Johan Gadolin
PROCESS CHEMISTRY CENTRE

Åbo Akademi University

Toward cleaner biomass thermal conversion technology – industry-academia collaboration and the importance of understanding the chemical details

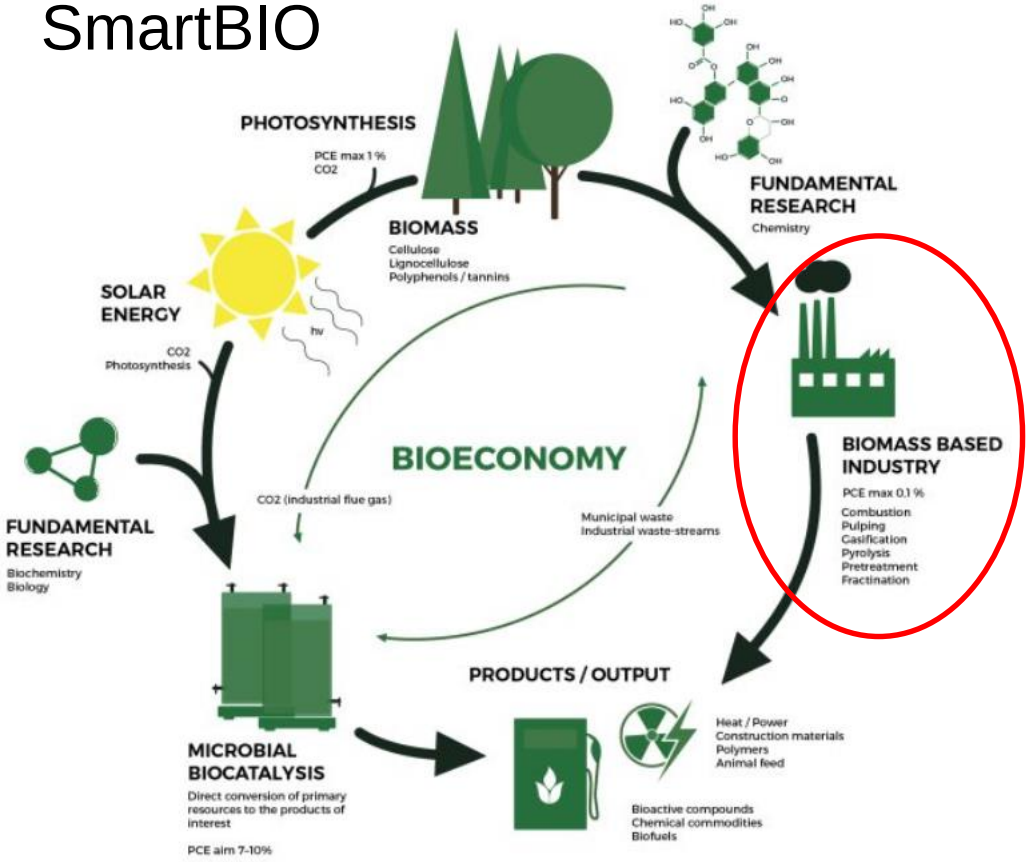
Markus Engblom

Johan Gadolin Process Chemistry Centre,
Inorganic chemistry

SmartBIO annual meeting 26.10.2022

SmartBIO, Bioeconomy and Inorganic chemistry

SmartBIO



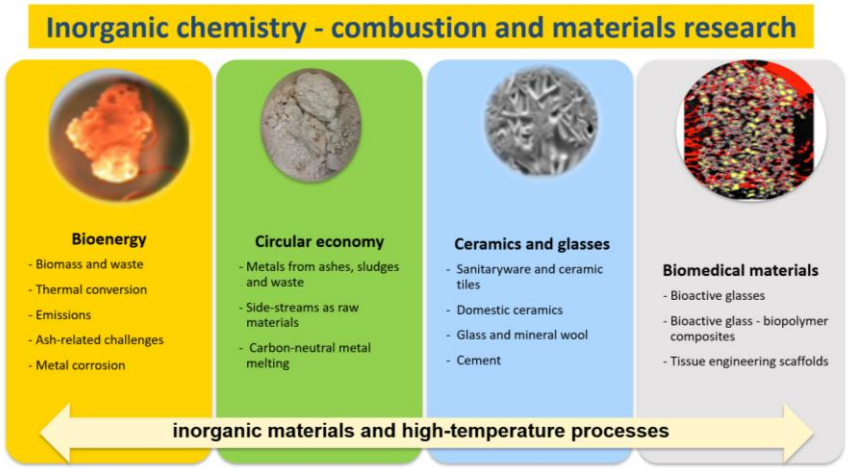
Johan Gadolin Process Chemistry Centre – PCC

Åbo Akademi University

PCC research groups

- Electrochemistry and electroactive materials
- Industrial chemistry and reaction engineering
- Inorganic chemistry
- Organic chemistry
- Wood and paper chemistry

