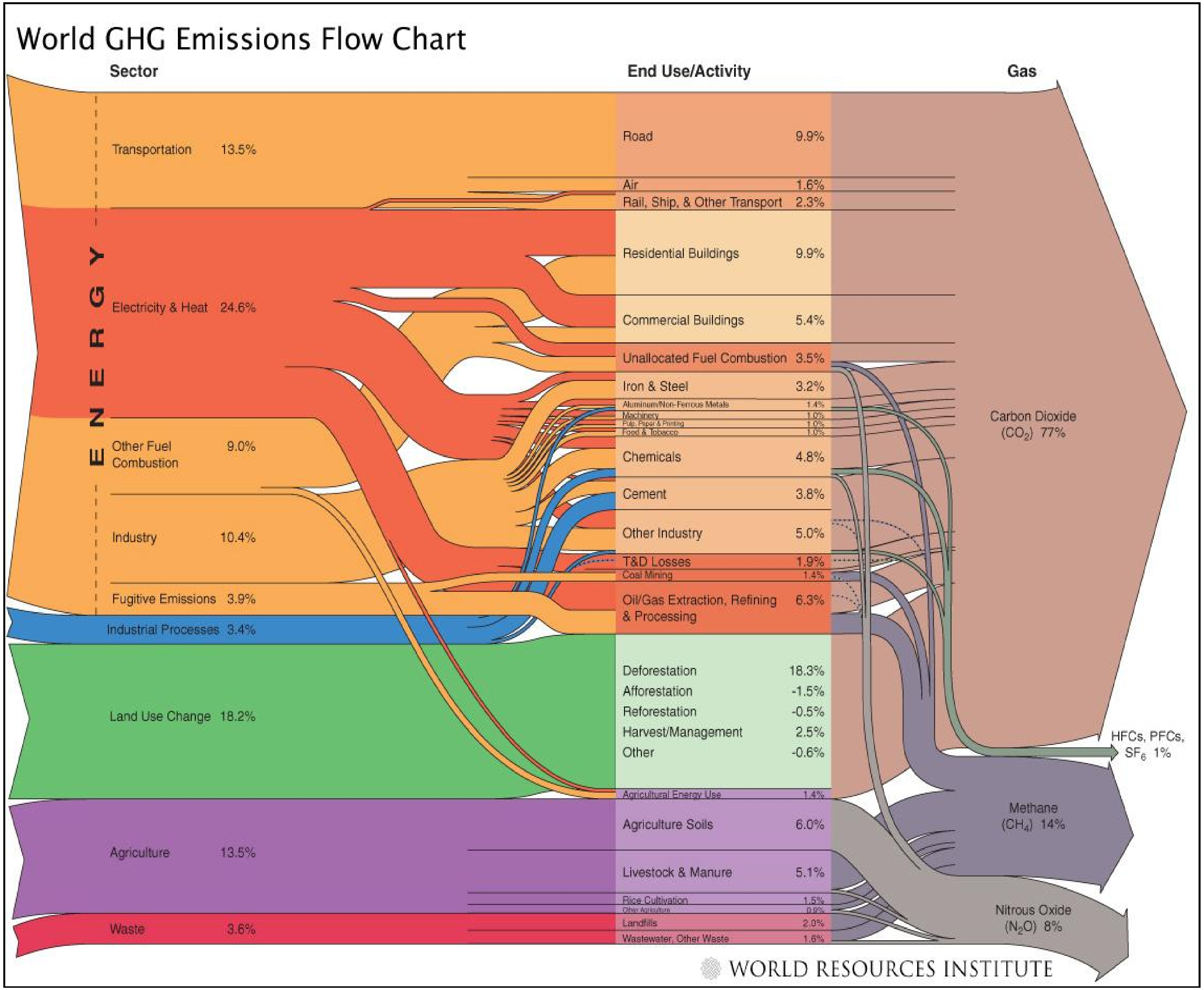
CCS and Pulp and Paper Industry

CCS in Process Industries workshop

10–11.3.2015 Lisbon, Portugal

Antti Arasto

VTT Technical Research Centre of Finland



World GHG Emissions Flow Chart
Sector
End Use/Activity
Gas
ENERGY
Transportation 13.5%
Electricity & Heat 24.6%
Other Fuel Combustion 9.0%
Industry 10.4%
Fugitive Emissions 3.9%
Industrial Processes 3.4%
Land Use Change 18.2%
Agriculture 13.5%
Waste 3.6%
Road 9.9%
Air 1.6%
Rail, Ship, & Other Transport 2.3%
Residential Buildings 9.9%
Commercial Buildings 5.4%
Unallocated Fuel Combustion 3.5%
Iron & Steel 3.2%
Aluminum/Non-Ferrous Metals 1.4%
Machinery 1.0%
Pulp, Paper & Printing 1.0%
Food & Tobacco 1.0%
Chemicals 4.8%
Cement 3.8%
Other Industry 5.0%
T&D Losses 1.9%
Coal Mining 1.4%
Oil/Gas Extraction, Refining & Processing 6.3%
Deforestation 18.3%
Afforestation -1.5%
Reforestation -0.5%
Harvest/Management 2.5%
Other -0.6%
Agricultural Energy Use 1.4%
Agriculture Soils 6.0%
Livestock & Manure 5.1%
Rice Cultivation 1.5%
Other Agriculture 0.9%
Landfills 2.0%
Wastewater, Other Waste 1.6%
Carbon Dioxide (CO_2) 77%
HFCs, PFCs, SF_6 1%
Methane (CH_4) 14%
Nitrous Oxide (N_2O) 8%
WORLD RESOURCES INSTITUTE

