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Assessing the value of pulp mill biomass savings in a climate change conscious economy

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Abstract

Pulp mills use significant amounts of biofuels, both internal and purchased. Biofuels could contribute to reach greenhouse gas emission targets at competitive costs. Implementing process integration measures at a pulp mill in order to achieve pulp production with less use of energy (biofuels) has not only on-site consequences but also off-site consequences, such as substitution of fossil fuels elsewhere by the saved pulp mill biofuels, and less on-site electric power generation. In this paper a method, a linking model, is suggested to analyse pulp mill biofuel saving measures when carbon dioxide (CO_2) external costs are internalised. The linking model is based on equilibrium economics and links information from CO_2 constrained energy market future scenarios with process integration measures. Pulp mill economics and marginal energy market CO_2 response are identified. In an applied study, four process integration measures at a Swedish pulp mill were analysed using five energy market future scenarios emanating from a Nordic energy model. The investigated investment alternatives for biofuel savings all result in positive net annual savings, irrespectively of the scenario used. However, CO_2 emissions may increase or decrease depending on the future development of the Nordic energy market.

Keywords: Energy market scenarios; Pulp mill biofuels; Greenhouse gas emissions

1. Introduction

Biomass is attractive for energy purposes in at least three respects: Contribution to sustainable development, reduction of fossil fuel related anthropogenic greenhouse gas (GHG) emissions, and security of supply. To develop sustainable energy systems with low CO_2 emissions it is necessary to not only increase the use of biofuels, but also to use such fuels as efficiently as possible.

Stabilisation of GHG concentrations in the atmosphere calls for targets on anthropogenic global GHG emissions. A wide range of international energy market studies suggests that the use of biofuels is cost-effective to reach global targets, e.g. (Johansson et al., 1996; Nakicenovic et al., 1998; Azar et al., 2003; UNDP, 2000). In a Nordic perspective, different studies show that biofuels may play a significant role for cost-effective GHG reductions (Azar et al., 1998; Nyström and Cornland, 2003; Unger, 2003)

According to Swedish energy statistics the total energy consumption for the industrial sector was 150 TWh in 2001, which constitutes approximately 1/3 of Swedish total energy consumption (Swedish Energy Agency, 2002). The pulp and paper industry's part is 47% or 70 TWh. Of these 70 TWh, approximately 42 TWh were biofuels, corresponding to 43% of the total Swedish biofuel usage (97 TWh). Hence, for Sweden, if energy savings in pulp mills are cost competitive the potential for biomass savings is significant.

Several studies of more energy efficient pulp mills have been performed at the author's department. The Swedish "EcoCyclic Pulp Mill" project has defined the energy system for a reference mill incorporating best

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available technology (STFI, 2000). According to this project, future pulp mills should not only be energy self-sufficient using internal biofuel resources, but should also be able to export excess biofuels and lignin (Wising, 2003; Algehed, 2002). Identifying potential energy efficiency measures for retrofitting of a pulp mill requires the use of appropriate process integration (PI) tools, including both traditional pinch technology tools, e.g. (Linnhoff, 1994) and advanced tools specially suited to retrofit situations, e.g. (Carlsson et al., 1993; Nordman and Berntsson, 2002).

Economic analysis of PI projects often neglects externalities, e.g. (Taal et al., 2003; Mou and Qvale, 2002; Goršek and Glavič, 2003). Adding the challenge of curbing CO_2 emissions a widened perspective is necessary in order to internalise CO_2 emission externalities.

In the previous work, appropriate tools and methods for systematic analysis of CO_2 emissions associated with PI retrofit measures have been presented (Axelsson et al., 1999; Ådahl et al., 2000). These methods take the off-site effect of a changed electricity balance at a mill into account and assume that fossil fuel is saved at the plant site. However, biofuels will be the marginal fuel for pulp mills in a near term future. Biofuels are generally assumed to be CO_2 neutral due to the closed carbon cycle. Hence, biofuel savings at a pulp mill may only lead to CO_2 emissions reductions if the saved biofuel is used to substitute fossil fuels somewhere else in the energy system–not otherwise.

In this paper we suggest a method—a linking model, to analyse investment economics and total CO_2 emissions consequences (including on-site and off-site consequences) for PI biofuel saving retrofit measures at a pulp mill. Energy market future scenarios are used representing diversity in e.g. energy market CO_2 targets, energy end use, and technology evolution. For the linking model, a scenario is defined by the development of reference marginal power production and fuel, heat and electricity prices when CO_2 external costs are internalised. An important challenge we face in this paper is to identify marginal biofuel usage in the energy market, given assumptions regarding the development of the future energy system. By such identification, it is possible to assess the total CO_2 emissions consequences of biomass saving measures at a pulp mill. We illustrate the method by using data from an energy efficiency study at a Swedish pulp mill (Bengtsson and Berntsson, 2004) and data from a Nordic energy market project (Nordleden, 1999, 2003).

2. Methodology

Fig. 1 illustrates the energy flows in the model future mill mentioned in the introductory section. Implementing energy efficiency measures in such a mill, or in an existing mill, as is assessed in the applied study in Section 3, changes the biofuel and electricity balance. Long-term investments in an industrial energy system call for knowledge about the development of the energy market regarding, e.g. fuel prices, environmental policy instruments, and technological development.

Analyzing marginal benefits of PI measures for a process plant in a climate conscious society can be accomplished in different ways. Parameters such as fuel prices and CO_2 penalties can be set according to own assumptions and expertise suggestions, and varied in a sensitive analysis. In this case input data is completely

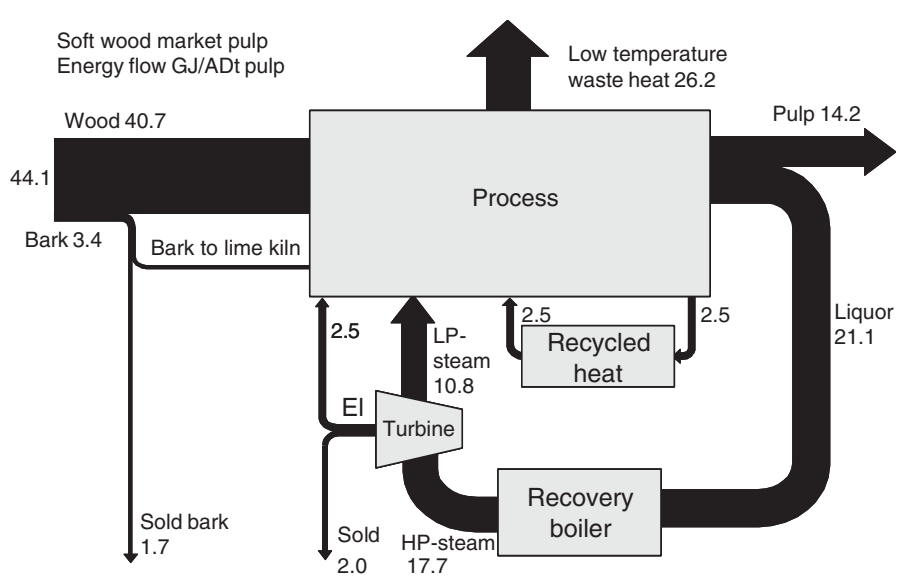

Fig. 1. Energy flows (GJ/ADt pulp) in a model future pulp mill, Eco-Cyclic Pulp Mill (STFI 2000).