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Fluidized Bed Combustion of Biomass and Waste-derived Fuels – Current Status and Challenges

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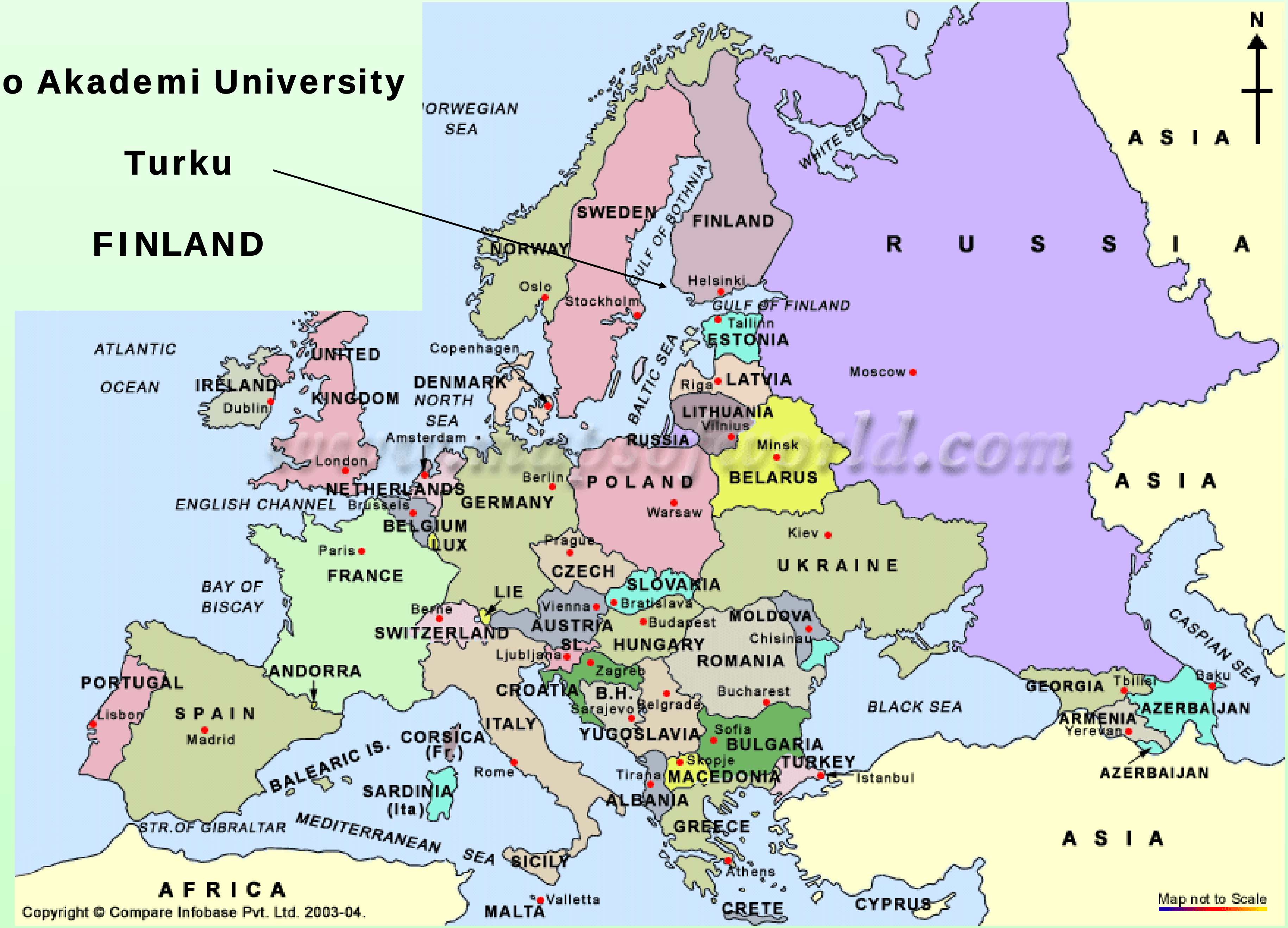
FINLAND



Åbo Akademi University
Process Chemistry Centre

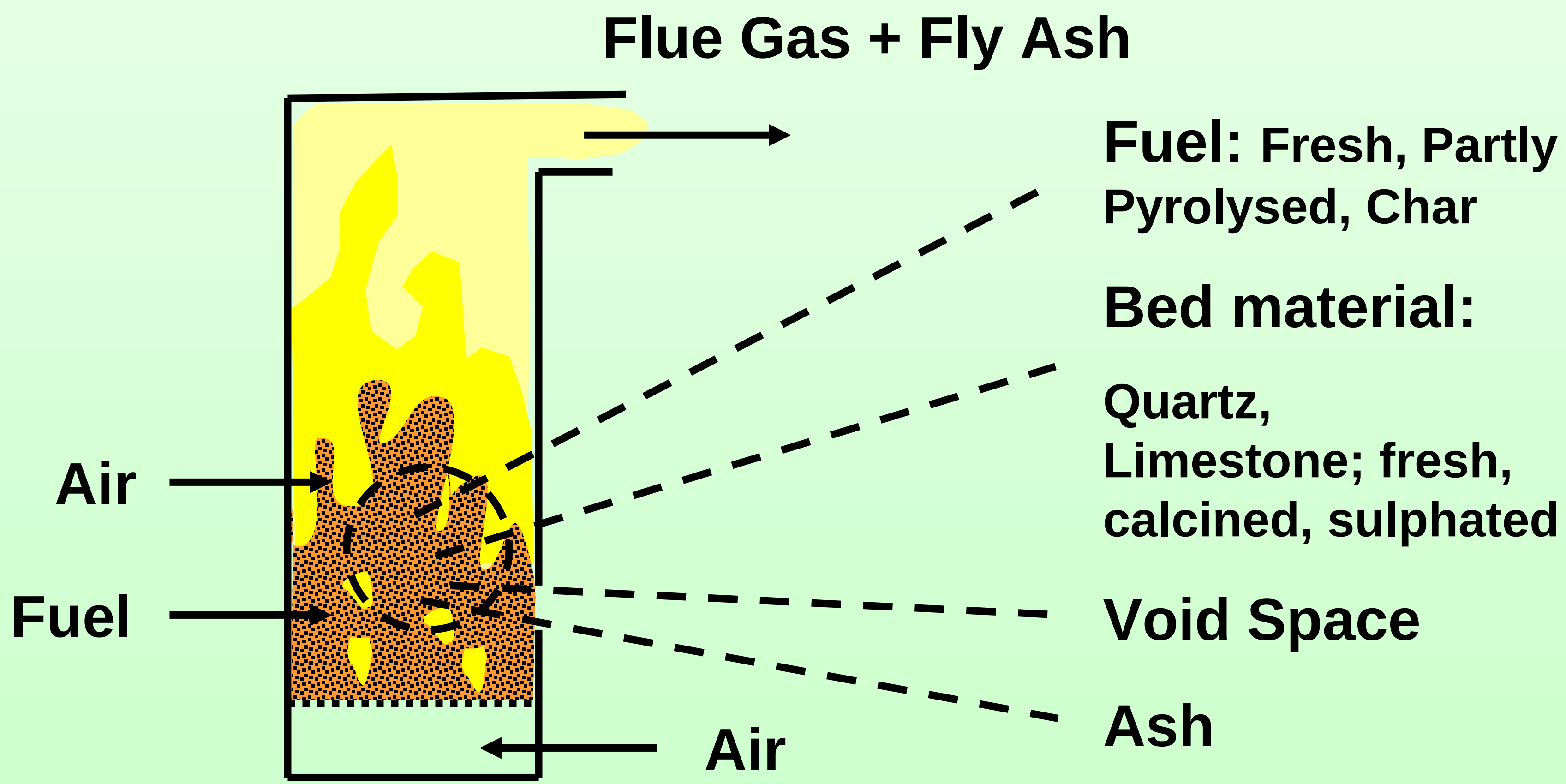
- Combustion chemistry
- Wood and paper making chemistry
- Sensors and process analysis
- Kinetics and catalysis

20 faculty and post docs
35 ongoing PhD Theses
Intense collaboration with industry

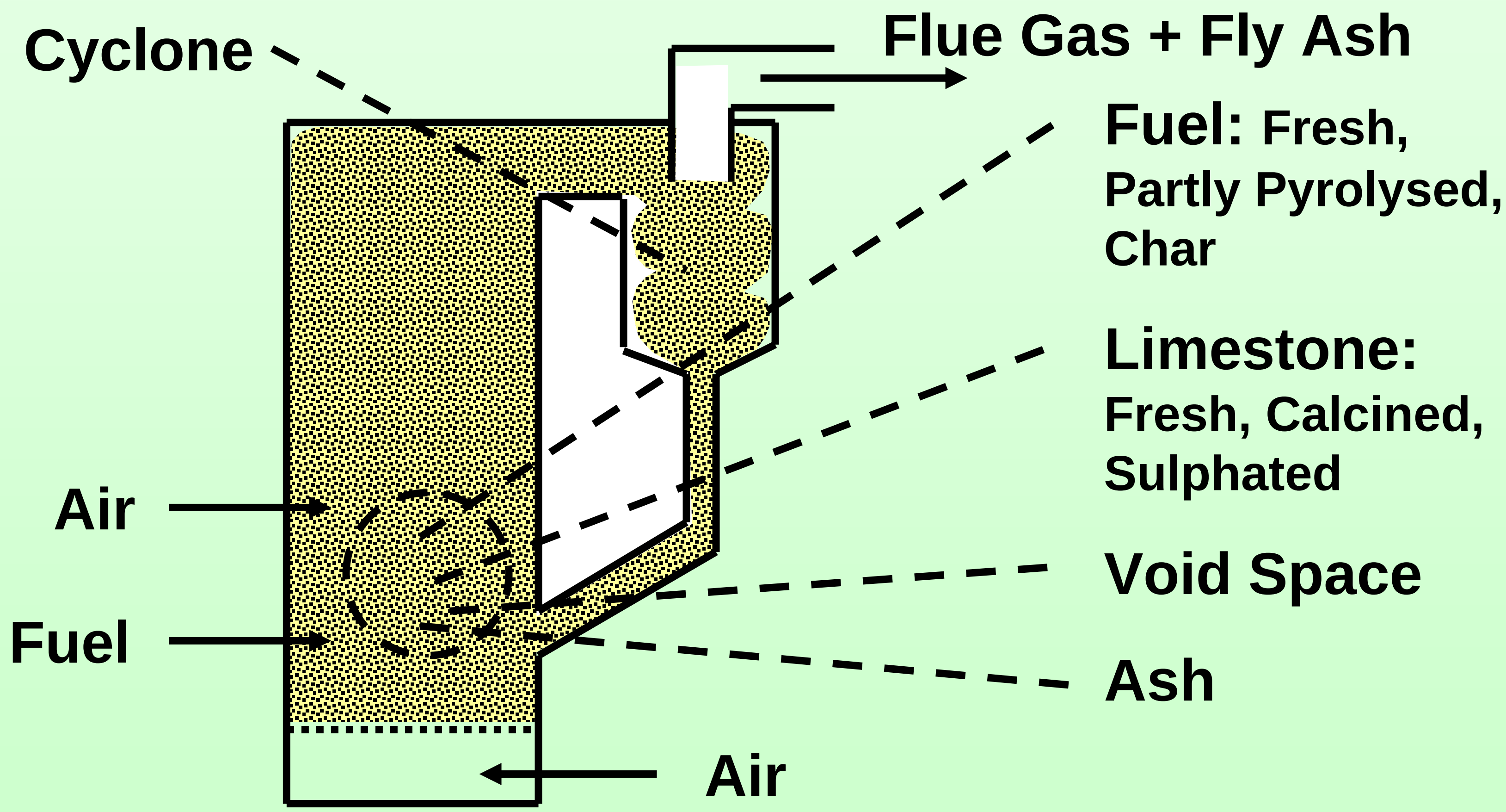
Fluidized Bed Combustion of Biomass and Waste-derived Fuels – Current Status and Challenges

- Introduction
- Status of the FBC technology
- Current research
- Fluidized bed gasification
- Conclusions

Bubbling Fluidized Bed Combustion



Circulating Fluidized Bed Combustion



Fluidized Bed Combustion Systems

BFBC: Bubbling Fluidized Bed Boilers
- fluidization velocity 1-3 m/s
- reactive fuels (wood and biomasses)

CFBC: Circulating Fluidized Bed Boilers
- fluidization velocity 6-10 m/s
- less reactive fuels (coal, oil shale, petroleum coke)