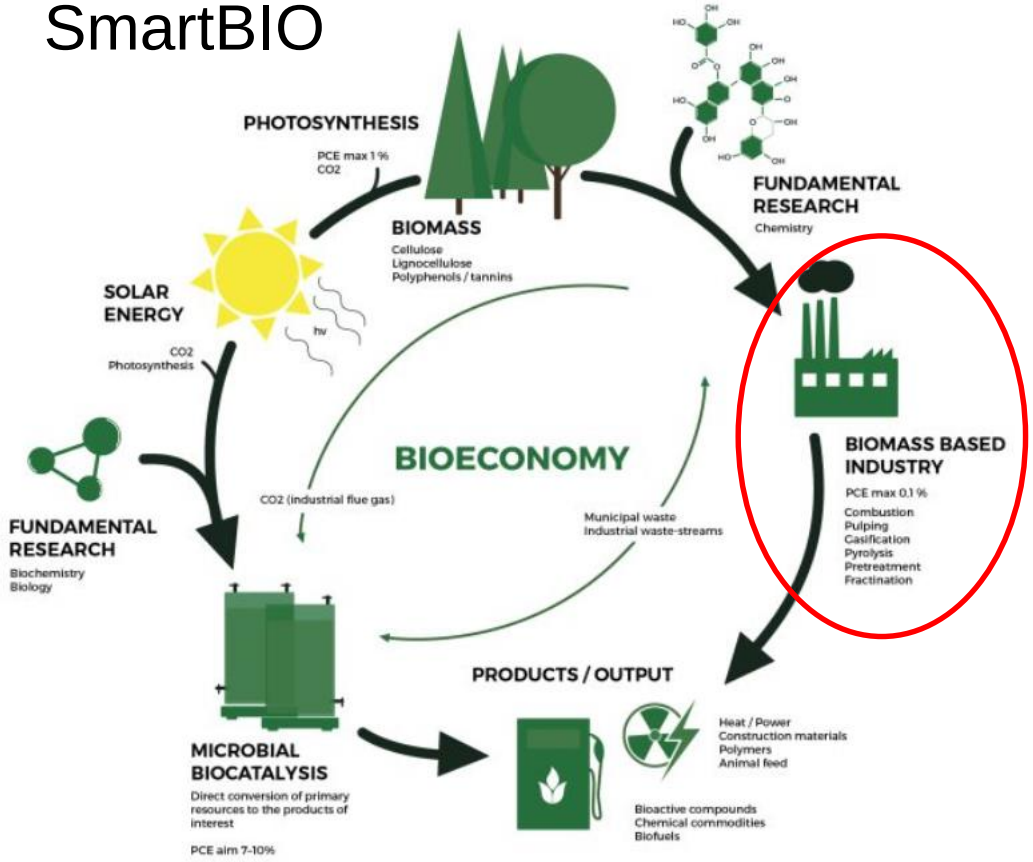
Johan Gadolin Process Chemistry Centre 2019

