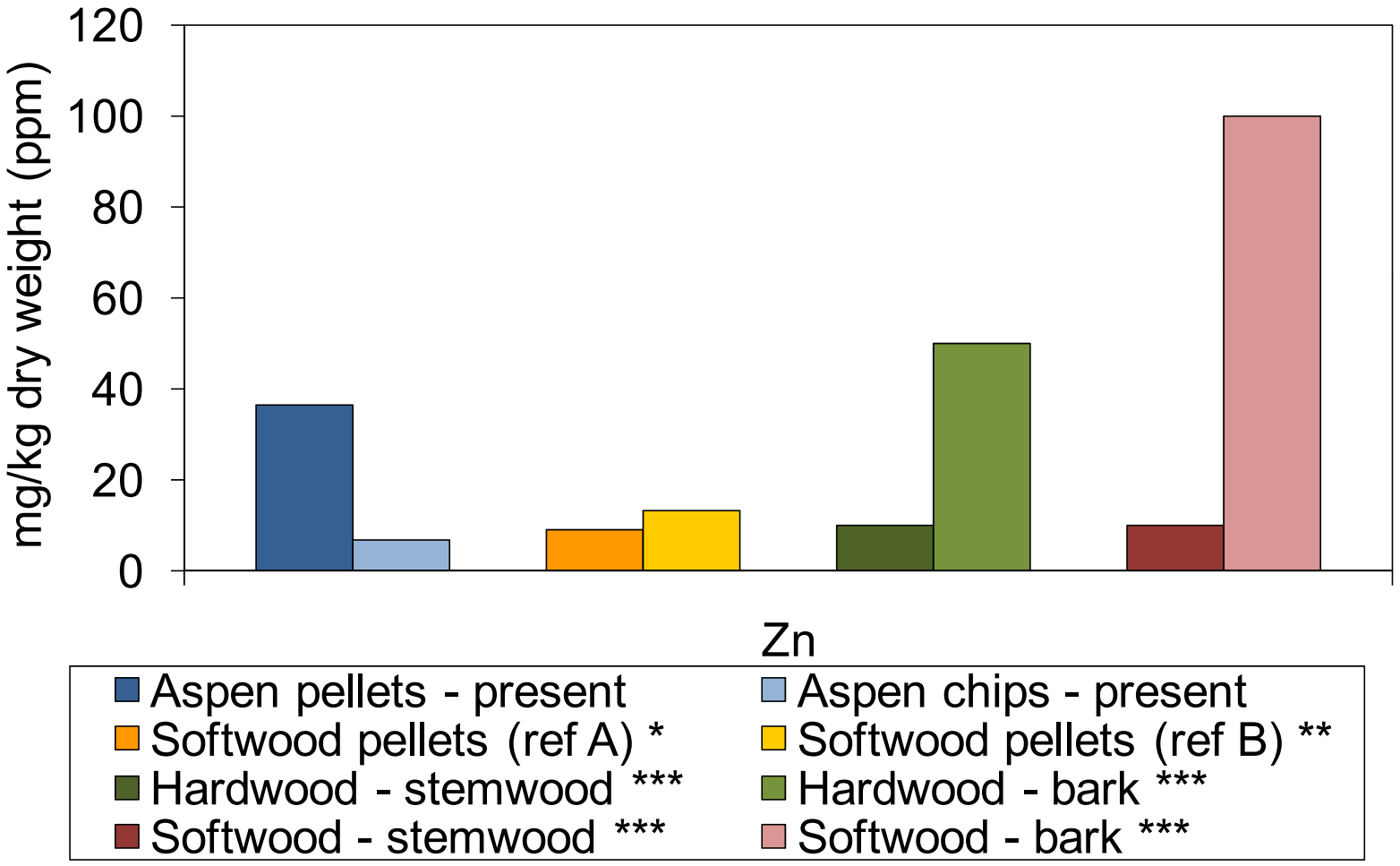
	m/m_0 (%)	*l/l_0 (%)*	*d/d_0 (%)*	*Char density (kg/m^3)*
800°C, 10% O_2				
Aspen pellets	14.3 ± 0.2	89.9 ± 1.7	83.3 ± 0.7	270 ± 8.7
SoLett Biopellets (ref)	13.3 ± 0.2	89.0 ± 3.1	87.9 ± 3.2	234 ± 15.8
1000°C, 21% O_2				
Aspen pellets	11.8 ± 0.1	88.2 ± 1.8	85.0 ± 1.8	219 ± 7.3
SoLett Biopellets (ref)	11.1 ± 0.2	88.1 ± 1.4	89.1 ± 2.6	193 ± 13.4

Ash forming elements and trace metals – a comparison with other woody biofuels



* Softwood pellets from Glommers Miljöenergi AB, ** Europeen reference data (CEN/TC 335—WG2 N94) [13], *** Werkelin J. et al, 2005.

Increased concentrations of some ash forming elements as well as trace metals (Zn, Cu ,Pb) compared to standard softwood pellets



* Softwood pellets from Glommers Miljöenergi AB, ** Obernberger I. et al, 2004,
*** Europeen reference data (CEN/TC 335—WG2 N94)

Conclusions

- Significant potential of hardwood resources for energy purposes exist in Russia and potentially also in northern Sweden
- Aspen seem to be suitable for pellets production regarding pelletizing process and pellet fuel quality
- No/low slagging potential (low Si and high Ca in ash)
- Higher NO (fuel related!) and CO (appliance/fuel related!?) than typical softwood pellets
- Similar combustion behavior (i.e. conversion times) were seen for single aspen pellets compared to reference pellets
- Similar char yield determined, although with somewhat increased shrinking and densification of the char for the aspen pellets compared to reference pellets
- In general, whole tree assortments will increase the content of ash forming elements and trace metals in the fuel
- This first pilot study with aspen pellets is promising but needs further evaluation and verification before any general conclusions/recommendations can be made

InterReg inventory project - Report

Lundmark A. ***Inventory and analysis of commercial use of white hardwood.*** Glommers Miljöenergi AB, 2007. Project CCI 2000 CB 160PC021 within Interreg IIIA Nord.

Combustion evaluation of aspen - Report

Boman C, Israelsson S, Öhman M, Lundmark B.
Förbränningsegenskaper och miljöprestanda vid småskalig eldning med pelleterad lövvedsråvara av asp / Combustion properties and environmental performance during small scale combustion of pelletized hardwood raw material of aspen.
Swedish Energy Agency, Report P30011-01, 2007. (Also as Umeå University report, ISSN 1653-0551, ETPC Report 07-01)

Thanks for your attention!

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