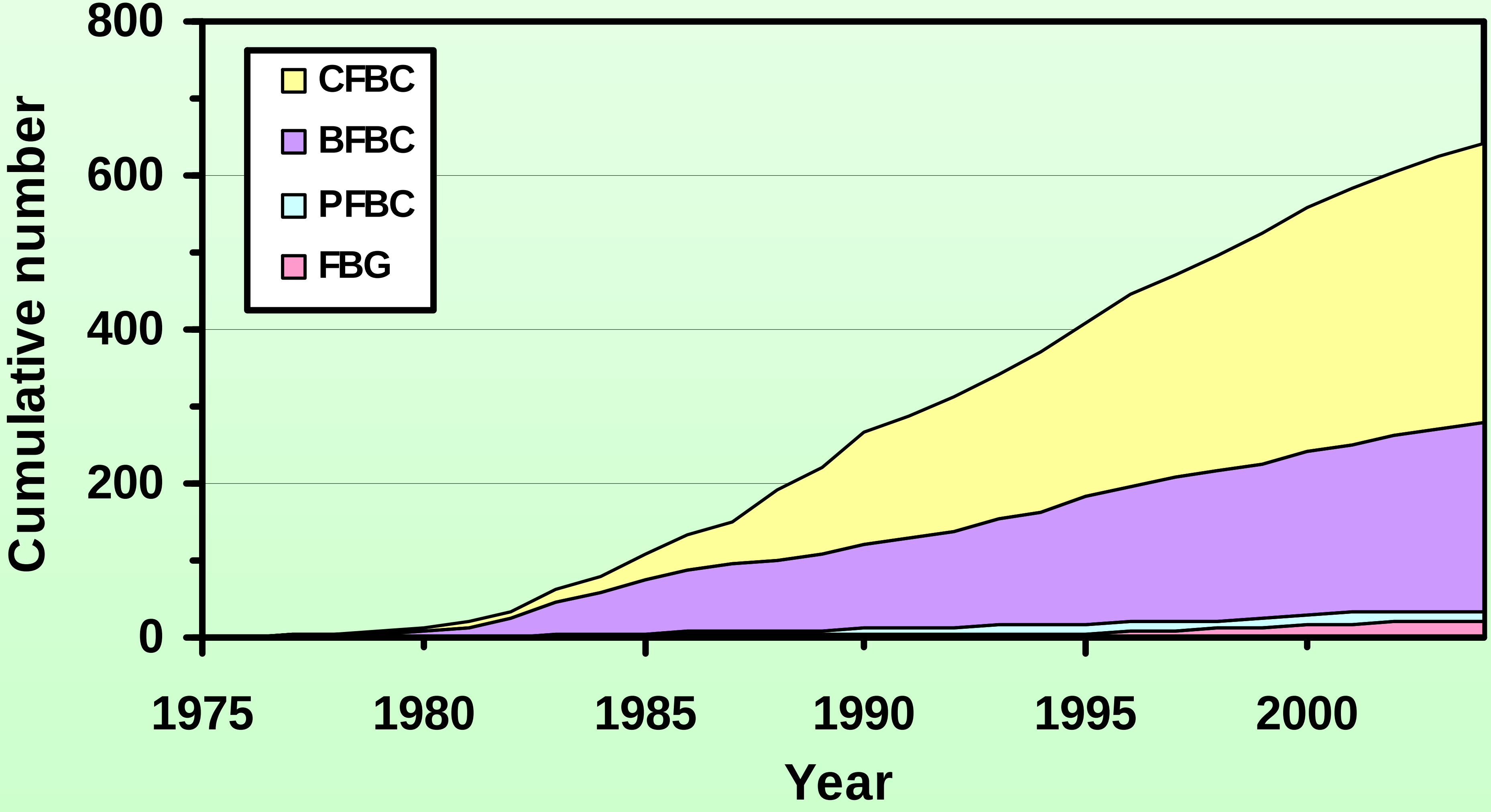
Fluidized bed boilers – common features

+ low combustion temperature
+ flexible to fuel quality and variations
+ high combustion efficiency
+ low NO
+ easy SO_2 reduction

- ash components may cause bed sintering
- residual ash may be difficult to dispose

Commercial status

Number of FB devices worldwide (2004)



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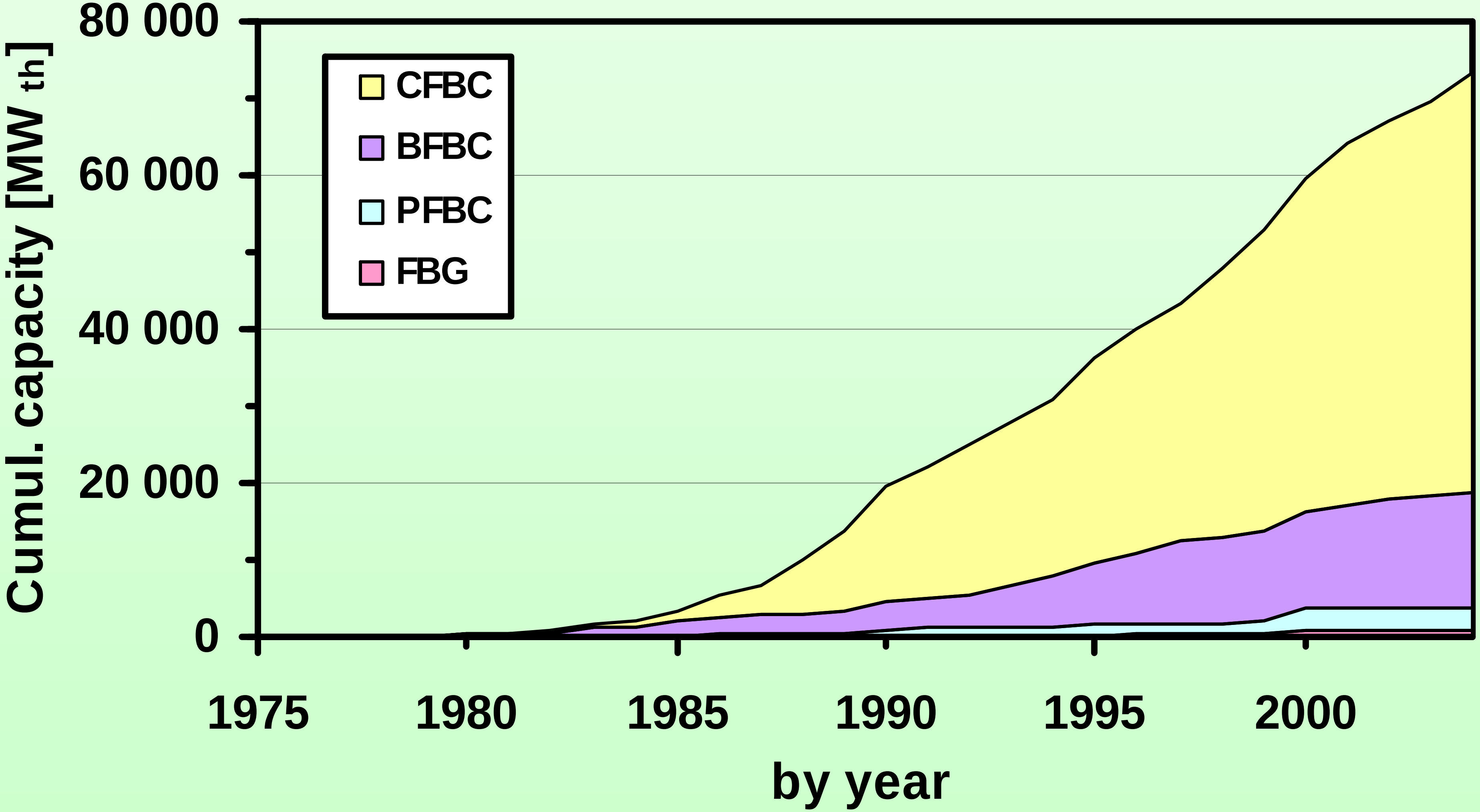
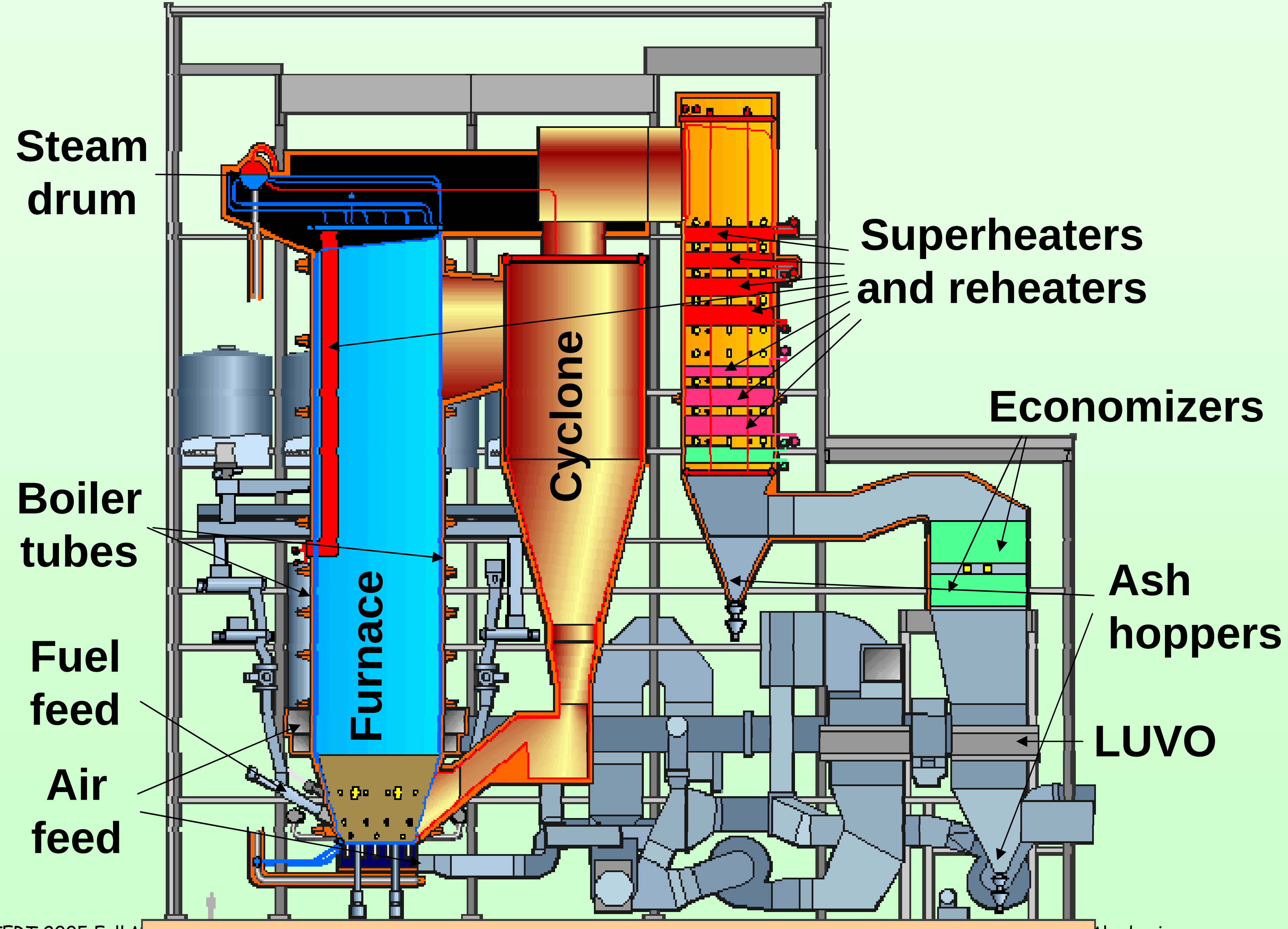
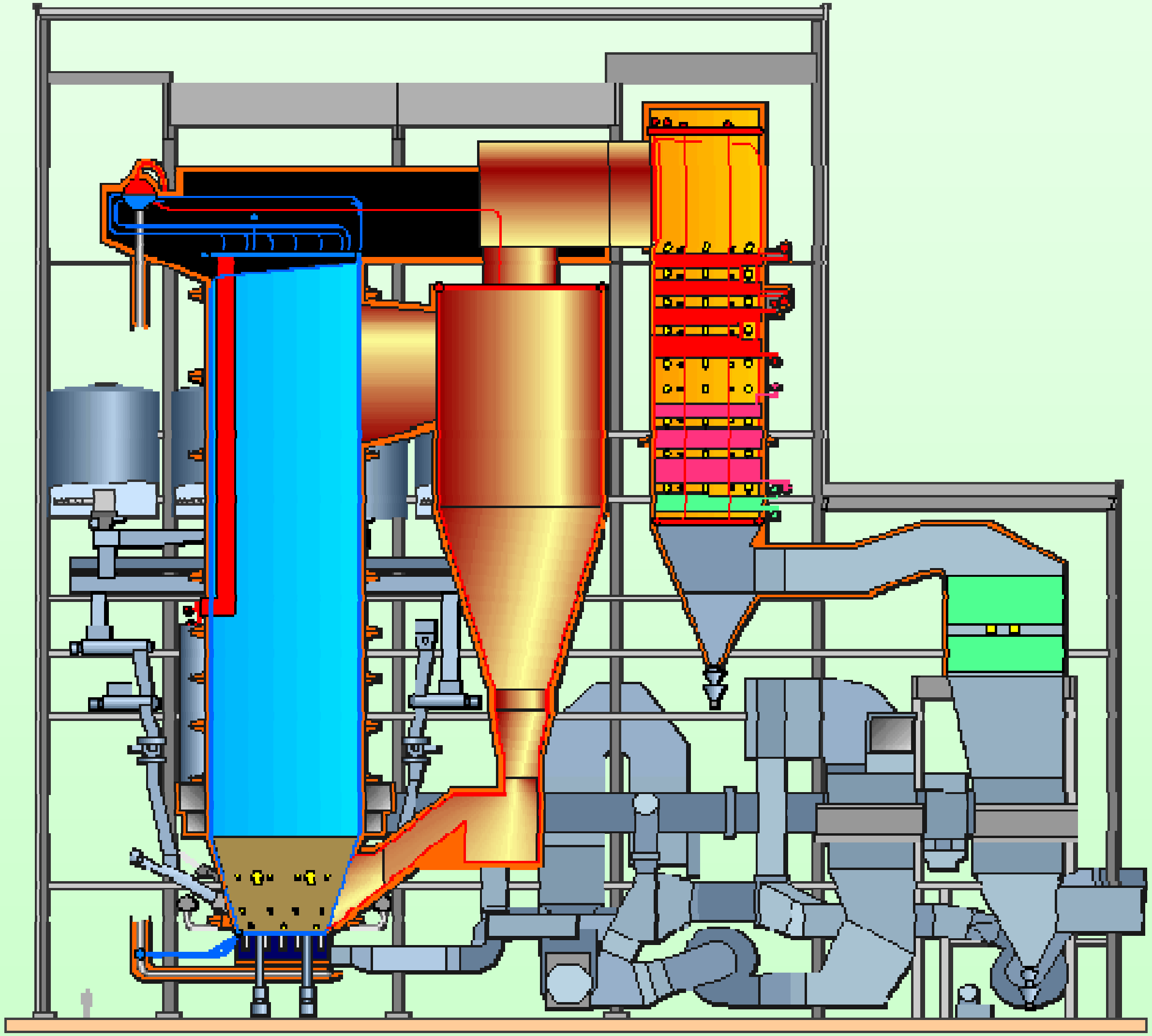
Capacity of FB devices worldwide (2004)