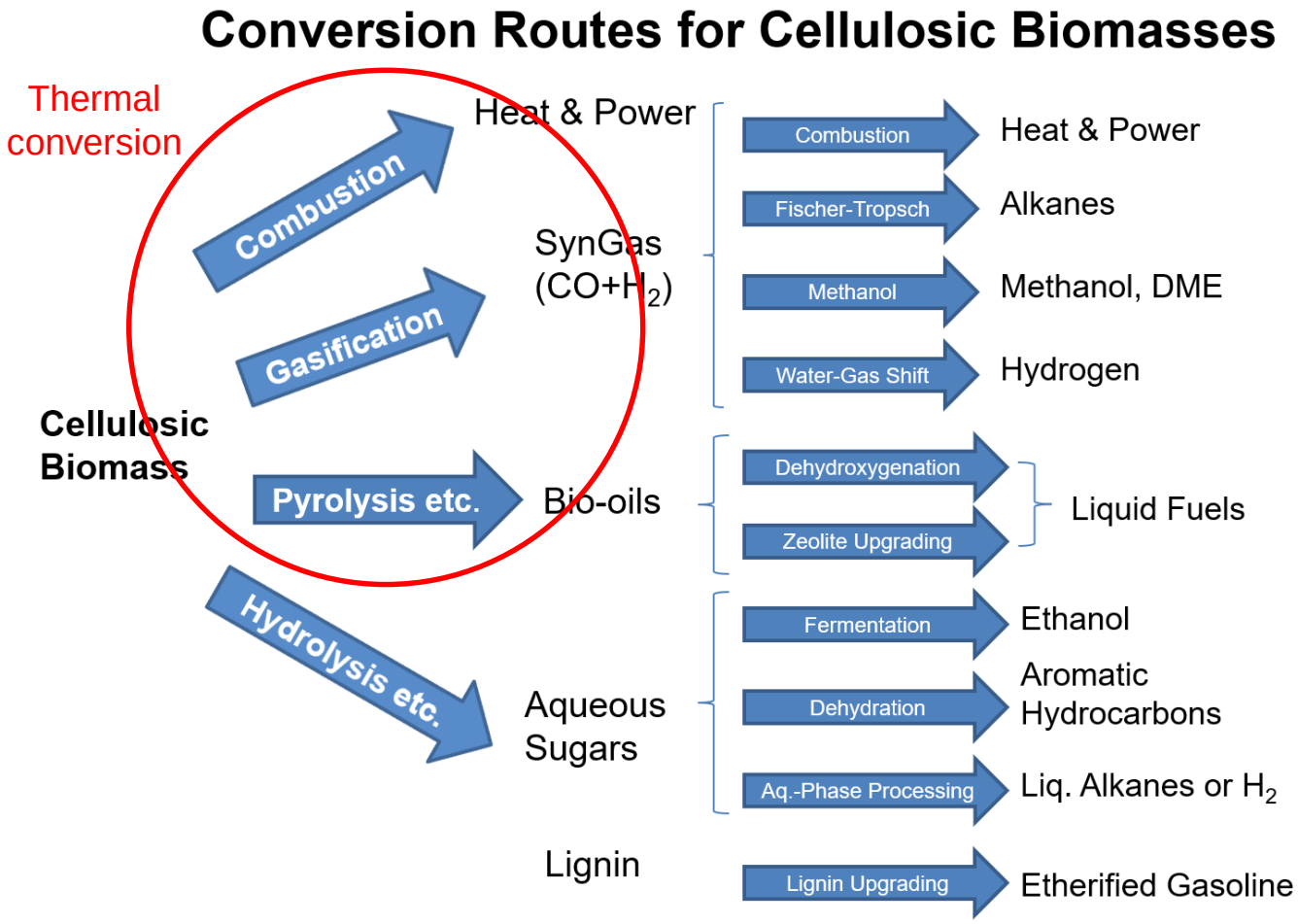


Inorganic chemistry, 2022

SmartBIO, Bioeconomy and Inorganic chemistry

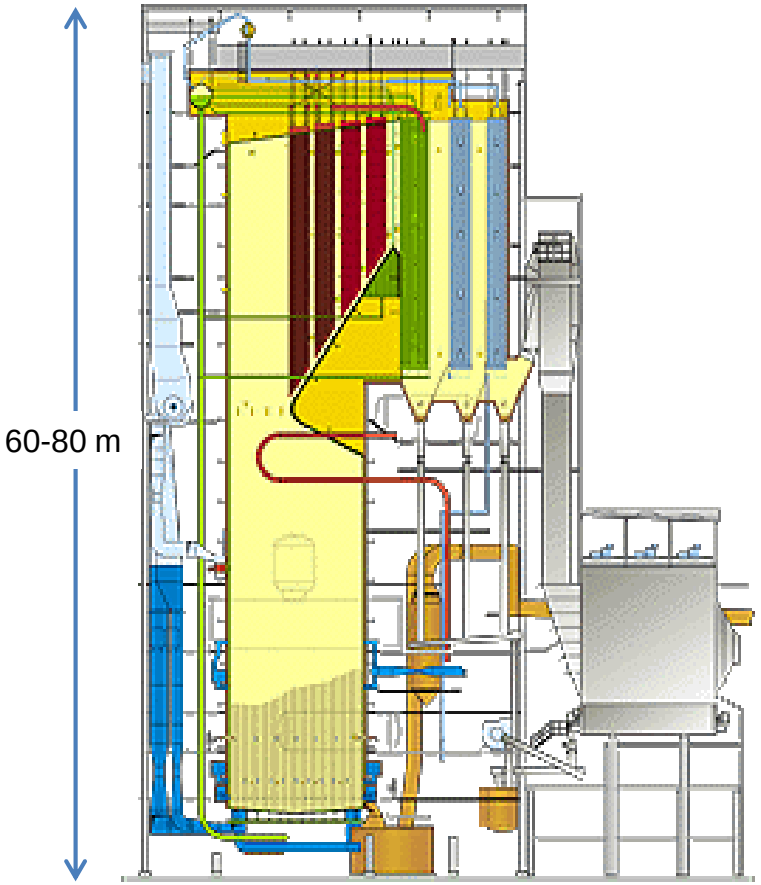
SmartBIO





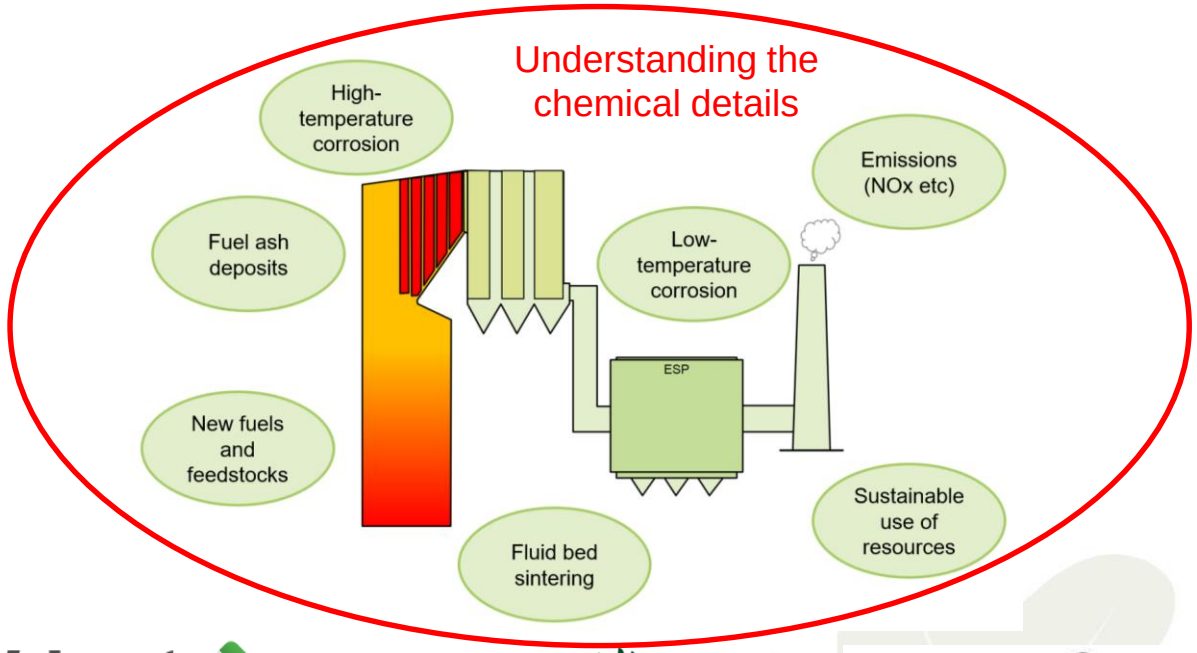
(M. Hupa)

Toward cleaner biomass thermal conversion technology – industry-academia collaboration



Pulp mill / biorefinery
black liquor recovery boiler

- Lower emissions
- Higher electrical efficiency and boiler availability
- New fuels and feedstocks



