25 October 2011

TECHNOLOGY AND POTENTIAL OF BIOCCS IN PULP AND PAPER INDUSTRY

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Introduction

The global pulp and paper industry is dominated by North American, northern European and East Asian countries. Australasia and Latin America also have significant pulp and paper industries. At the moment global pulp markets are driven by only very large production units in Brazil and Uruguay. In northern Europe, especially in Finland and Sweden pulp and paper industry accounts for a major share of the CO_2 emissions emitted in the area. This CO_2 is to a large extent from biogenic sources and thus considered carbon neutral. Photosynthesis binds carbon from the atmosphere and the carbon is again released during biomass combustion. Capturing and permanently storing the CO_2 from pulp and paper production processes would lead to net negative emissions and therefore create a carbon sink. Nevertheless, current climate and energy policies do not consider biogenic CO_2 emissions comparable to fossil CO_2 emissions. For instance, the current EU ETS do not recognize negative emissions and therefore no fiscal incentive for capturing biogenic CO_2 exists yet.

This paper briefly describes the CO_2 emissions and their sources in the pulp and paper industry. The background and visions of pulp and paper production as a European industry with the focus on climate change mitigation is also briefly discussed. The pulp and paper production is investigated from the carbon capture point of view and the prospects of application of various capture technologies are assessed and discussed. This paper lays an insight to prospects of applications of CCS to pulp and paper industry. The potentials are compared on a European scale and possible implications on the carbon market, on the technological breakthrough of CCS, and to the European pulp and paper industry are discussed.

Potential for CCS in pulp and paper industry

As there is no significant increase to be seen in the European pulp production in the future, the potential for carbon capture and storage from pulp and paper industry in the future can be roughly estimated based on production rates of today. Based on Pöyry databases altogether 38 large scale installations were identified in Europe, ranging from 140 to 700 MWth. This includes 18 recovery boilers and 20 power boilers, recovery boilers being generally of larger scale. The assumption was that largest production units in Europe will remain in operation and renew themselves. If all these installations would be equipped with carbon capture, this would total approximately 20 Mt CO_2 / year. This is less than IEA blue map scenario estimates for the year 2020 [IEA 2009].

In comparison to the entire Europe, pulp and paper industry in Finland and Sweden account for a significant share of the total CO_2 emissions (biogenic and fossil). Finland's pulp and paper industry accounted for 21 Mt of CO_2, of which 17 Mt was biogenic. Total emissions from facilitie emitting >0,1Mt CO_2/a were 61Mt CO_2 in 2007. In Sweden pulp and paper accounted for 24 Mt CO_2 / a, of which 22 Mt were of biogenic origin. Total emissions from facilitie emitting >0,1Mt CO_2/a were 48Mt CO_2 in 2007 [Teir et al., 2010] These include also installations smaller than considered in the European potential.

Emissions and technologies for carbon capture

Pulp and paper mills are traditionally characterised by a high level of internal and external integration on energy and material flows. The CO_2 emissions from one installation are scattered around to several stacks around the site. In addition to this, the operating conditions, flue gas compositions, impurities and the operating environment are more challenging compared to carbon capture and storage from coal fired power plants.

CO_2 emission sources at a pulp mill or an integrated pulp and paper mill differ due to the different energy requirement on and off site. As a consequence, the power production facilities can vary significantly from site to site. Large European pulp mills are generally based on the Kraft process. CO_2 emissions from an integrated pulp and paper mill are scattered to several stacks around the site. The majority of the emissions are generally of biogenic origin. The three biggest sources of CO_2 on site are recovery boiler, lime kiln and a power boiler or a bark boiler. The size of a power boiler varies significantly, depending on the additional energy production. Recovery boiler sizes at large integrated pulp and paper mills are generally in the range of 150 – 700 MWth while the lime kiln CO_2 emissions are generally in the range of one?? sixth of the recovery boiler. Carbon combusted in the recovery boiler originates from black liquor and is thus of biogenic origin. Natural gas and oil are normally used as fuel in lime kiln, but also biomass fuelled lime kilns exist. The size of the recovery boiler and the lime kiln is directly related to the pulp production process and can vary significantly from site to site. In addition, flue gas compositions from different sources on site vary significantly, depending on the nature of the raw material or raw material blend utilized in the Kraft process. The CO_2 content of a recovery boiler flue gases is 10 – 20 vol-percent whilse the CO_2 content in lime kiln flue gases can be significantly higher, up to 15 – 25 vol-percent.

