CCS and Pulp and Paper Industry

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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
- Integration 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 CO$_2$ from the atmosphere
Carbon flows in a modern standalone kraft pulp mill:

- Crude tall oil: 1.7%
- Waste water: 2.4%
- Gasifier, to recovery boiler: 4.4%
- Gasifier, to lime kiln: 4.6%
- Pulp: 39.8%
- Recovery boiler fg: 47.0%
"Conventional" CCS in pulp and paper industry flue gases

- **Lime kiln**
  - Also part of chemical cycle
  - CaCO₃ → CaO
  - Rotating kiln
  - High temperatures ~1100°C
  - Generally not Biogenic
  - Size in tens of MWs

- **Power / bark boiler**
  - Comparable to bio-CHP
  - CFB boiler technology
  - Often supplying heat outside mill site
  - Size limited by heat demand to some hundreds of MWs

- **Recovery boiler**
  - Essential part of Kraft pulping process
  - Recovery of cooking chemicals
  - Recovery of energy
  - Producing power and heat
  - 2000 adt/d market pulp mill: 1.3MtCO₂/a

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<thead>
<tr>
<th></th>
<th>Lime Kiln</th>
<th>Recovery boiler</th>
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<tbody>
<tr>
<td>CO₂, vol-%</td>
<td>15 – 25</td>
<td>10 – 20</td>
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<tr>
<td>NOₓ, mg/Nm³</td>
<td>150 – 200</td>
<td>150 – 200</td>
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<tr>
<td>SOₓ, mg/Nm³</td>
<td>varied</td>
<td>5 – 20</td>
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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…

![Graph showing the unit cost of carbon capture and storage vs plant size/MW](image)
Case study on potential of CCS

**CO₂ 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 ~>25MtCO₂/a

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

- Potential ~>12MtCO₂/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)