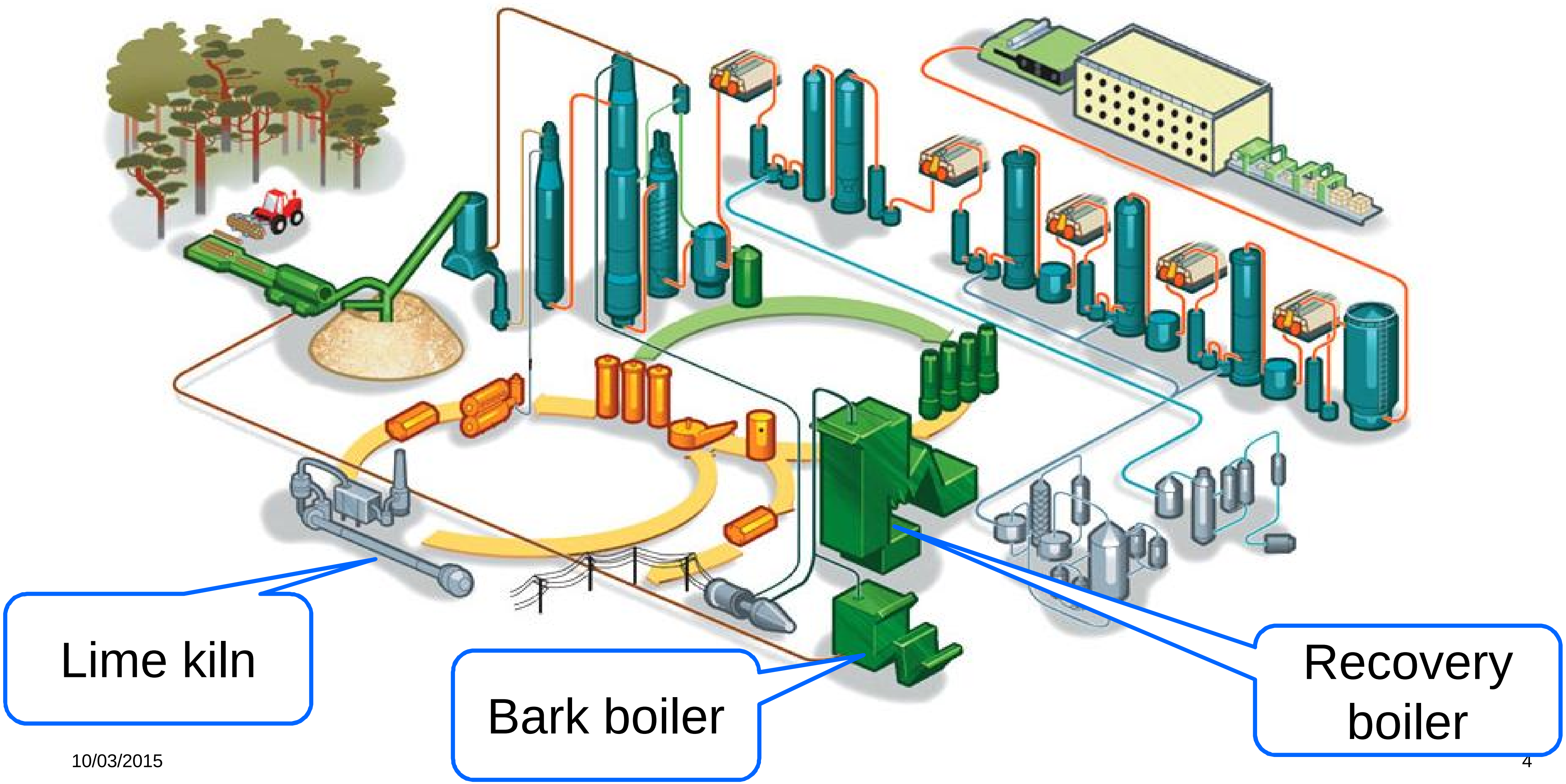
Pulp production

- Chemical and mechanical pulping from virgin woody biomass most common
- Recycled fibres also significant in papers
- Trends
  - from fine paper to packaging boards and tissue paper
  - from mechanical to chemical pulping
- Intergration to energy production