Table 1 Properties of flue gases

	Lime Kiln	Recovery boiler
CO_2, vol-%	15 – 25	10 – 20
NO_x, mg/Nm^3	150 – 200	150 – 200
SO_x, mg/Nm^3	varied	5 – 20

There are three basic first generation technological pathways to capture carbon dioxide, namely pre-combustion capture, post-combustion capture and oxyfuel combustion. Pre-combustion capture can be applied to a pulp and paper mill in connection to black liquor gasification. This is a process that would replace the recovery boiler and increase the electricity production efficiency. Application of black liquor gasification would enable the application of pre-combustion carbon capture from the product gas of gasification. Gasification technologies currently under consideration are based on air gasification, while oxygen gasification is needed to gain full benefit from physical solvents in pre combustion capture. However, this technology could only account for a part of the emissions from site. The black liquor gasification technology is still in the development phase and is not a commercially available technology yet. Oxyfuel combustion could in theory be applied to the combustion processes on site. However, the oxyfuel technology is currently being developed for coal combustion processes. Operational conditions, availability requirements, temperature profiles and impurity levels are more challenging in both lime kiln and recovery boiler and thus makes the application of oxyfuel combustion to these processes far more challenging compared to a coal combustion process. This technology is not seen as a near or a medium term solution for pulp and paper production. Post-combustion carbon capture can be applied to all major emission sources on site, the lime kiln, bark boiler and the recovery boiler processes. While SO_x levels are generally lower in these processes than for coal fired power plants, peaks in concentrations can occur, especially in lime kiln flue gases. The sulfur components in the lime kiln flue gas originates mainly from odorous gases and dissolving tank vapours that are let into these gas streams for treatment prior to emission. The handling of sulphur containing gases varies significantly from site to site. The sulphur in recovery boiler flue gas originates from the cooking chemicals and the sulphur levels in flue gas are rather constant. NO_x levels in both flue gases are rather high and can pose difficulties to application of post-combustion capture processes. The NO_x are due to the demanding conditions and high temperatures especially in a lime kiln. High NO_x concentrations lead to the degradation of amine solvents and generate nitrous amine compounds in the carbon capture process off gas. This calls for additional investments (for additional water washes stage) in the carbon capture process. There is also a need for additional investment for dust removal, as dust levels are very high in both flue gases, again especially in lime kiln flue gas.

Costs of carbon capture at a pulp mill are considered to be higher [Figure 1] than in most of the industrial scale applications considered e.g. in ZEP´s The Costs of CO2 Capture, Transport and Storage – Post demonstration CCS in the EU [2011]. This is mostly due to the relatively small scale of applications that reflect not only to the investment price of the equipement, but also to the unit price of transportation of CO_2. Although the location of a pulp and paper mill is good considering maritime logistics of CO_2 transportation, even small CO_2 volumes would increase the unit costs significantly [Teir et al., 2011]. As CCS would be installed at existing pulp and paper productions sites, lay out issues are expected to rise. Both processes, particularly the recovery boiler, are in the hearth of the mill processes and thus typically in the centre of the site. This requires either long ducting infrastructure for flue gas or a small installation area. These issues can further raise the costs of carbon capture on site and further in the production costs of pulp in comparison to market pulp from Brazil and Uruguay