Steam drum
Superheaters and reheaters
Economizers
Boiler tubes
Cyclone
Furnace
Ash hoppers
Fuel feed
Air feed
LUVO



Alholmen CFBC
Jakobstad, Finland

550 MW (545 C)

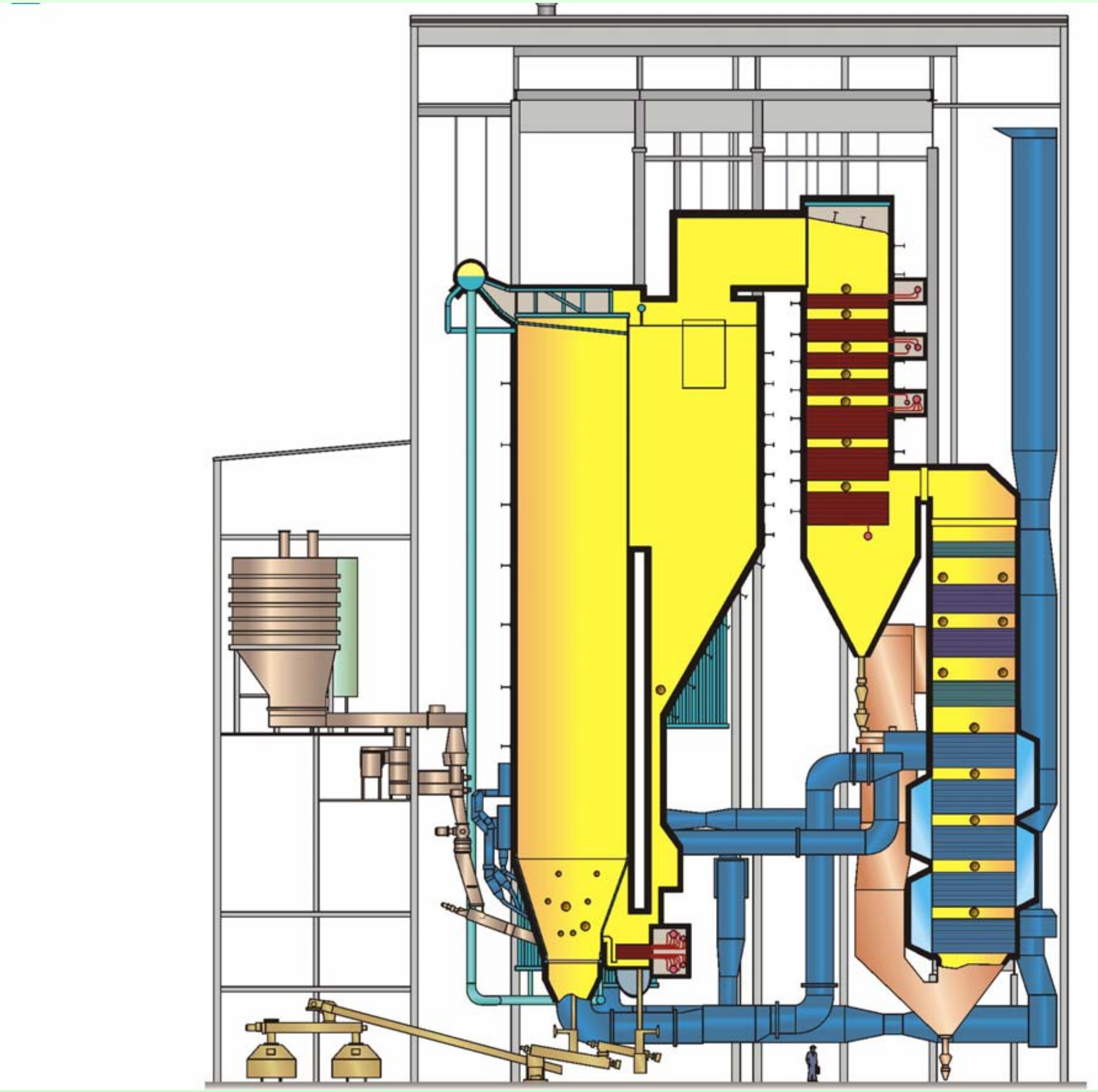
Peat, Bark, REF, Forest Residue, Sawdust, Coal, Oil