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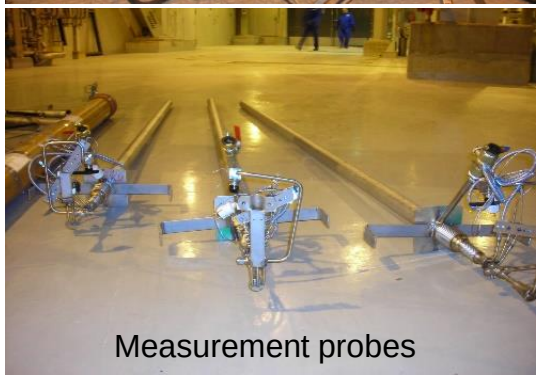
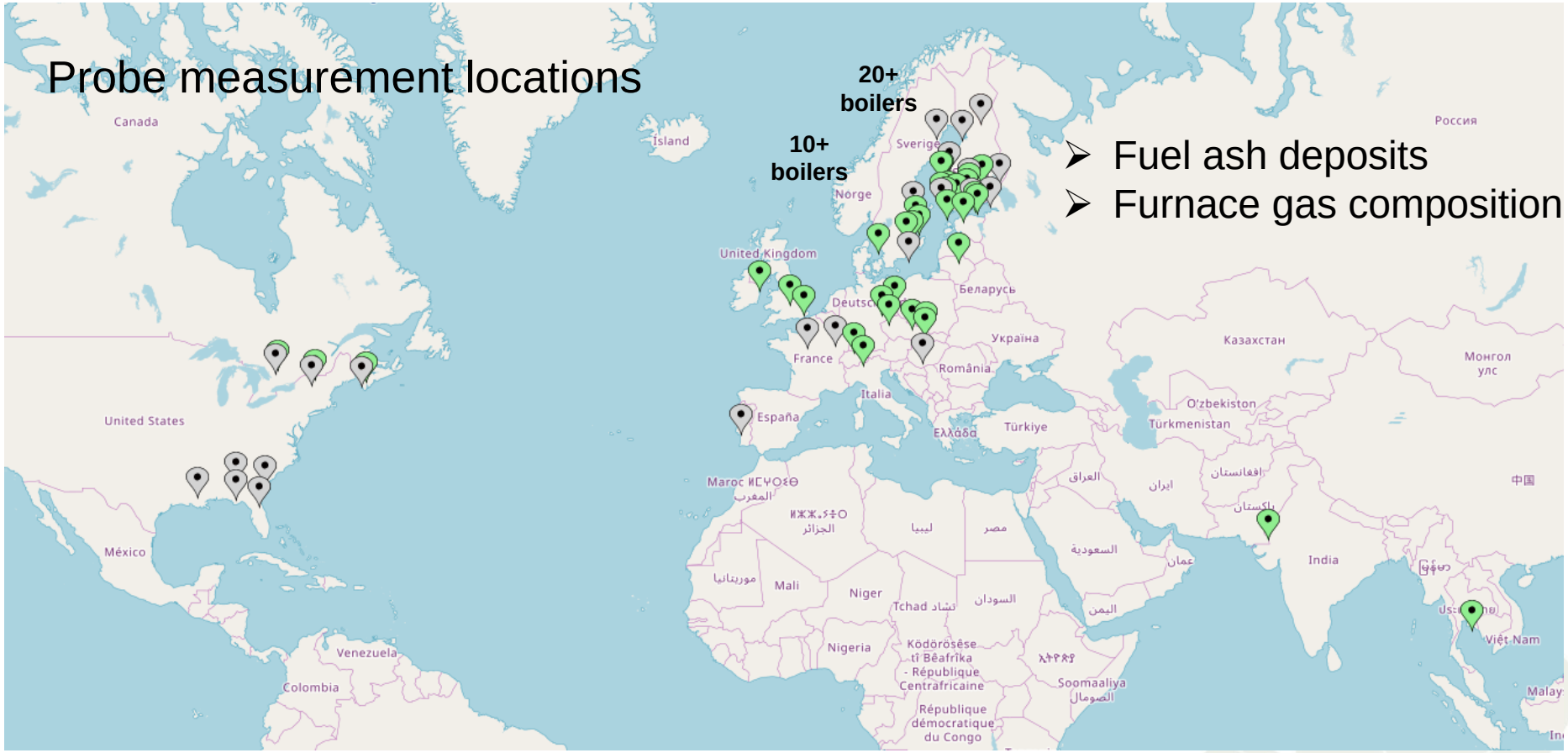
1. Boiler measurements

