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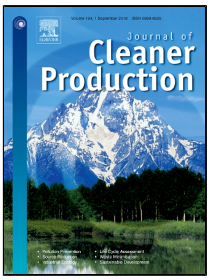

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Energy efficiency and environmental assessment of papermaking from chemical pulp - A Finland case study.

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Abstract

Pulp and paper manufacturing sector constitutes one of the largest industry segments in the world in terms of water and energy usage as well as of significant use and release of chemicals and combustion products. Since its chief feedstock –wood fiber– is renewable, this industry can play an important role in sustainable development, becoming an example of how a resource can be managed to provide a sustained supply to meet society's current and future needs. This calls for a thorough assessment of environmental costs and impacts associated to pulp and paper operations, including both direct and indirect inputs supporting the whole papermaking process as well as the main outputs, co-products and by-products. By means of Life Cycle Assessment (LCA) methodology, this paper aims at assessing the environmental sustainability of the pulp and paper production so as to identify those phases across the whole supply chain that entail the highest environmental loads, thus requiring improvements. To determine the environmental impacts as accurately as possible, the manufacturing stages performed in the pulp and paper mill complex of Stora Enso Oyj Veitsiluoto Mills at Kemi, Northern Finland, were taken as a model and assessed by means of the SimaPro 8 LCA software, utilizing ReCiPe Midpoint (H) method for the impact assessment. As expected, most of the resulting impacts are caused by the industrial production phase. The production processes of pulp and paper jointly affect all the investigated impact categories with the highest shares, ranging from 50% of generated impacts on water depletion up to 88% on freshwater eutrophication. Generally, the main contributions to environmental loads come from the electricity and heat requirements and, only at a minor extent, from the use of chemicals such as the sodium hydroxide and sodium chlorate. In particular, pulp production process generates the main loads on global warming (46% of the total impacts), ozone depletion (39%), freshwater eutrophication (55%), human toxicity (46%), metal depletion (42%) and fossil depletion (46%). In the remaining investigated impact categories, namely terrestrial acidification, photochemical oxidant formation and terrestrial ecotoxicity, most of impacts derive from the use of optical brighteners and fillers in the final steps of paper production and from the intensive consumption of water in the recycling step of end-of-life affecting water depletion. Moreover, the implementation of measures for material and energy efficiency in the assessed system, such as the use of renewable energy generated *in situ* from black liquor and residual biomass to support the requirements of the integrated pulp and paper mills and the waste paper recycling, resulted to be crucial in lowering the environmental burdens. In particular, the partial fulfillment of electricity and heat requirements by means of a circular use of residues within the system leads to a noteworthy reduction of impacts in all the investigated impact categories, up to more than 70% in global warming and fossil depletion potentials, thus contributing to higher process sustainability compared with other averaged European systems for paper production.

The obtained research results are a valuable source of management information for the decision makers, at both company and national levels, with the aim to improve the environmental performance of pulp and paper industry.