Boiler Efficiency 92 %

NO_x	**50**	**mg/MJ**
SO_2	**100**	**mg/MJ**
Particulate	**30**	**mg/m^{3}n**

Kvaerner Power Oy - 2001

Mälarenergi AB, Västerås



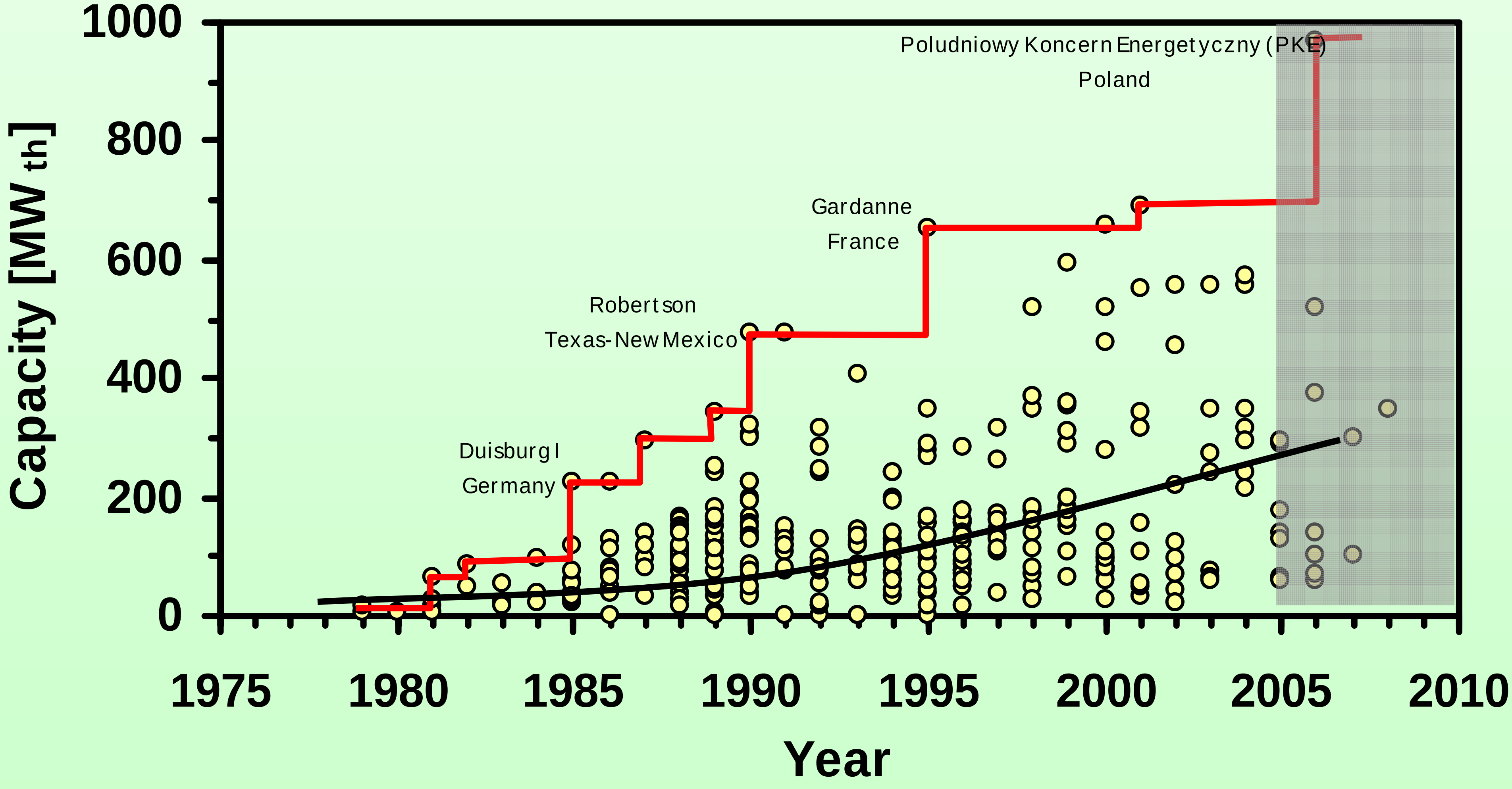
157 MWth

170 bar
540 C

wood residues
peat
coal

Foster Wheeler
2002

Thermal Power (MW_{th}) of the CFBCs Worldwide

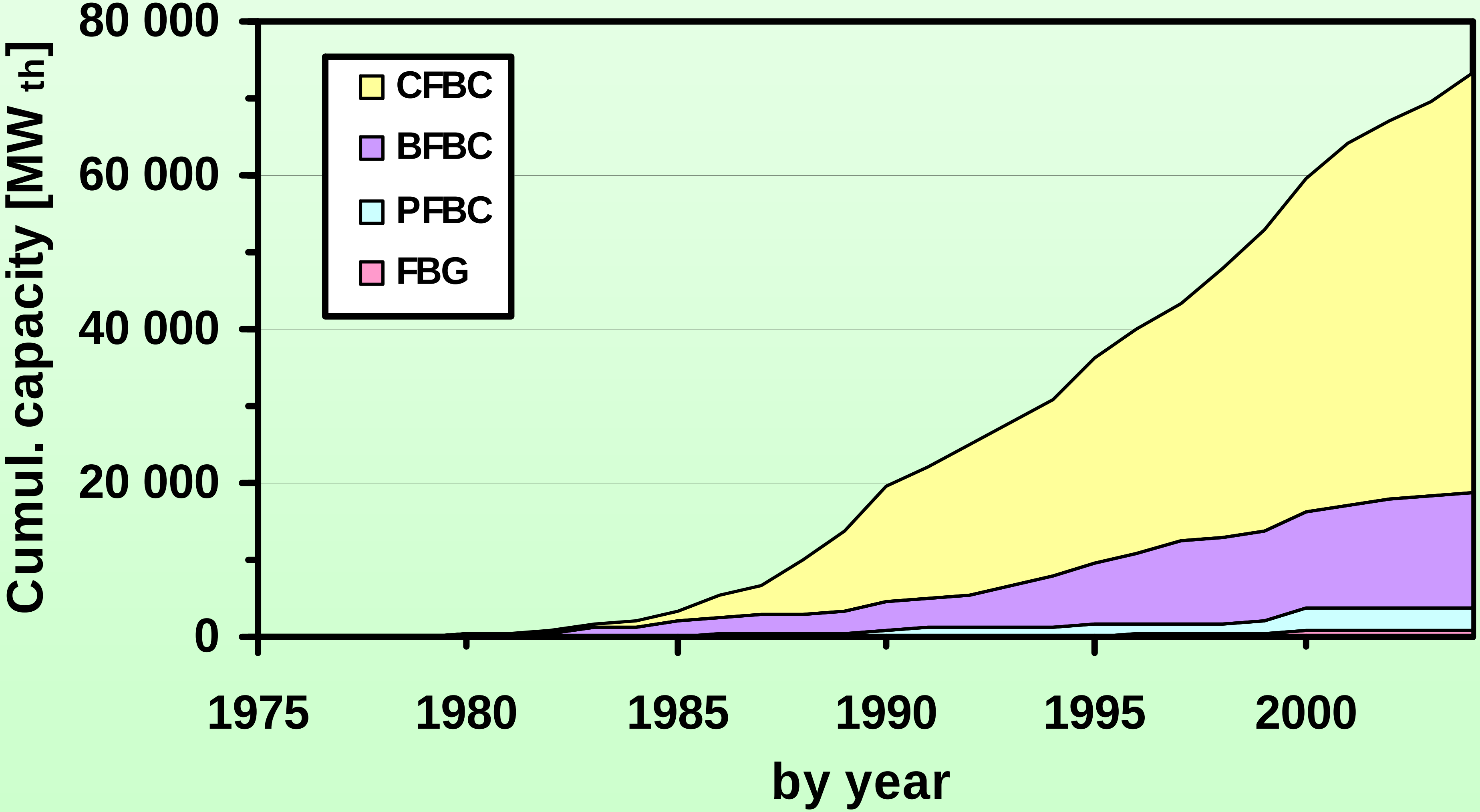


Boilers in by Chinese Companies

Zhongyang Luo, Kefa Zen (2005)

- 150 MW_{th} range: 50+ units operating
- 300 MW_{th} range: 10 operating + 10 under construction
- 400 MW_{th}+ range: 100 units commisioned/under constr.

Capacity of FB devices worldwide (2004)



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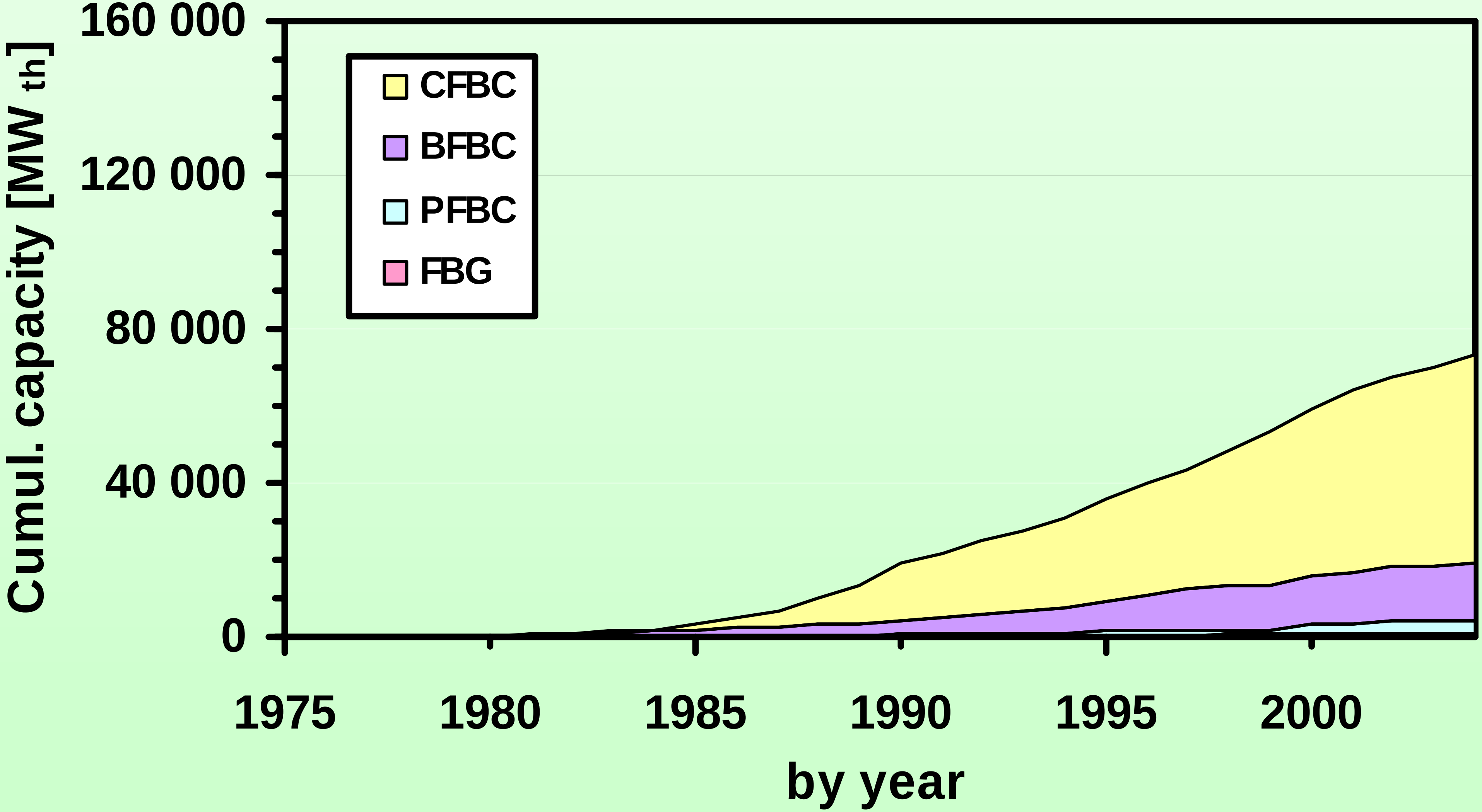

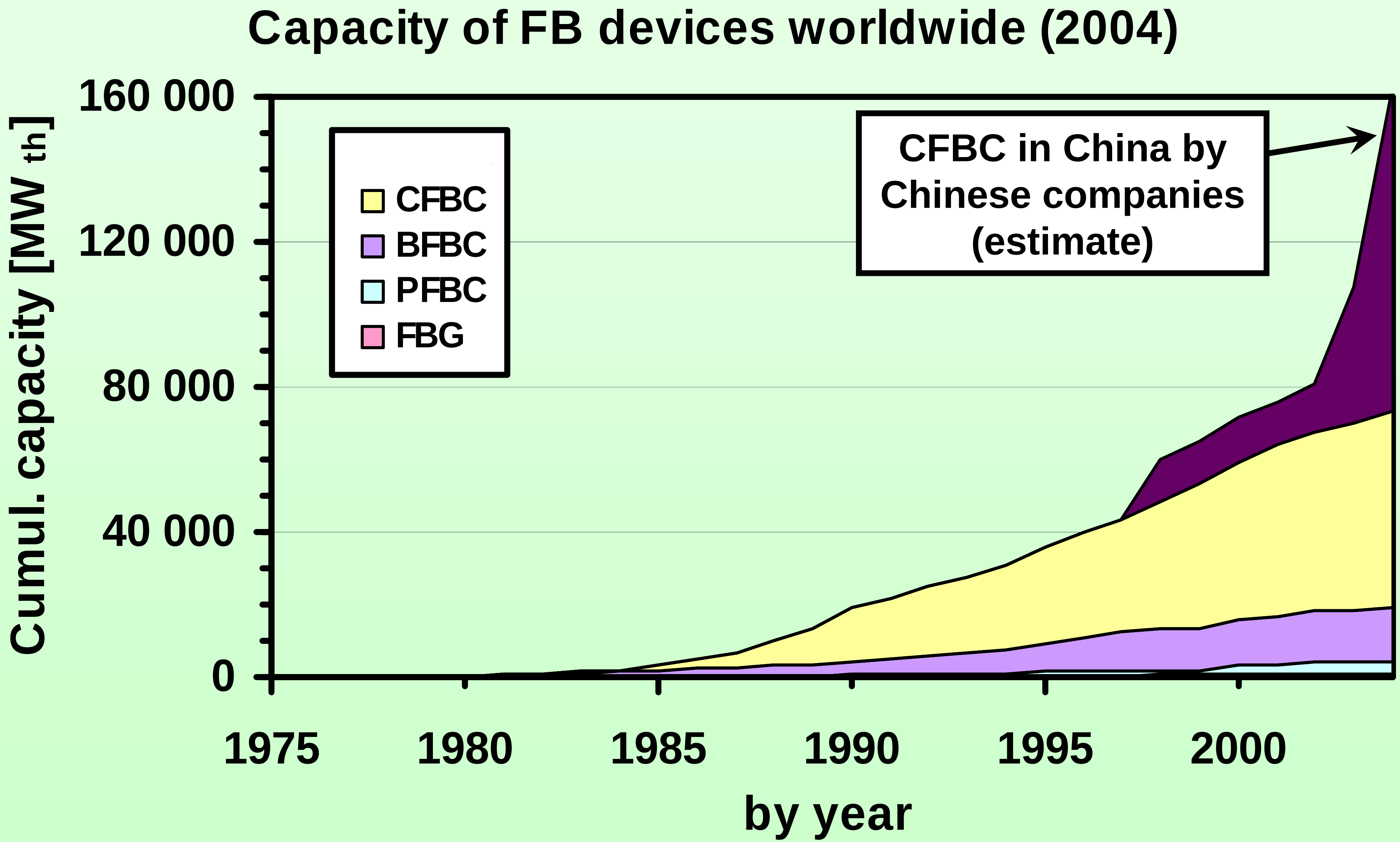

Capacity of FB devices worldwide (2004)
Cumul. capacity [MW th]
160 000
120 000
80 000
40 000
0
CFBC
BFBC
PFBC
FBG
CFBC in China by Chinese companies (estimate)
1975
1980
1985
1990
1995
2000
by year

Fuels

Biofuels – Waste derived fuels – “Opportunity fuels” for FBC?