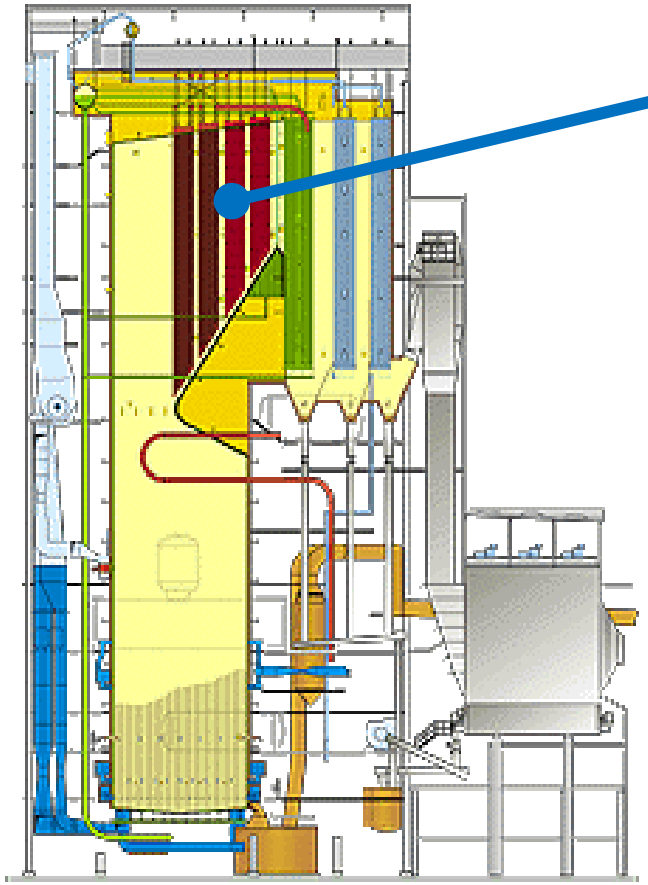


Measurement probes

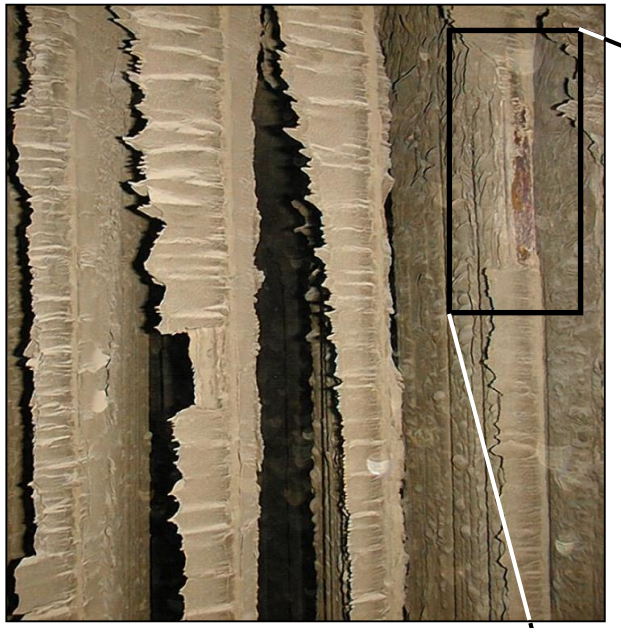


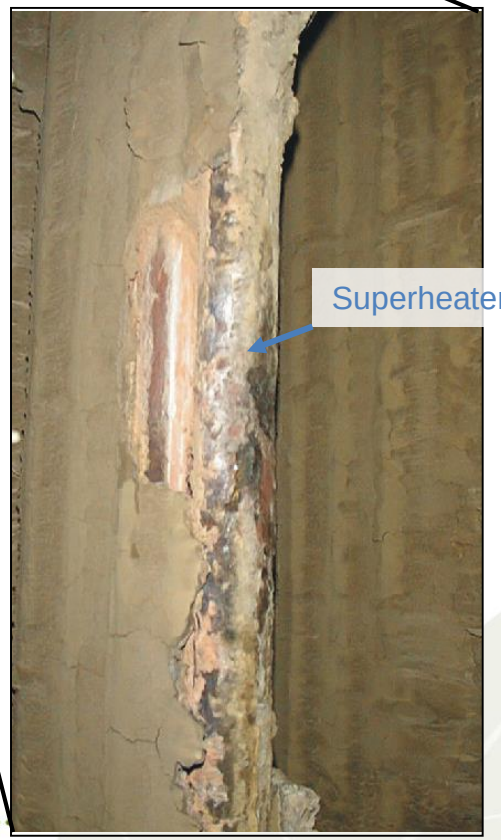
- Fuel ash deposits
- Furnace gas composition