- Mechanical/semi-chemical pulps
- Bleached softwood kraft pulps
- Bleached hardwood kraft pulps
- Unbleached kraft pulps
- Sulphite pulps
- Non-wood pulps
- Recovered paper
- DES, Organosolv…

Kraft process for wood chemical pulping

50% yield from wood



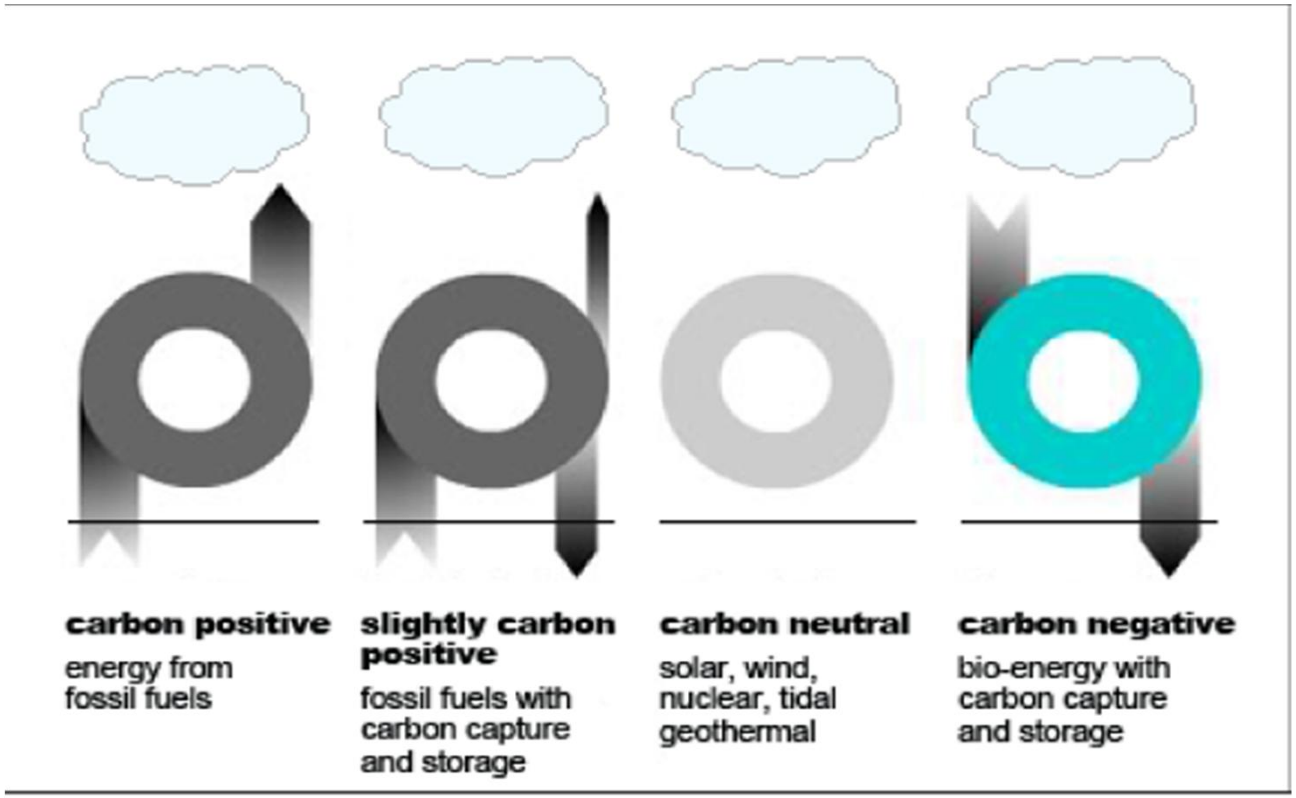
What is bio-CCS?