Forest residues
Annual crops
Prunings
Shells, husks & hulls
Olive stones
RDF (refuse derived fuels)
Waste sludges
MBM (meat and bone meal)
Chicken litter
Coal Slurry
Pet coke

Åbo Akademi Fuel Data Bank

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Emissions

Bed sintering

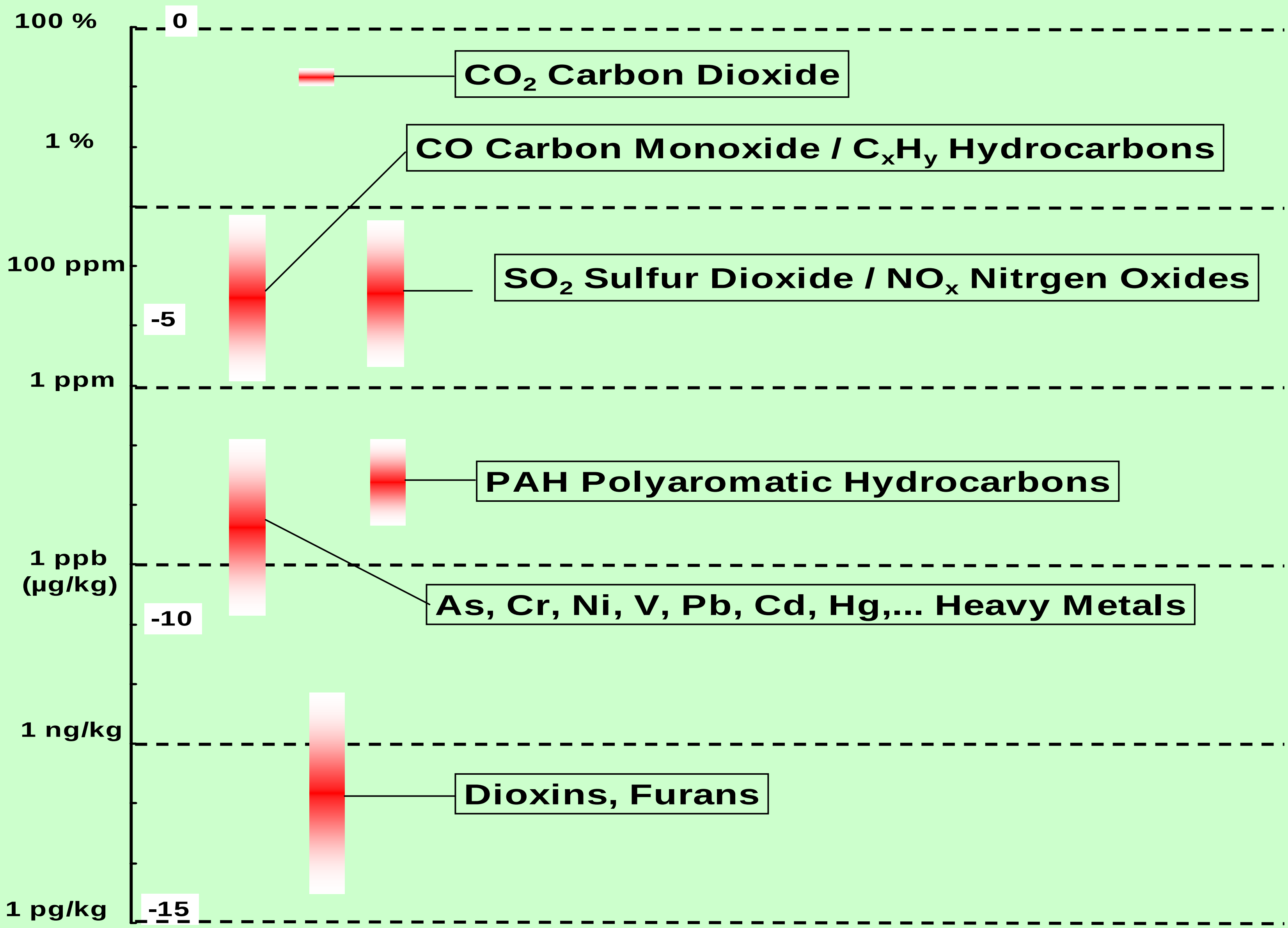
Fouling & corrosion

Fuel Mixtures!

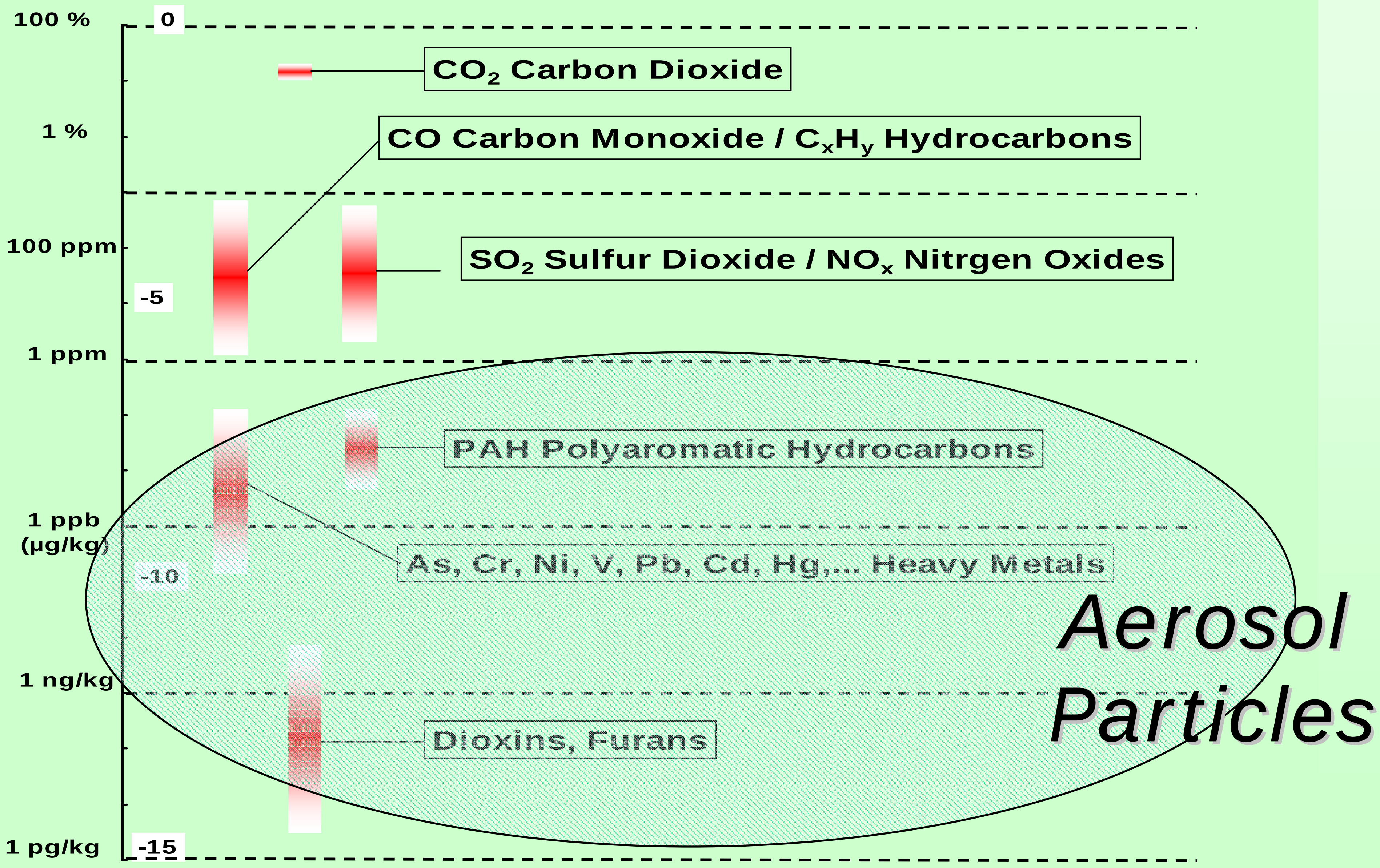
Åbo Akademi Fuel Data Bank

Emissions

Flue Gas Emission Components



Flue Gas Emission Components



EU Directive on Incineration of Waste Containing Fuels

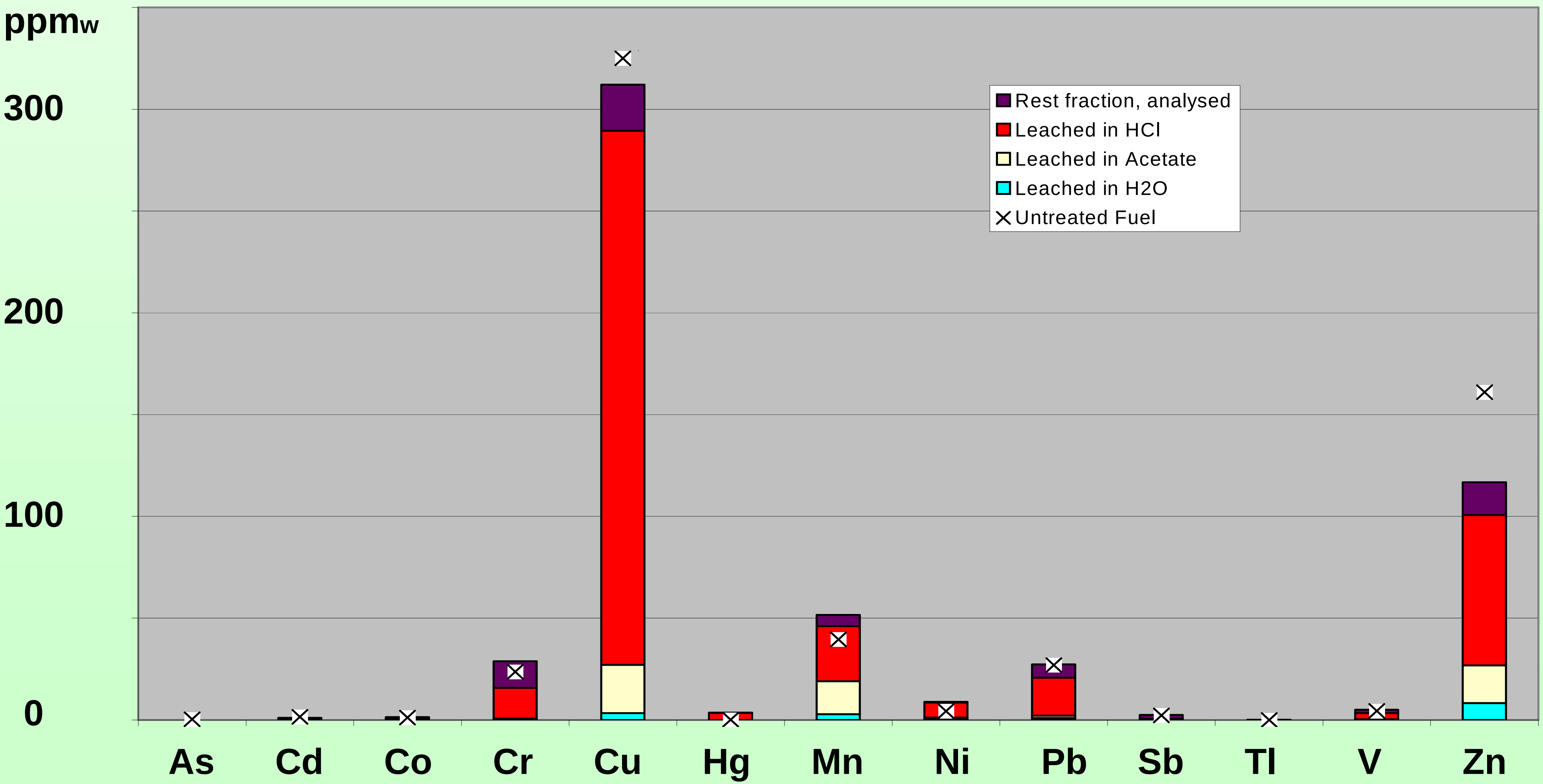
Acidic Gases	
• HCl	10 mg/m^{3}n (on-line)
• HF	1.0 mg/m^{3}n (on-line)
• SO_2	50 mg/m^{3}n (on-line)
• NO_x	200 mg/m^{3}n (on-line)
Dust	10 mg/m3n (on-line)
Metals, ”EDD”	
• Hg	0.05 mg/m3n (twice a year)
• Cd+Tl	0.05 mg/m3n (twice a year)
• Sb+As+Co+Cr+ Cu+Pb+Mn+Ni+V	0.5 mg/m3n (twice a year)

(0.05 mg/m3n in flue gases ≈ 0,4 mg/kg dry fuel)

Dioxins and furans	0.1 ng/m^{3}n (measurement twice a year)

