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Biorefinery product potentials using tree biomass as feedstock – A survey on opportunities and threats to the new wood products industry

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ABSTRACT

A questionnaire survey on the potential of biorefinery products was carried out along with an analysis of energy prices and wood assortments. Electricity production was considered to have the potential for the highest investment return over ten years, followed by solid wood products, bioenergy assortments and textiles. Only pulp and paper were perceived as returning lower potential investment values over the next ten years than over the next five. Of the survey respondents, 95% believed that the value of woody biomass will increase over the next ten years, mainly through its replacement of oil-based products, although there will be problems due to lack of suitable raw material. A wide range of chemical products were described but a greater confidence in more traditional solid fuel products still prevails. Stemwood is the most favored part of the tree with only a few respondents saying that they wanted specific chemicals extracted. The electricity price and wood fuel price were found to be strongly correlated and 91% of respondents said their products would be affected by the electricity price. Electricity prices within OECD countries are expected to increase by 15% from 2011 to 2035, with wood fuel prices increasing by roughly 10% during the same period. Therefore, the electricity price could become a decisive factor in the future use of biomass in biorefineries. Our results suggest that large-scale commercial biorefinery production will soon be possible but new wood assortment classifications are needed that include both fiber properties and chemical properties such as extractive content.

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1. Introduction

The production of fuels, chemicals and materials from lignocellulosic non-food biomass instead of oil may be part of the

solution to achieve a sustainable future, especially in countries with extensive forest cover [1]. Biomass does not only act as a substitute for CO₂-releasing fossil fuels. The more biomass that is grown, the higher the carbon sequestration will be through photosynthesis – a good alternative to fossil

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feedstocks [2]. As Sjöström [3] pointed out 20 years ago, wood already constituted an enormous, renewable raw material resource for the production of both energy and chemicals. The function of wood as a construction material and as a source of fibers will presumably remain unchanged or even become more important in the future e.g. for building environmentally-friendly houses (CO₂ sinks). The production of lignocellulosic biomass on marginal non-food producing land can also result in important contributions to the social and economic development of rural communities [4].

Asikainen [5] stressed that to be profitable, the value of the new biorefinery products, or the net profits generated, have to exceed the values and net profits provided by traditional wood-based industries. Thus, the capacity to pay must be at least as high for biorefineries as for bioenergy and pulpwood industries. If there is a wish to increase the use of tree biomass, in favor of, for example, oil products, resources have to be mobilized. New harvest techniques are needed in order to derive whole-trees and harvest residues in profitable ways from young, dense forest stands [6,7] and thus utilize the surplus forest biomass growth from these forests [8]. Today, the bulk of the forest residue is left in the forest or burnt for energy. The latter could be done in energy-biorefinery combines, after the most valuable components, such as materials especially rich in extractives, have been separated off [9].

The demand for bioenergy and forest-based biofuels has been promoted through lobbying and by public policy measures that increase the cost of fossil fuels in favor of biofuels [10,11]. Such measures are, for example, carbon dioxide taxes, subsidies, tax relief on bio-based alternatives and providing favorable conditions for green technology. The promotion of renewable energy can also be regarded as an insurance against high oil prices in the future [12]. To be effective, these measures have to be combined with a value proposition for green technologies i.e. describing the advantages to corporations and consumers [13]. EU launched their 20–20–20 agreement in 2008, which included the reduction of greenhouse gas emissions by 20% and increasing the proportion of renewable energy to 20% by 2020 [14]. In the US, the Department of Energy together with The Department of Agriculture and the paper industry have invested several hundred million dollars in biorefinery projects aimed primarily at developing alternative fuels [13].

The realistic biomass potential of European forests in 2030 is estimated to be in the range of 623–895 million m³ yr⁻¹. This amounts to 58–80% of the theoretical potential. However, to reach 70% of the theoretical potential, a fundamental change to very intensive forest management would be required [15]. Commercial forestry is a long-term commitment, involving several management activities during the course of each rotation that strongly influence the growth, density, structure and profitability of the stands. In general, forest management practices have been quite uniform for a long time, with the consistent aim of optimizing the production of saw timber and pulpwood. To date in Swedish forestry, the harvested biomass used to generate energy has mostly consisted of logging residues [16] and have, thus, been dependent on harvesting levels decided on by the forest industry following traditional guidelines.

The market potential for different biorefinery products depends on the energy price in complex ways. Tree biomass is suitable both for producing biorefinery products and for producing heat and electricity. The value of woody biomass is increasing, as the search for renewable substitutes for fossil fuel products progresses. In addition, biorefineries are as dependent on energy prices as all other industries. It seems that the electricity price is an important driver of the total value of biomass raw material, but how the energy price affects biorefinery profits has not been thoroughly investigated. The business potential of different biorefinery products and product categories must be analyzed to identify the wood types and compounds required. To harvest suitable forest biomass in the coming decades, we must adapt forestry management today.

The objectives of this study were to

1. estimate the potential of biorefinery products from forest biomass, assess raw material requirements for promising biorefinery product areas and evaluate opportunities and threats to the biorefinery industry through a questionnaire study
2. ascertain the connections between energy and forest raw material prices over time and the price relationship between existing assortments

2. Material and methods

The methodological approach of this study consisted of both a questionnaire survey regarding wood-based product market potentials and an analysis of electricity prices and wood raw material prices.

2.1. Questionnaire survey of wood-based product potentials

The questionnaire [17] in the present study was posted in late February 2011 to 102 individuals from industry (43%), universities (29%) and business organizations (28%), who we were informed all worked with wood product-related issues. These individuals were resident predominantly in Sweden (69.6%) but also in other countries. Finding people with relevant knowledge on these matters willing to answer a comprehensive survey like the one used here is not easy, and the ca 100 respondents were chosen to make a good spread of different views and actors while not making the dataset of answers too large to analyze carefully both quantitatively and qualitatively. One reminder was sent out two months later containing a new copy of the questionnaire. The questionnaire answers were analyzed in 2012–2013.

The questionnaire consisted of two parts with, in total, 16 questions, some of them with sub-questions (a, b, c ...). The first part contained three questions where the respondents estimated potentials of tree biomass and biorefinery products in general. The second part contained 13 questions where the respondents described promising lignocellulosic products and estimated product development, tree biomass/raw material need and electricity demand linked to these products.

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