Capture and storage of CO_2 from biogenic origin

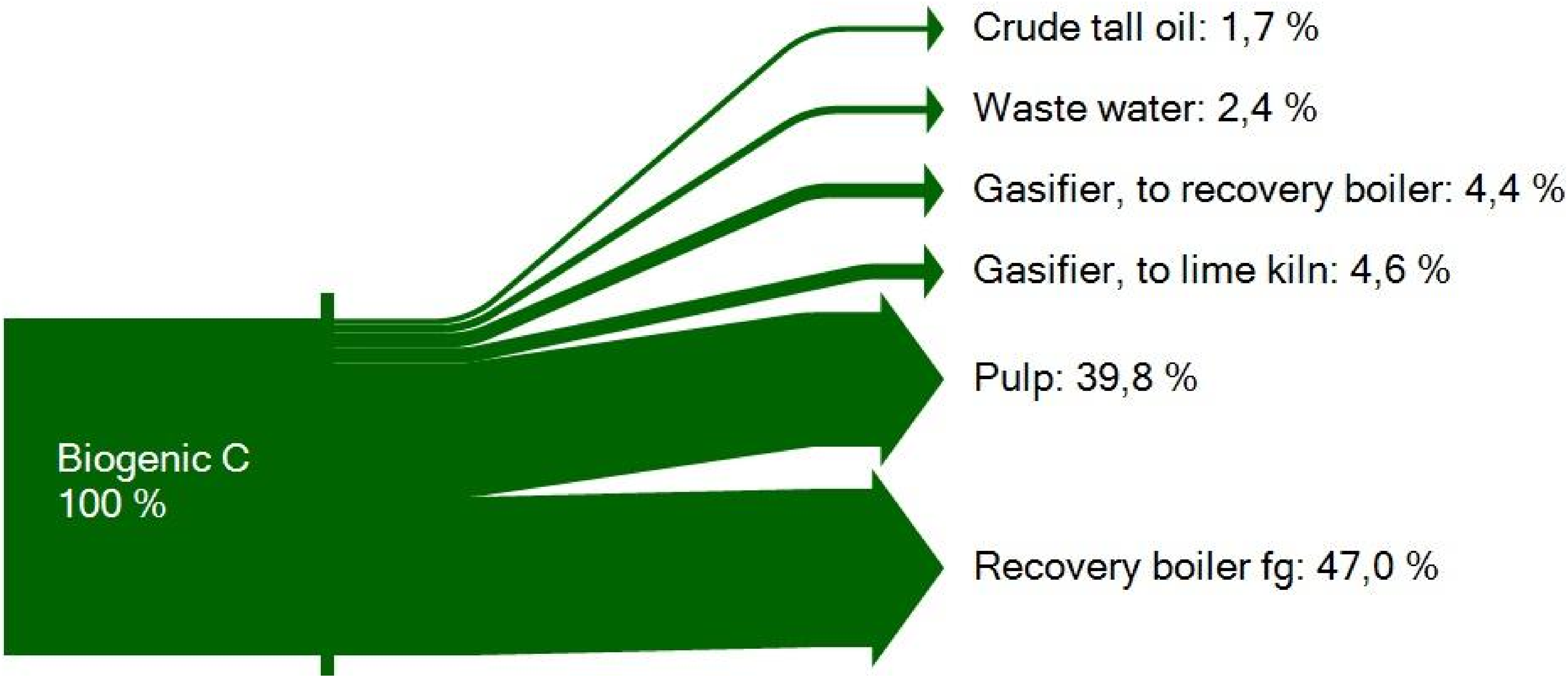
Capturing CO_2 from industrial processes and power production utilising biomass as raw material