1. Boiler measurements

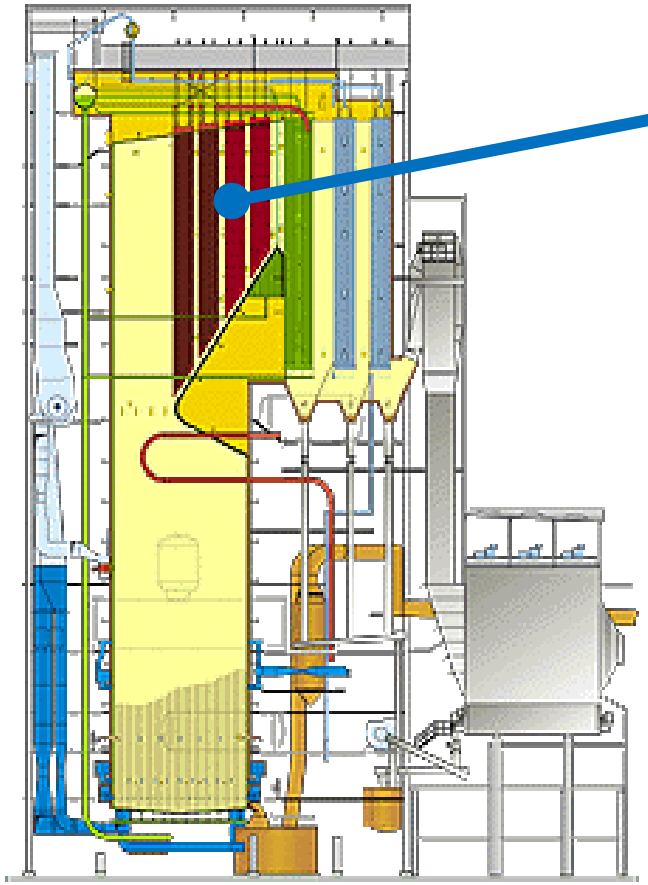


Superheaters



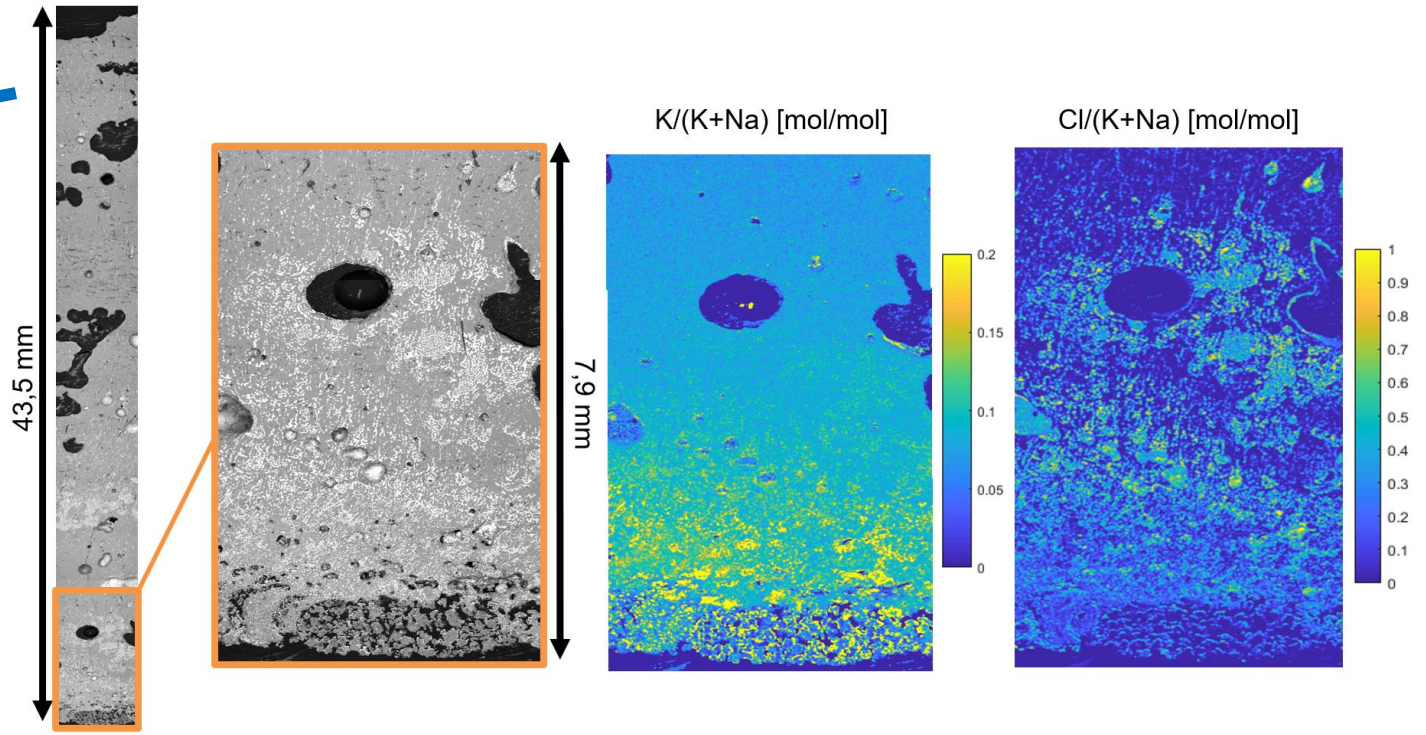


1. Boiler measurements



Flue gas

Superheater Deposit cross section



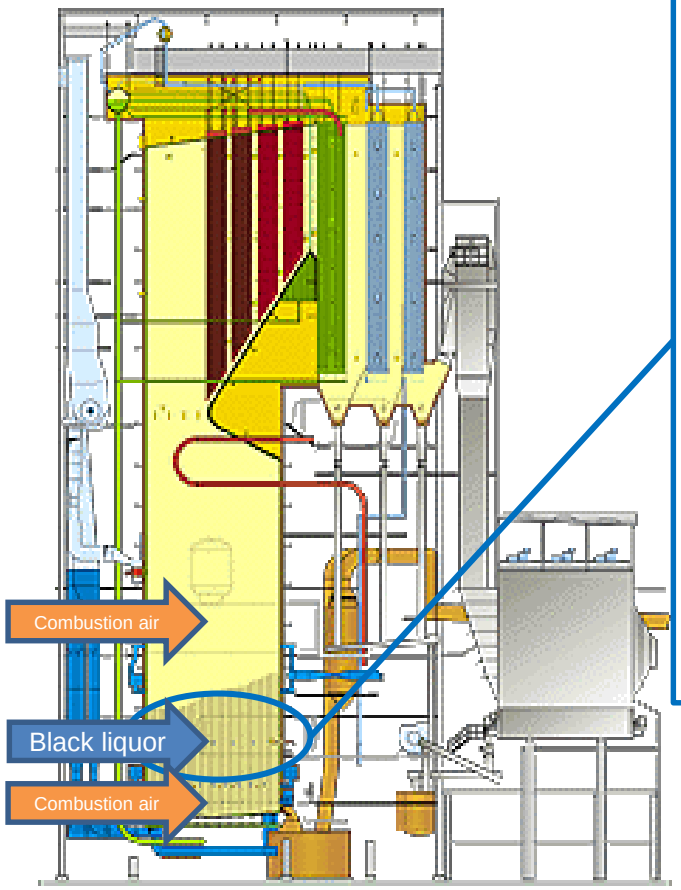
Superheater surface

Corrosive alkali chlorides move toward superheater surface with time

(Balint, 2021)

2. From large scale to laboratory

Pulp mill / biorefinery
black liquor recovery boiler

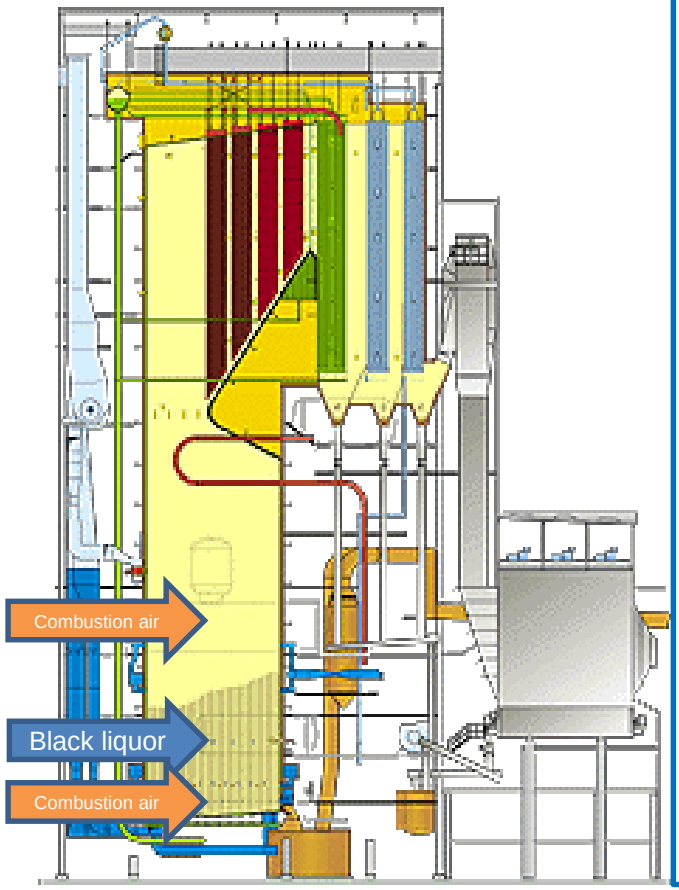


Black liquor spray inside furnace

Black liquor spray from outside the furnace

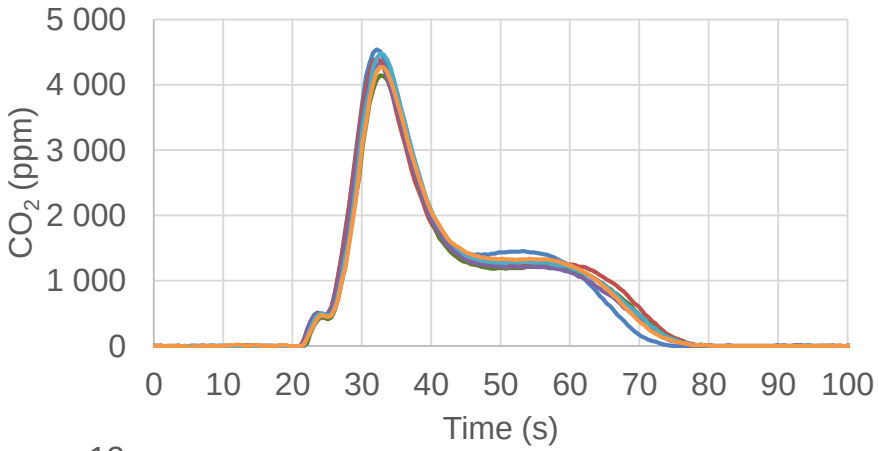
2. Laboratory experiments – single droplet

