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Estimating the potential and costs for carbon dioxide removal in the European pulp and paper industry

Sebastian Karlsson[a], Elin Svensson[a], Luca Riboldi[b], Simon Roussanaly[b,*], Rahul Anantharaman[b], Simon Harvey[a]

[a]*Division of Energy Technology, Chalmers University of Technology, Gothenburg, Sweden*
[b]*SINTEF Energy Research, Trondheim, Norway*

Abstract

Meeting the targets outlined in the Paris Agreement of limiting global warming to 2℃ and pursuing efforts to keep warming below 1.5℃, will require deep emissions reductions, along with carbon dioxide removal (CDR) at the gigatonne scale [1]. The pulp and paper industry, and specifically kraft pulp mills, has a large potential for CDR via bioenergy with carbon capture and storage (BECCS) (e.g., approximately 62 $MtCO_2$/year of biogenic emissions from the pulp and paper sector in Europe that could be captured [2]) due to the prevalence of large point sources of biogenic CO_2 flows with relatively high CO_2 concentrations (13-20%). Previous work performing sector-wide techno-economic assessments in the Swedish context (a country with a large and active forest industry) has investigated the CO_2 capture costs from large industrial facilities (> 500$ktCO_2$/year) including the pulp and paper industry. Such studies typically find that large pulp and paper mills present cost-effective opportunities for implementing CO_2 capture. However, to facilitate implementation, further understanding of factors affecting the potential and costs need to be investigated and discussed. Thus, the overall aim of this work is to assess the potential and cost for CDR from the pulp and paper industry at the European level, considering regional and geographical conditions (e.g., different energy prices and CO_2 transportation opportunities) and the impact of different heat integration scenarios.

The AMP/PZ capture technology is considered for estimations of CO_2 capture costs and the analysis covers sites in the European pulp and paper industry with biogenic emissions above 250 $ktCO_2$/year, thereby covering most of the large emissions sources in the sector. The timeframe of the analysis is assumed to be the 2040-2050's, since BECCS is not expected to be deployed at a large scale in the near term. To perform the analysis, this work builds upon results from previous research in the ACCSESS project that performed case studies investigating CO_2 capture costs for case study mills, based on different heat integration scenarios [3].

To estimate the potential for BECCS in pulp and paper mills, publicly available emissions and location data from the European Pollutant Release and Transfer Register (E-PRTR), individual company websites and environmental reports were collected and used. To assess the impact of heat integration on the cost for BECCS and sector-wide energy balances, two scenarios are compared. For the reference scenario, no heat integration is considered between the industrial site and the capture process, and a stand-alone biomass boiler is assumed to be installed to supply the required heat to the reboiler. The minimized fuel use scenario, defined based

* Corresponding author. Tel.: +47 47441763
E-mail address: simon.roussanaly@sintef.no

on learnings from Lacaze-Masmonteil et al. [3], assumes that the CO_2 capture process can be integrated with the host site, and that the heat required for the reboiler in the capture plants can be supplied by high pressure steam extracted before any turbine stages. This means that electricity generation is sacrificed in favor of supplying heat to operate the capture plant.

The results of this work quantify the geographically resolved potential for BECCS in the European pulp and paper sector, along with the associated costs for CO_2 capture, conditioning and transportation to a permanent storage site using the iCCS toolset [4]. The mapping of biogenic CO_2 emissions from the pulp and paper is shown in Figure 1. Most of the included sites are kraft pulp mills, with large biogenic emissions emanating primarily from the recovery boiler. The sites are mainly located along the coastline, or along waterways that are connected to the coast. Minimizing inland transport and facilitating easier ship transportation of CO_2 could in turn reduce the cost of the BECCS chain. In central Europe and the UK, the prevalence of recycled paper mills, mechanical pulp mills, and paper mills is higher. These sites typically emit lower amounts of biogenic CO_2 than the kraft pulp mills. The paper also presents costs for BECCS in the form of a marginal abatement cost curve (MACC), covering the emissions sources shown in Figure 1 considering the different heat integration scenarios. In addition, maps showing regional costs are presented, to highlight the impact on the cost of BECCS due to geographical, sectoral and energy price differences between regions.

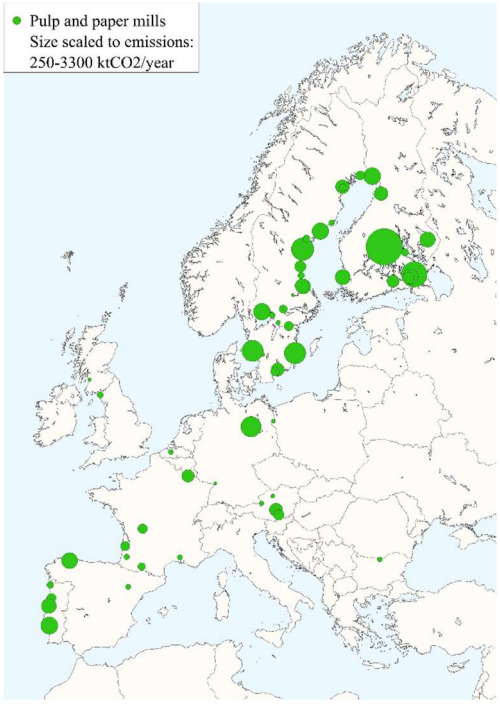

Figure 1. Biogenic CO_2 emissions from sites in the European pulp and paper industry covered in the analysis. The size of the sites is scaled according to biogenic emissions. In total, 58 mills are included.

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Keywords: CDR; BECCS; Pulp and paper; Techno-economic analysis; Negative emissions potential;

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