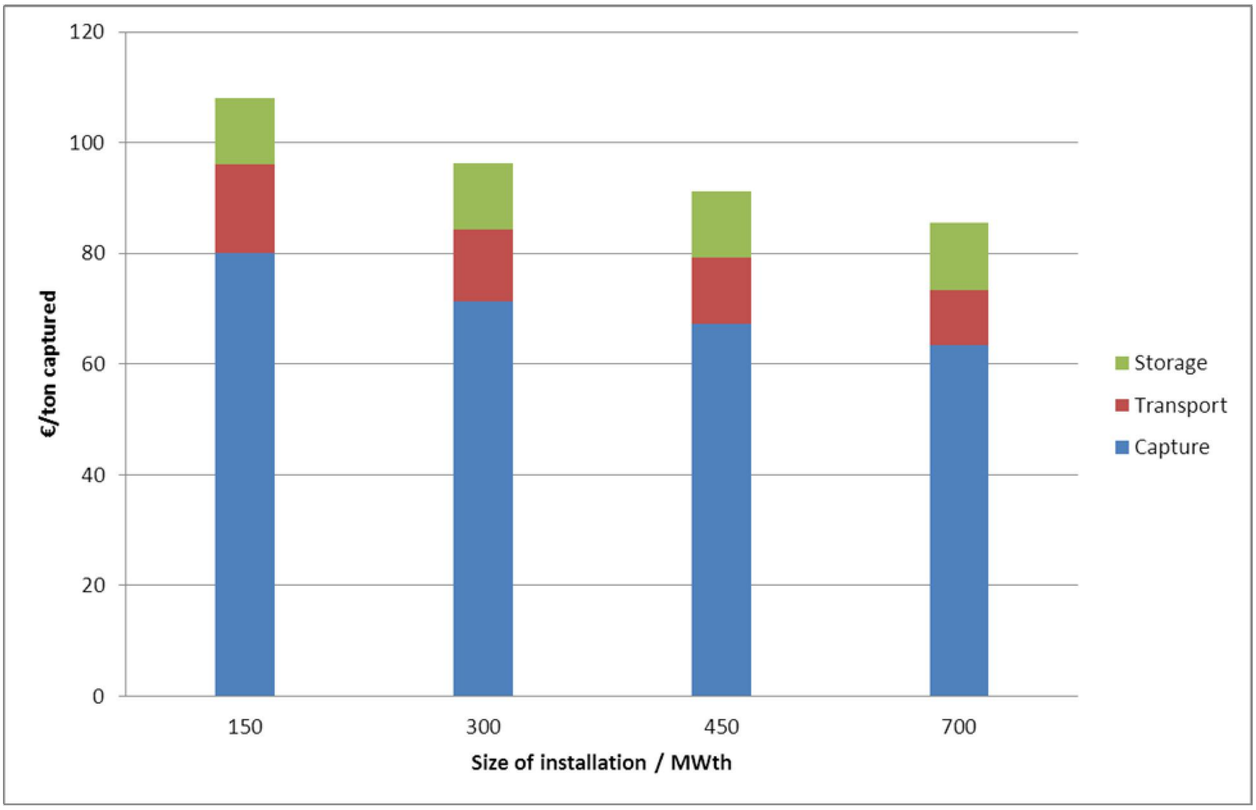

Figure 1 Cost of post combustion carbon capture, transportation and storage in different pulp mill applications

Conclusion and discussion

Pulp and paper industry can account for a significant share of national emissions as is the case in Finland and Sweden. Nevertheless, the potential in Europe is rather moderate if compared to the roadmap targets, fossil CCS potentials and even to other BioCCS opportunity potentials, such as capture of CO_2 from thermochemical production of liquid biofuels. In addition to the moderate potential, carbon capture from pulp and paper industry is considered to be more expensive than from e.g. fossil power plants [ZEP 2011]. The higher costs are mainly due to the small scale of applications, geographical locations and challenging conditions in the pulping process.

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