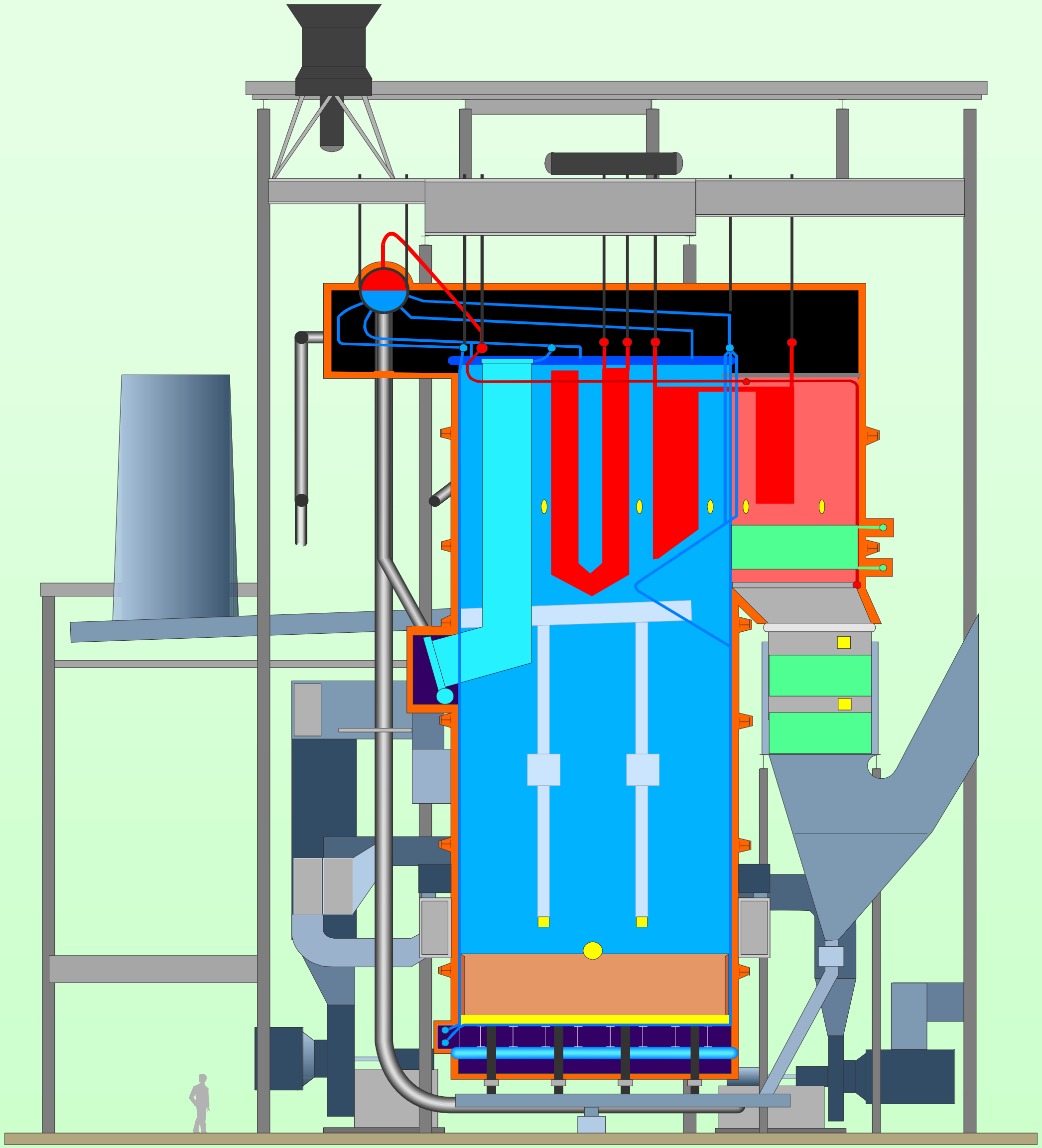
Recovered Wood Fuel Metal Contents

(ppm_w = mg metal/kg fuel)

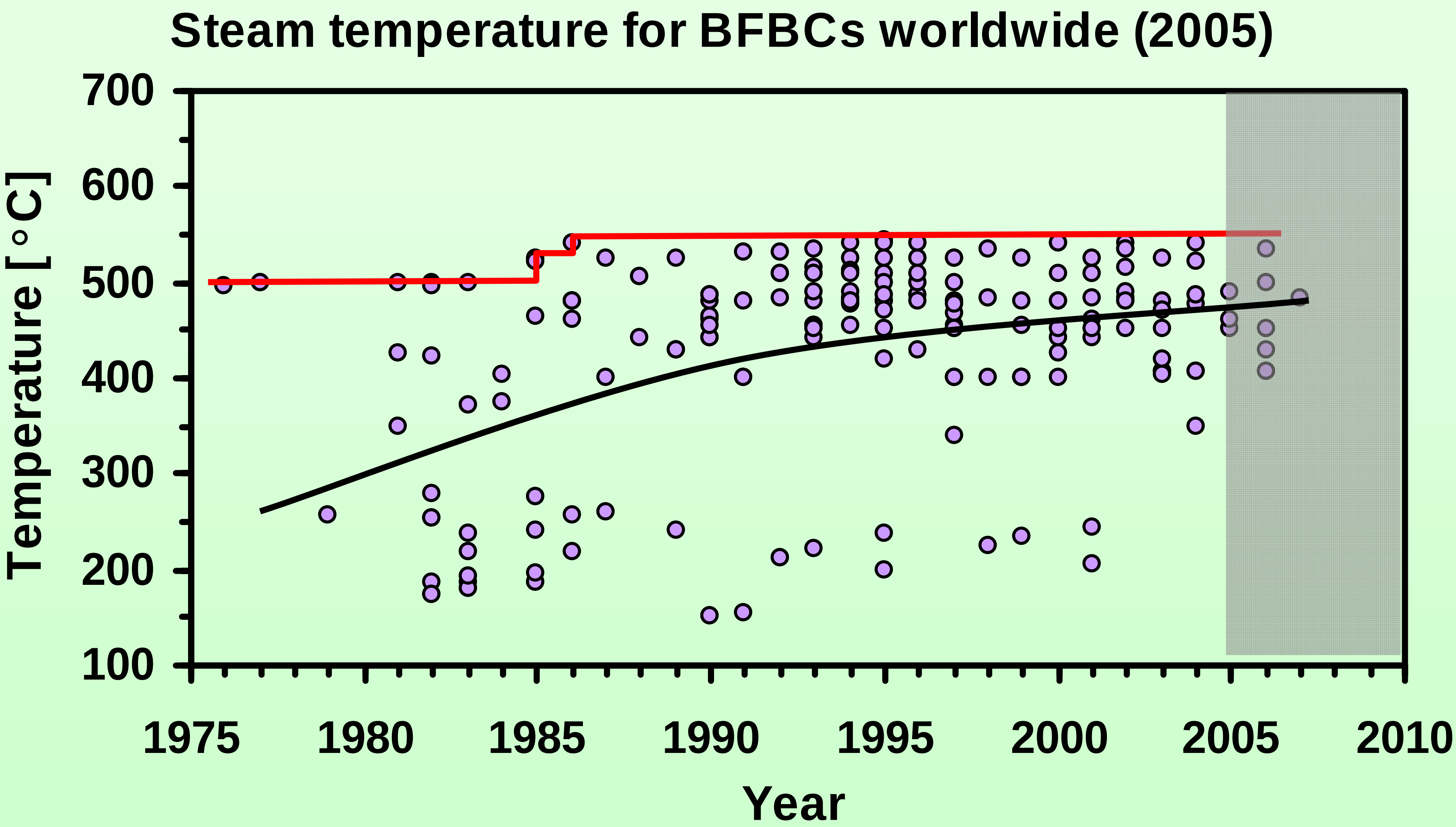


Fouling and corrosion

BFBC for Biomass Fuels

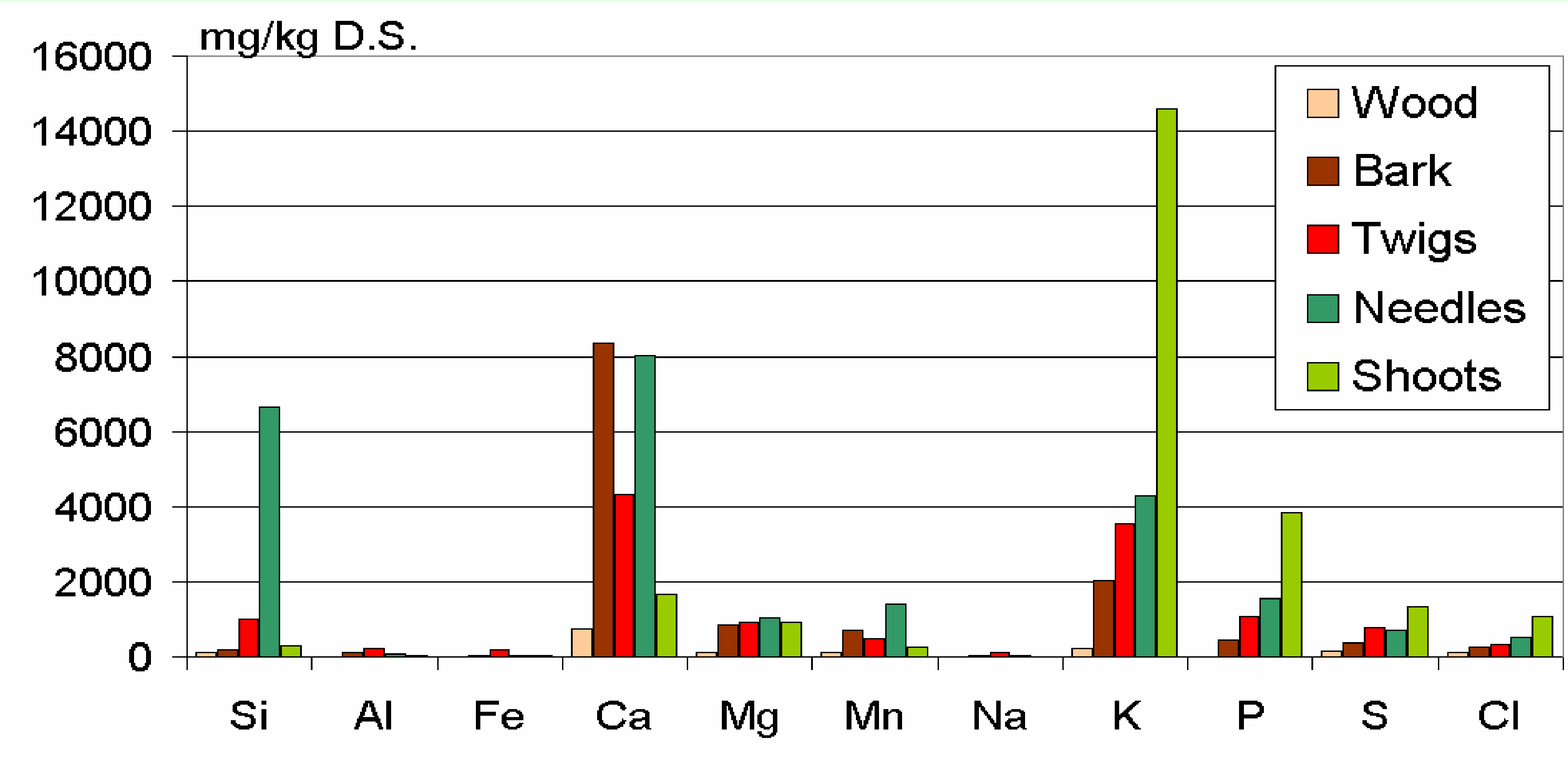


Rice husk
Eucalyptus bark


Steam temperature for BFBCs worldwide (2005)
Temperature [°C]
700
600
500
400
300
200
100
1975
1980
1985
1990
1995
2000
2005
2010
Year

Ash Elements in Spruce Tissues

(J. Werkelin 2005)