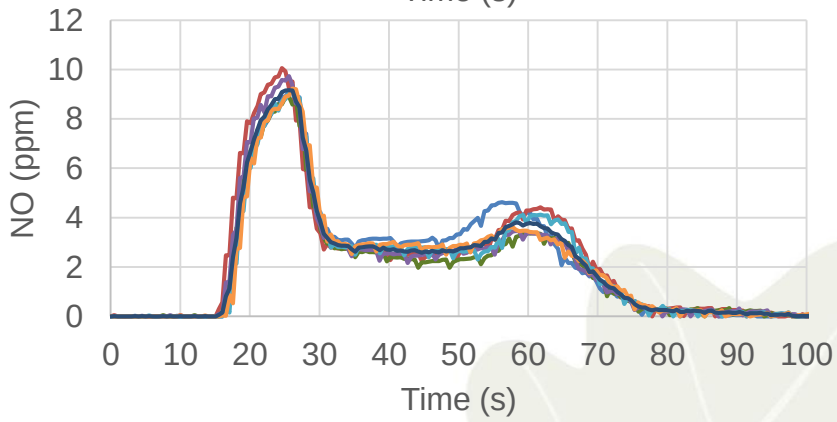
Pulp mill / biorefinery
black liquor recovery boiler



Burning of single black liquor droplet in a laboratory reactor

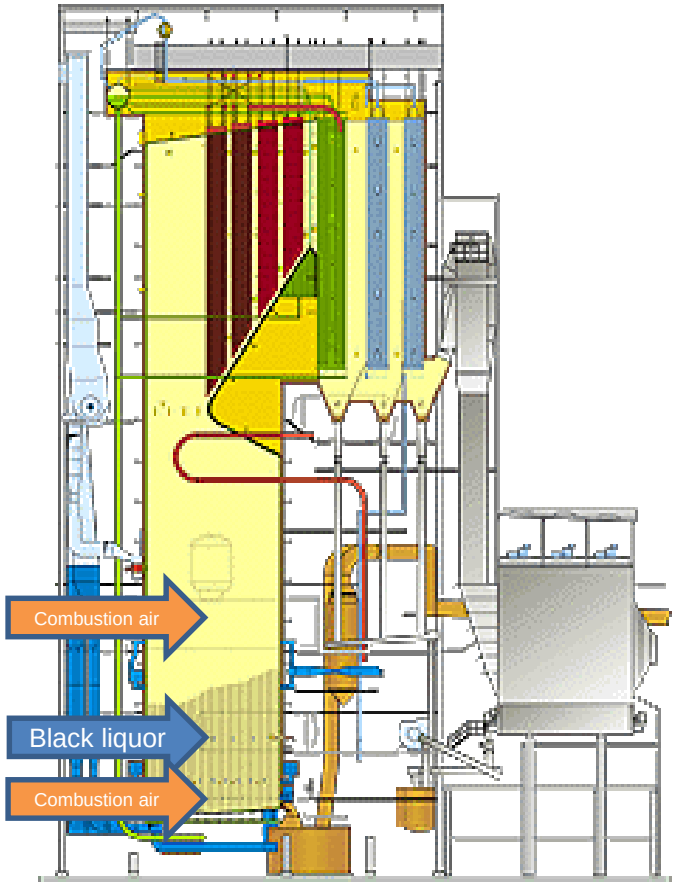
Droplet emission formation



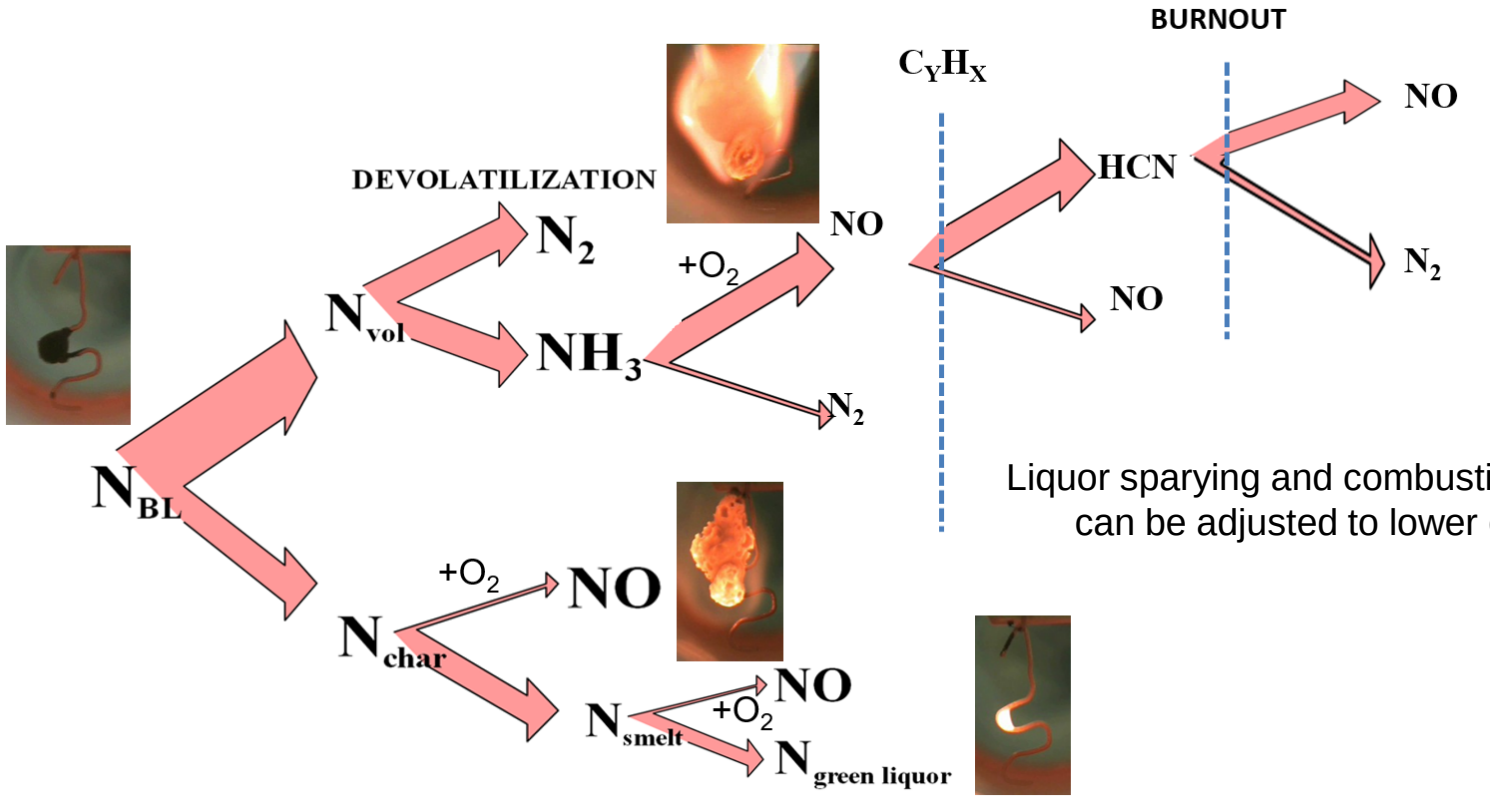


2. From laboratory back to large scale

Pulp mill / biorefinery
black liquor recovery boiler



Black liquor nitrogen and NOx formation chemistry



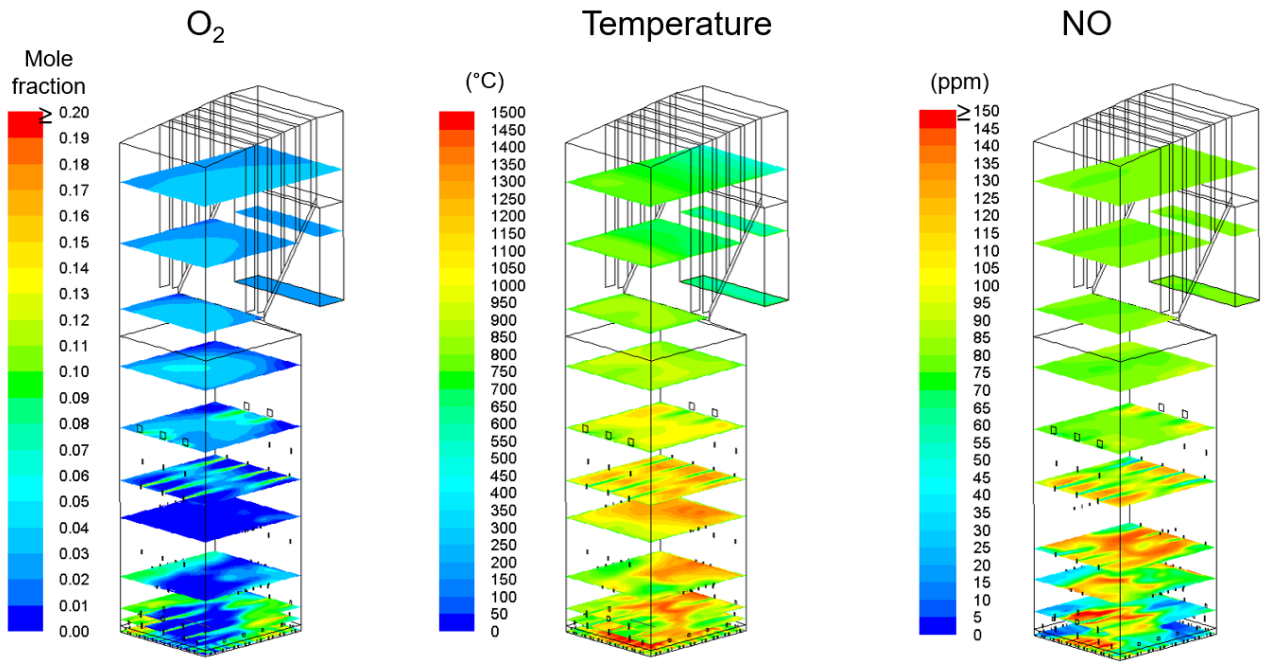
Liquor sparying and combustion air delivery can be adjusted to lower emissions

