Comparison of efficiency and cost for ship fuel production from pulp mills' residues through HTL, e-Methanol, and solvolysis

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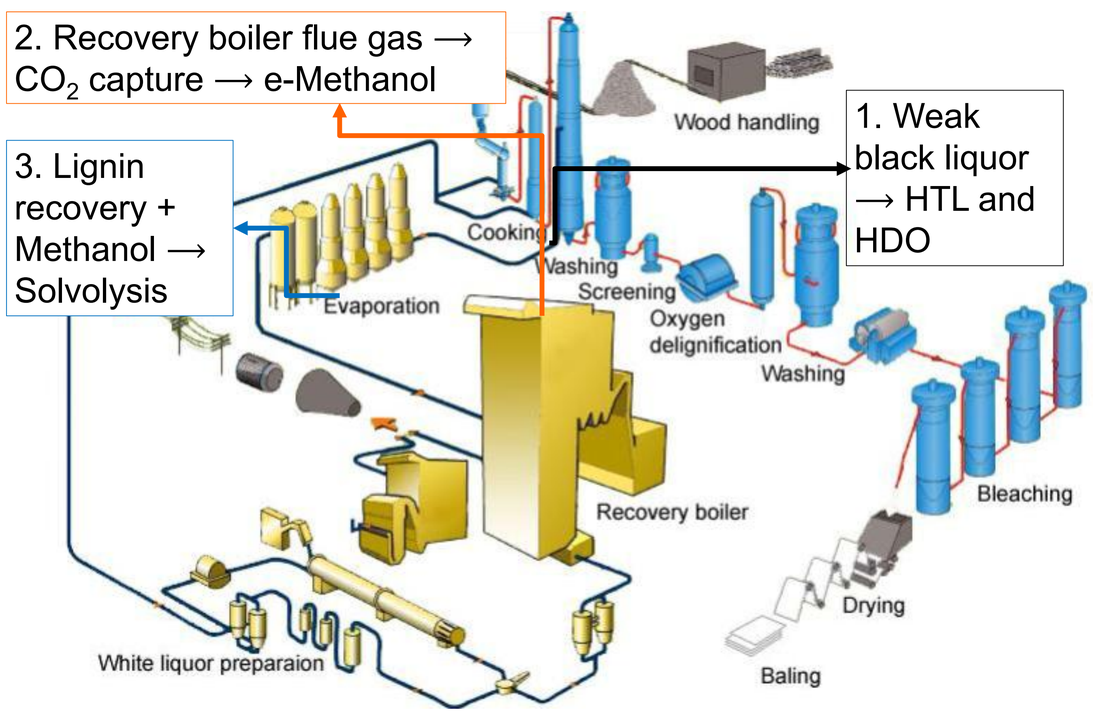
Background

Decarbonization of shipping requires sustainable alternatives to fossil fuels. In addition to electrification, biofuels and e-fuels are expected to play an important role. Kraft pulp mills offer multiple opportunities for renewable fuel production through the utilization of black liquor, lignin and biogenic CO_2 streams.

Methods and Assumptions

Parameter	Value
Kraft pulp mill capacity	500 000 ADt/a
Black liquor utilization	20%
CO_2 capture case	20% of flue gas CO_2
Tool	Process simulation
Outputs	Fuel production, energy balance, H_2 demand, production cost

Case 1: Hydrothermal liquefaction (HTL) of black liquor, followed by hydrodeoxygenation (HDO) to produce renewable hydrocarbon marine fuel. **Case 2:** Capture of biogenic CO_2 from pulp mill flue gases (20% of total CO_2 emissions) using MEA absorption, followed by e-methanol synthesis using renewable hydrogen produced by water electrolysis. **Case 3:** Recovery of Kraft lignin from black liquor (equivalent to 20% of black liquor flow), followed by solvolysis using biomethanol produced from forest-residue gasification and subsequent HDO upgrading to renewable marine fuel.



Results

160 000 ton/, HHV=13.3 MJ/kg, 67.5 MW
HTL includes integrated salt separation reported in BL2F project [1]

HTL and downstream HDO plant

~scaled plant investment cost ~170 M€, reported biocrude minimum fuel selling price 2.1-1.7 €/l >250-210 €/MWh

~38200 ton/a of Biocrude 37.4 MW and 34 MW upgraded fuel. The reduction in mill power production 20 MW

CO2 capture and e-Methanol plant

Approximately 200 000 ton/a 20% of total amount in recovery boiler flue gas

Own calculation [2]

~105 000 ton/a of Methanol ~70 MW **133 MW** of Power input to the mill!

20 % Kraft Lignin ~50000 t/a separated from BL +27000t methanol

Lignin extraction and solvolysis with methanol

~27000 t Crude lignin oil product!

Lignin extraction plant 38 M€
Power & Biomass to-Methanol plant 45 M€

The make-up methanol per ton of lignin unclear, but reported value for forest residue used as 1st estimate

Conclusions

- The Power-to-X pathway showed the highest electricity demand among the investigated routes
- The black liquor HTL case resulted in high estimated fuel costs for the specific configuration, including integrated salt separation, but another study reports < 1 €/gasoline equivalent l for 80 kt/a scale [3]
- Literature-based HTL costs are feedstock- and case-dependent
- Lignin solvolysis is a promising but less mature route; yields, methanol demand and salt recovery require further validation

References

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