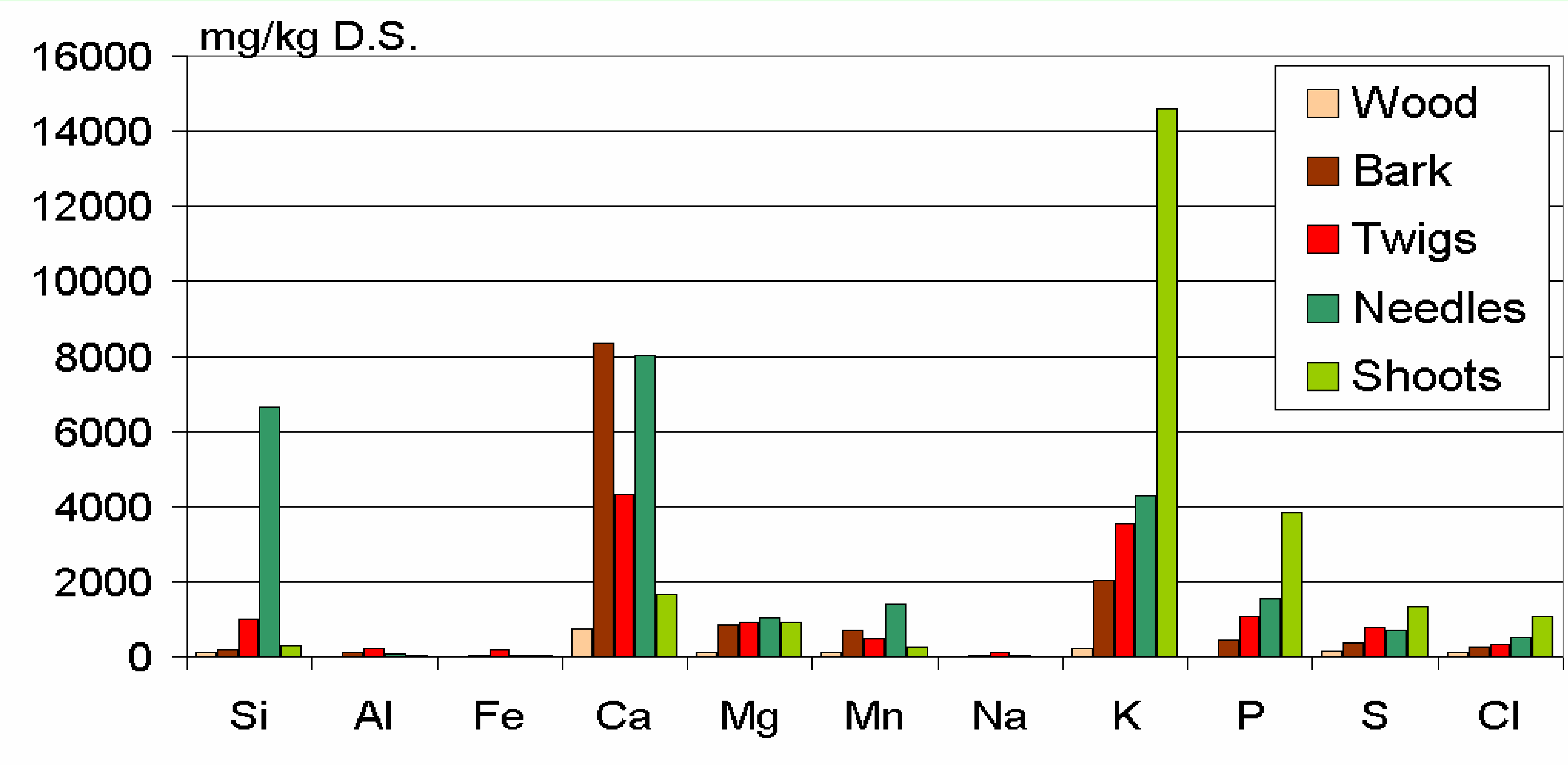


Five Spruce Tissues

Wood Bark Twigs Needles Shoots

Ash Elements in Spruce Tissues

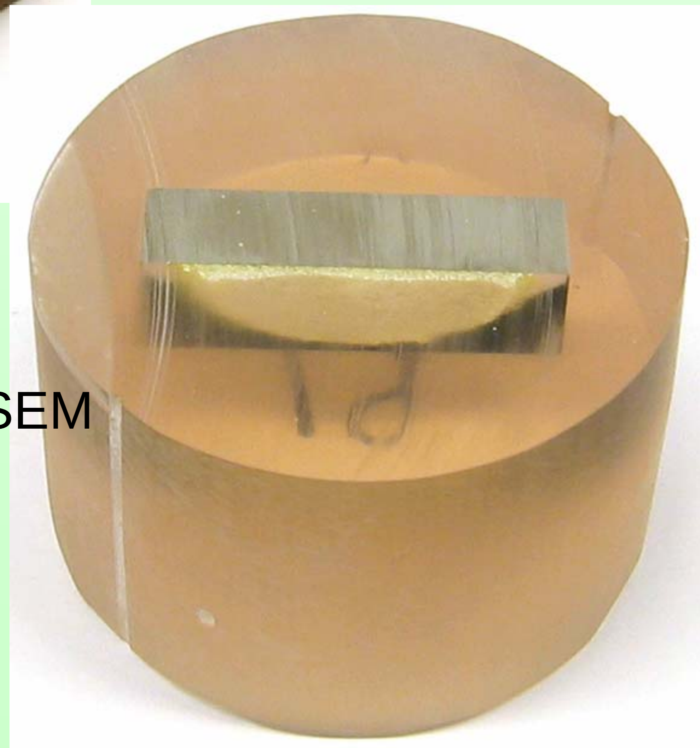
(J. Werkelin 2005)



Corrosion Test by Alkali Salts

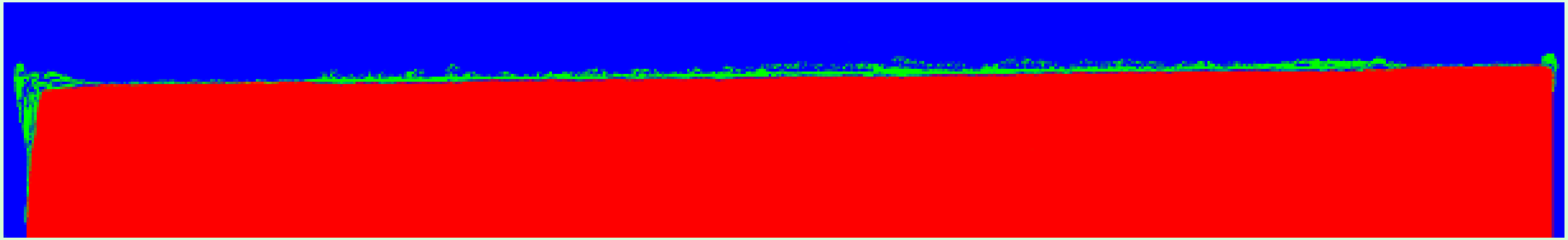
Before
heat treatment

After heat treatment



Prepared for SEM

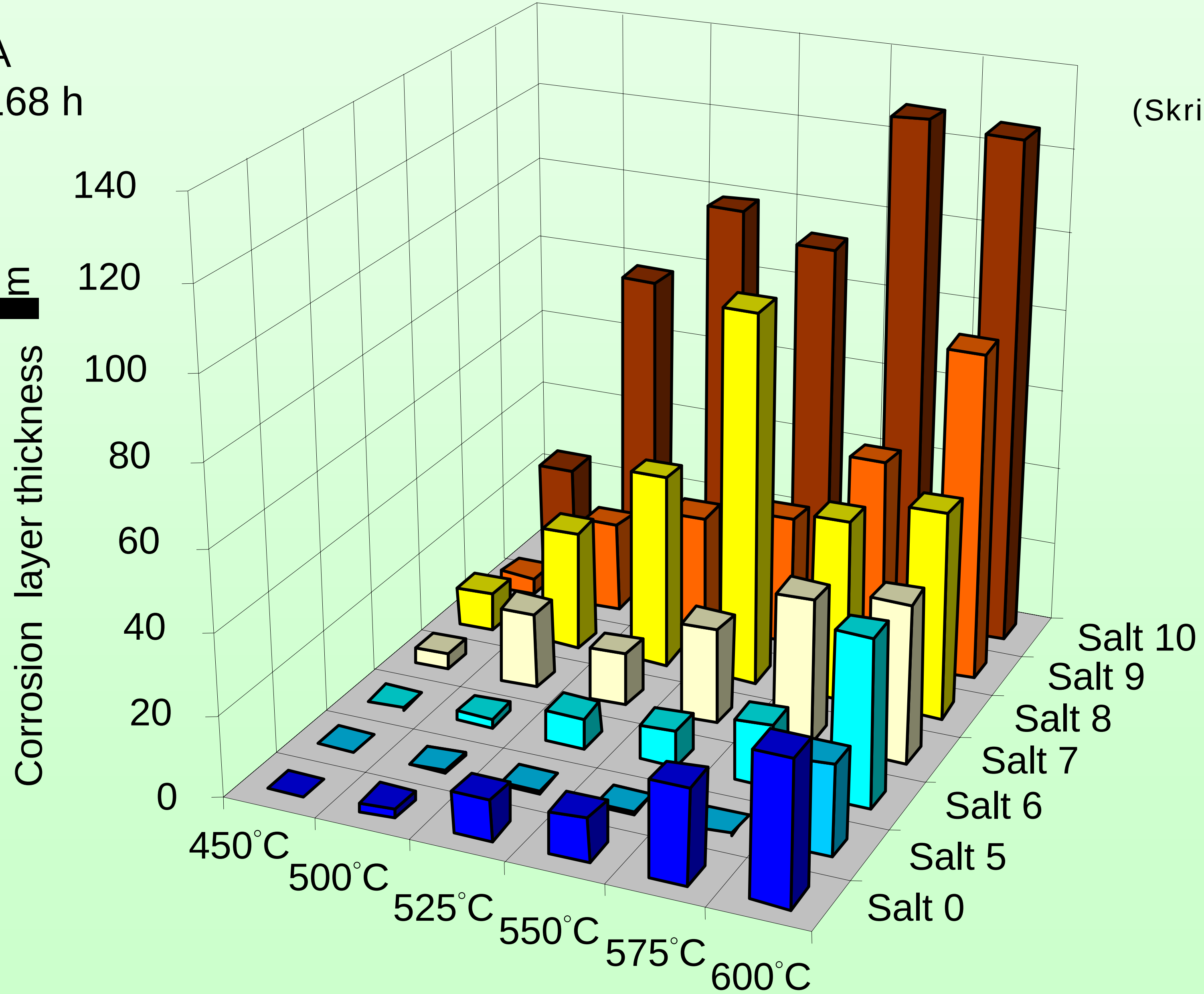
Corosion Analysis by SEM



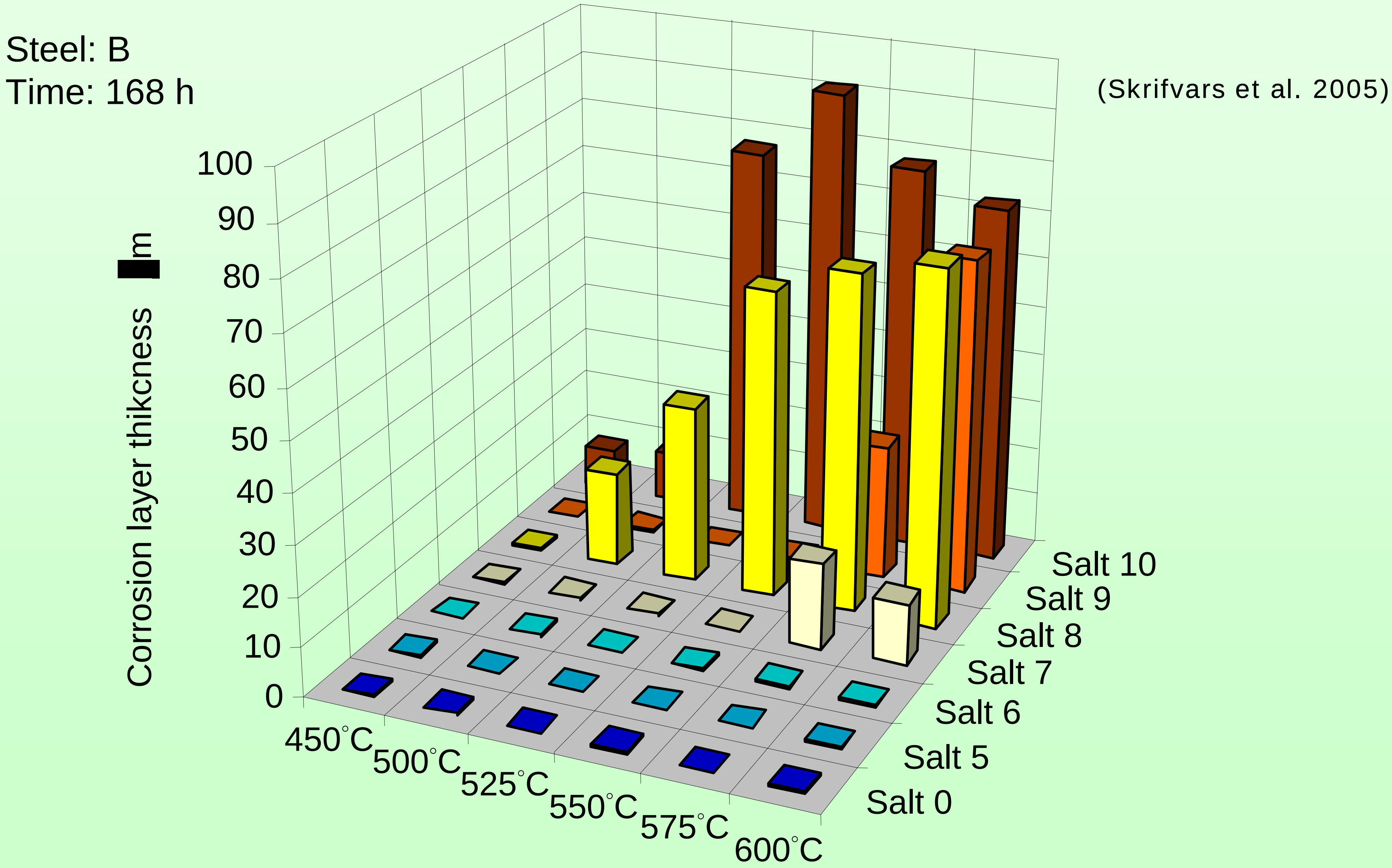
Corrosion due to Alkali Salts

Steel: A
Time: 168 h

(Skrifvars et al. 2005)