Because biomass binds carbon dioxide in photosynthesis, carbon capture from biomass fired installations would lead to negative emissions on a life cycle basis, which means removing CO_2 from the atmosphere

Urgency highlighted in the IPCC Fifth Assessment Report calls for solutions that can remove CO2 from the atmosphere



Carbon flows in a example modern standalone kraft pulp mill



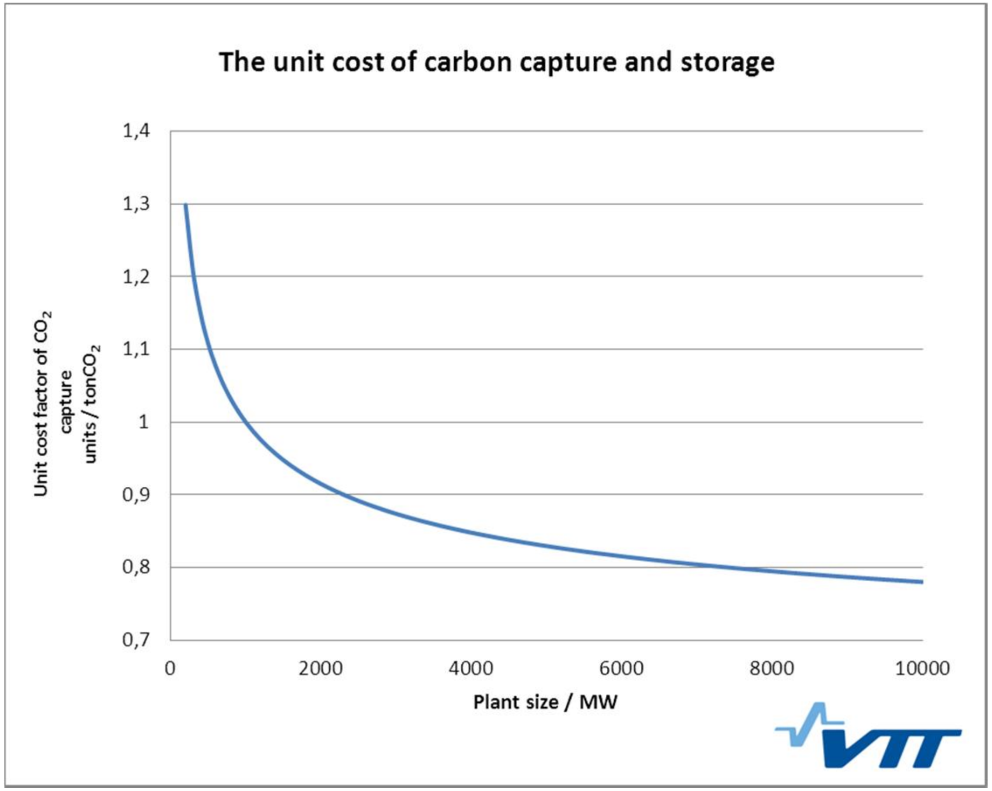
”Conventional” CCS in pulp and paper industry flue gases