Forssén, M., Kilpinen, P., Hupa M., NO_x Reduction in Black Liquor Combustion – Reaction Mechanisms Reveal Novel Operational Strategy Options, *TAPPI Journal* 83 (2000)
Vainio, E., Brink, A., DeMartini, N., Hupa, M., Vesala, H., Tormonen, K., Kajolinna, T., *Journal of Pulp and Paper Science* 36 (2011)

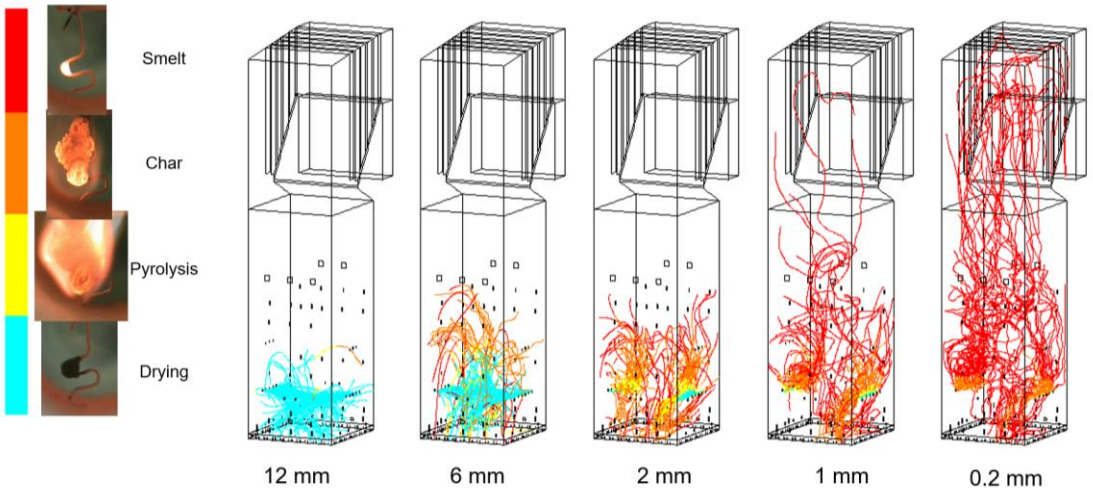
3. Mathematical modeling

- Thermodynamic / Chemical equilibrium
- Chemical kinetics
- **Computational Fluid Dynamics (CFD)**

Furnace combustion and NO emission formation



Black liquor droplet model and trajectory prediction



Trajectories of different sized droplets