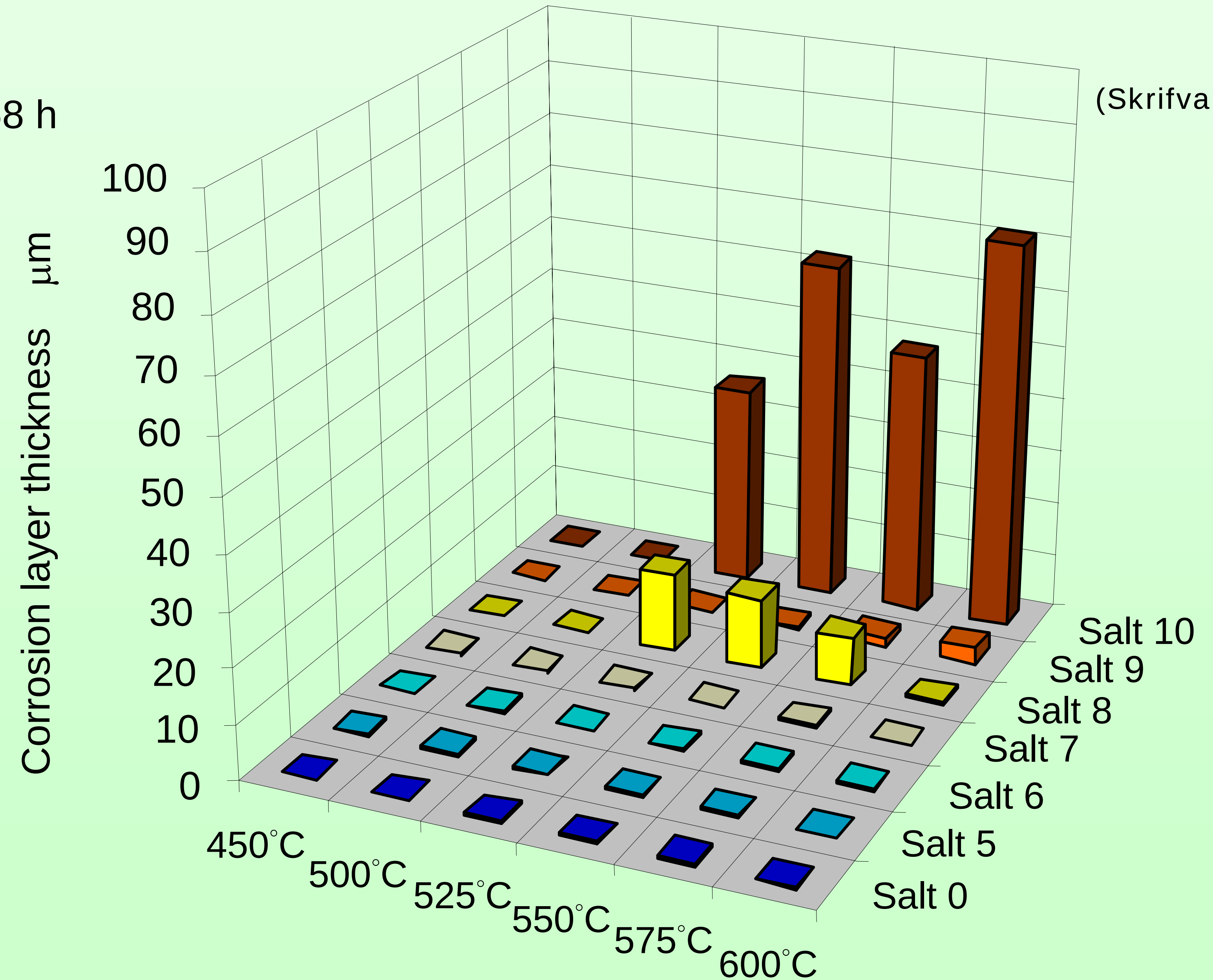
Corrosion due to Alkali Salts



Corrosion due to Alkali Salts

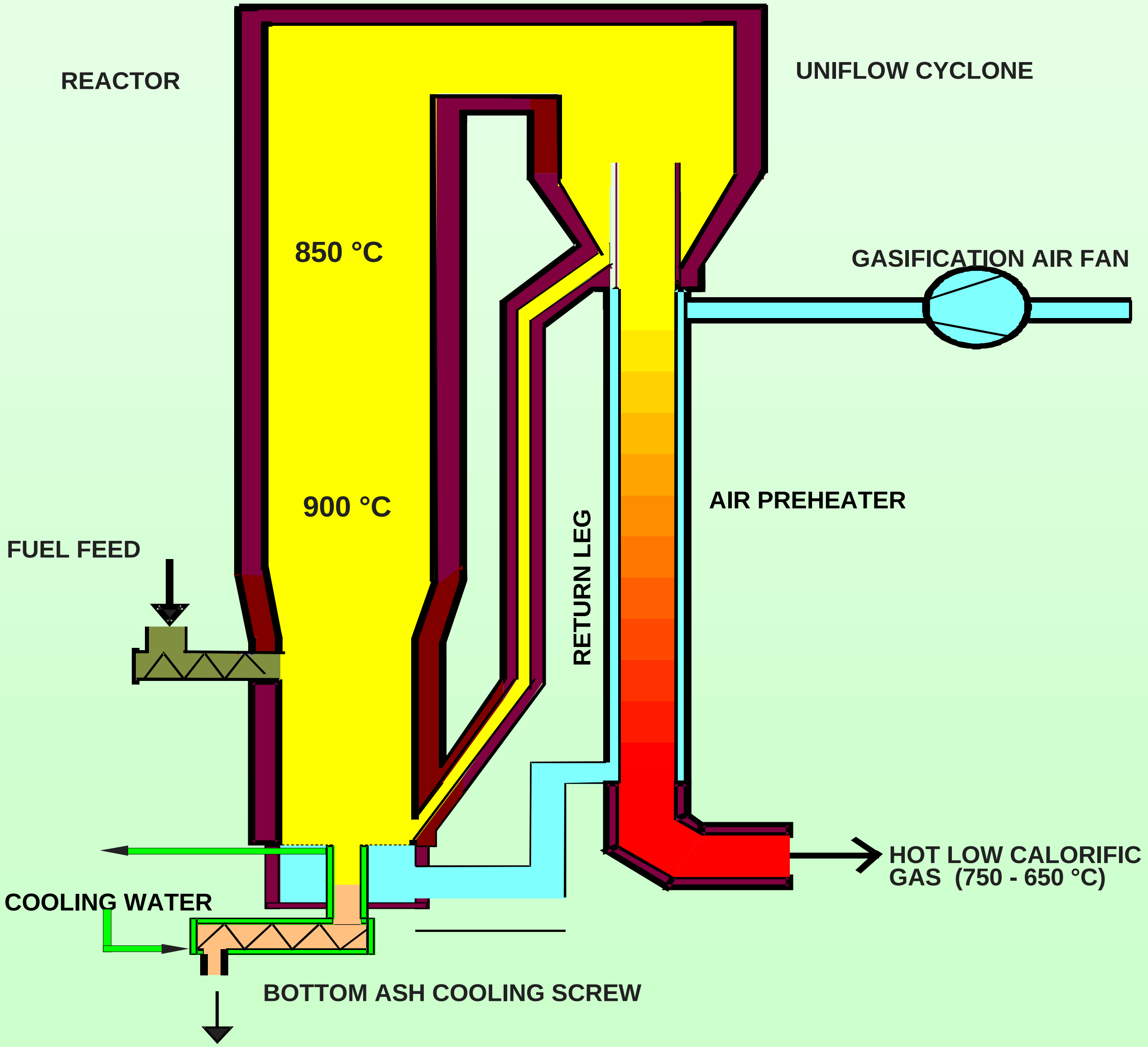
Steel: C
Time: 168 h

(Skrifvars et al. 2005)



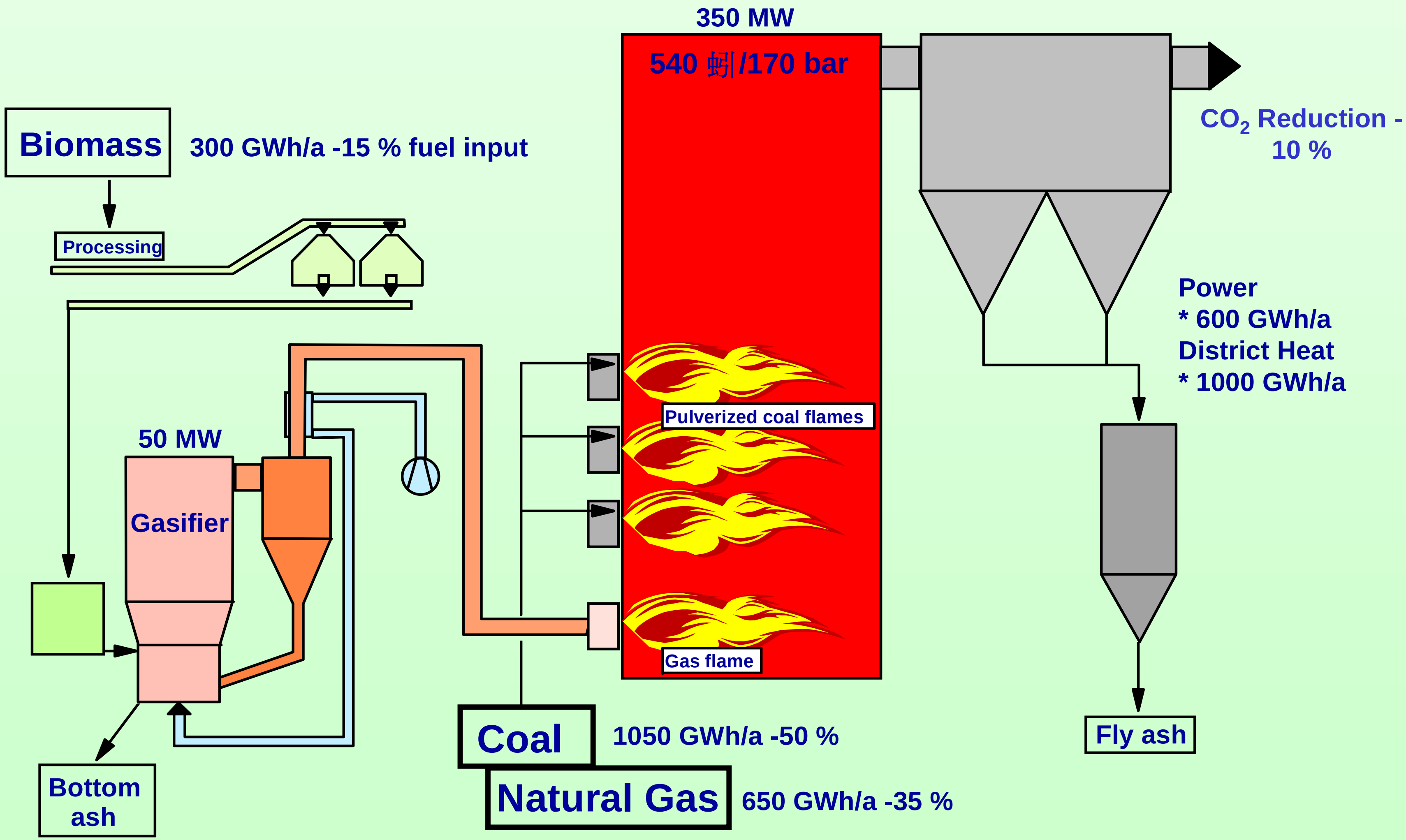
Gasification

CFB Gasifier



Foster Wheeler

BIOMASS GASIFICATION - COAL BOILER - LAHTI PROJECT



Foster Wheeler

Conclusions (i)

- FBC rapidly expanding – now especially in China
- CFBC
  - upto 1000 MWth
  - novel cyclones and superheaters
- BFBC
  - interesting for reactive fuels

Conclusions (ii)

- PFBC well demonstrated in 800 MWth class
- FB gasifiers promising for producing gas to co-firing

Conclusions (iii)

- Waste derived fuels great potential for FBC
- Challenge to boiler manufacturers & operators:
  - Emission control (heavy metals)
  - Bed sintering and fouling control
  - Corrosion control
  - Multifuel firing and fuel interaction

Aknowledgements

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Kvaerner Power, Foster-Wheeler, Vattenfall, Metsä-Botnia,
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Tekes, Academy of Finland