- Lime kiln
  - Also part of chemical cycle
  - CaCO3 - > CaO
  - Rotating kiln
  - High temperatures ~1100C
  - Generally not Biogenic
  - Size in tens of MWs
- Power / bark boiler
  - Comparable to bio-CHP
  - CFB boiler technology
  - Often suplying heat outside mill site
  - Size limited by heat demand to some hundreads of MWs
- Recovery boiler
  - Essential part of Kraft pulping process
  - Recovery of coocing chemicals
  - Recovery of energy
  - Producing power and heat
  - 2000 adt/d market pulp mill: 1,3MtCO_2/a

	Lime Kiln	Recovery boiler
CO_2, vol-%	15 – 25	10 – 20
NO_x, mg/Nm³	150 – 200	150 – 200
SO_x, mg/Nm³	varied	5 – 20

CCS technologies

- Post combustion capture
  - No fundamental technical restriction for applying
  - SOx, NOx, dust, lay-out restrictions
- Oxyfuel
  - operational conditions, availability requirements, temperature profiles and impurity levels not in favour
- Pre-combustion capture
  - Only applicable to gasification (BL, lime kiln)
- Removal of carbon from chemical cycle
  - Other products (incl. PCC in paper making)
  - Lignoboost, HTC, HTL…



Case study on potential of CCS

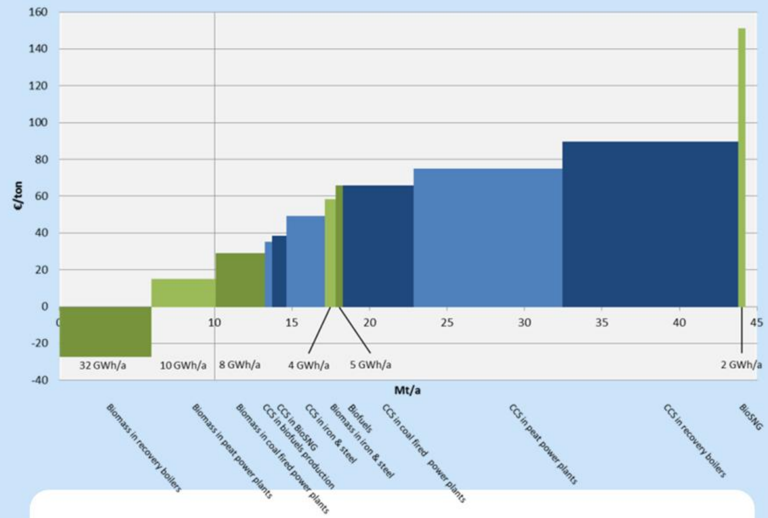
CO_2 captured from pulp and paper industry in Europe

38 large and medium sized units (>100MW recovery boilers and power boilers),

existing production, no increase projected

Potential ~>25MtCO_2/a

Bio-CCS including CCS in pulp and paper industry in Finland



Potential ~>12MtCO_2/a

Conclusions

- Bio-CCS can lead to carbon negative impact e.g. remove CO_2 from the atmosphere
  - Storing biogenic CO_2 should be considered as storing fossil CO_2
- A significant share of biogenic carbon input to pulp mills is currently ”stored” as products
- ”Conventional” CCS technologies can technically be applied
  - Costs higher in comparison to other CCS and Bio-CCS technologies (Mainly due to small scale and challenging operation conditions)
  - Opportunities in recovery cycle (gasification, lignign separation)
- According to VTT estimates, potential in large European mills is ”small” ~25Mt/a (Finland and Sweden majority)


TECHNOLOGY FOR BUSINESS
Antti.Arasto@vtt.fi