Biomass and Bioenergy 108 (2018) 415–425

Contents lists available at ScienceDirect

Biomass and Bioenergy

journal homepage: www.elsevier.com/locate/biombioe

Research paper

Prospects for producing liquid wood-based biofuels and impacts in the wood using sectors in Europe

A. Maarit I. Kallio[a,*], Rafal Chudy[b], Birger Solberg[b]

[a] Natural Resources Institute Finland, Helsinki, Finland
[b] Norwegian Universityof Life Sciences, Ås, Norway

ARTICLE INFO

Keywords:
Climate change mitigation
Forest biomass
Energy wood
Bioenergy
Forest sector

ABSTRACT

Rapid decarbonisation of the transport sector calls for increased use of biofuels. Part of the increase may be covered by fuels produced from logging residues, wood chips and round wood. This article addresses the economic potential and possible impacts of increased production of such wood based biofuels on the forest industries and production of wood based heat and power in the European Economic Area. A global model for the markets and trade of forest biomass and products, the EFI-GTM was applied for the analysis. The results indicate, firstly, that policy choices will have strong impacts on the allocation of biomass use between heat and power production and the production of liquid biofuels. Hence, the policy makers must have very clear goal setting for the preferred ways to solve the shift from the fossil fuel based energy system to a less carbon intensive one. Nevertheless, because large investments in biofuel production take time to plan and construct, and because the annual forest growth exceeds the harvests of wood in various parts of Europe, there is time to adjust the policies to control the market development. Secondly, even assuming the goal of limiting the global warming to 2 °C, the European forest industry production is projected to be rather little affected by the increased competition for biomass with the energy sector. This is because the rivalling regions are facing similar biomass demand challenges. Also, the relatively abundant wood biomass resources in Europe help the European forest industry to maintain its market shares.

1. Introduction

The Directive 2009/28/EC on renewable energy sources [1] set a 10% mandatory target for a share of renewable energy in the transport sector in the EU by 2020. Various measures, including subsidies and obligations to blend biofuels into conventional petrol and diesel fuels have been implemented by the member states in order to achieve that goal [2]. That has led to an increase in the share of biofuels in transport fuels in the EU28 to 4.2% in 2015 [3]. Yet, the sector is still heavily dependent on fossil fuels. The need for immediate action to decarbonize the transport sector that consumes one third of the final energy in the EU28 [3] paves the ground for a further increase in the use of biofuels. They can be used in existing vehicle stock under existing infrastructure [4]. Furthermore, the biofuels are practically the only available renewable energy source, when it comes to aviation, heavy duty road vehicles, and marine transports.

Although the majority of biofuels is currently and may also in the future be made from non-lignocellulosic biomass, it is expected there will be increased demand for biofuels made of woody biomass too. The EU's Indirect Land Use Change Directive [5] establishes a limiting quota for first generation biofuels and recently, the European Commission proposed a minimum share of 3.6% for advanced biofuels in transport by 2030 [6]. As one option, such fuels can be made of wood. The 3.6% share would require annually 48–62 million tonnes of woody feedstock without additional hydrogen input in production process and 16–24 million tonnes with it [7]. The possible increased use of wood in the production of liquid biofuels is expected to increase competition over biomass and thereby wood prices. That might force some of the other users of wood, for instance heat and power plants, to seek for alternative fuels or technical solutions [8–10].

Only few studies consider the market development and impacts of wood-based biofuels production separately from the biofuels made from other biomass types, or wood based biofuels production separately from all energy wood use. Lauri et al. [11] look at the impacts of increased aggregated demand for wood energy (biofuels + heat and power) on the forest sector and conclude that the global forest industry production is rather insensitive to increased wood demand in the energy sector even if bioenergy was to be produced in a scale required for the 2° C climate goal. They project that 5000 $hm^3\ y^{-1}$ of round wood and forest chips would be used for energy globally by 2100 in such case.

* Corresponding author.
E-mail addresses: a.maarit.i.kallio@luke.fi (A.M.I. Kallio), rafal.chudy@nmbu.no (R. Chudy), birger.Solberg@nmbu.no (B. Solberg).

https://doi.org/10.1016/j.biombioe.2017.11.022
Received 24 March 2017; Received in revised form 28 November 2017; Accepted 29 November 2017

Studies focusing on Norway [10] and Finland [8] demonstrate that large-scale investments on second-generation wood-based biofuels would increase biomass prices and reduce bioheat generation. Also the prices of sawmill chips could increase following such investments despite the abundant supply of biomass in the Nordic countries [12]. That can generate a modest increase in sawnwood production [11,12].

This study aims to examine (i) how alternative combinations of biofuel and biomass prices affect the production potential of liquid biofuels made of wood and allocation of wood biomass between biofuels and heat and power production in the European Economic Area, and (ii) what are the possible impacts that increased biofuel production could cause to the forest sector. The study focuses on bioenergy produced from logging residues, sawmill chips and round wood.

Large uncertainty prevails regarding the future supply and market prices of woody biomass and biofuels made of it. These factors are affected by the consumers' behaviour (e.g. demand for biofuels, heat and power, and forest industry products), by the costs and availability of alternative energy forms, and by the policies (taxation, subsidies, and prices of CO_2 emission allowances, etc.). These issues affect the tightness of competition for biomass between the users and make the investment and operation environment unpredictable. To overcome some of this uncertainty, we consider alternative future markets environments, where we explore the development of wood based biofuels production, allocation of wood feedstock between heat and power production and biofuels, and the impacts of the increased use of wood for energy on the forest industries. In order to create and consistently quantify these market environments, we use a global forest sector model, EFI-GTM [13]. The EFI-GTM model includes the international trade in all main wood biomass and forest industry products. This approach enables us to take into account for the vision that the use of wood based energy is increasing also outside of Europe [11,14,15]. Due to international trade, Europe is not isolated from the global developments.

2. Material and methods

2.1. The global forest sector model, EFI-GTM

The EFI-GTM is a multi-regional and multi-periodic partial equilibrium model of the global forest sector. It integrates forestry, forest industries, final demand for forest industry products and international trade in wood biomass and forest industry products. It includes 57 regions covering the whole world, but the regional disaggregation is most detailed in Europe. Most European countries are modelled as individual regions. The updated version used in this study encompassed about 30 forest industry and energy sector products, 5 round wood and 3 forest chips categories, 4 recycled paper grades, and the by-products of the forest industries.

The partial equilibrium approach implies that the other sectors of the economy than those related to the supply and demand of wood and forest-based products are only considered indirectly. The model finds the competitive market equilibrium prices and market equilibrium quantities of production, consumption and trade for products and regions included. Concerning transport biofuels, we include the trade in wood biomass that can be used in production of biofuels in any region where profitable, but we do not include further trade in biofuels although such trade can take of course place in practise.

The competitive market equilibrium is solved by maximizing the sum of consumers' and producers' surpluses of all regions and products minus the trading costs. The model is solved in a recursive-dynamic fashion by one period at a time, updating the relevant data for the next period in each step. The general model formulation is presented in the Appendix, while more details concerning the functional forms and solving the model can be found from Ref. [13].

2.2. Scenarios considered

We consider two scenario settings A and B described in their own sections in more detail below. In setting A, the focus is to explore the impacts of the increased use of wood-based energy on the forest industry. Setting B focuses on wood-based biofuel production and allocation of wood biomass between biofuel and heat and power producers.

In defining the global demand drivers for the forest industry products in these two settings A and B, we followed the assumptions elaborated within a scenario “Bioinno” in a recent study by Kallio et al. [15]. The regional consumptions per capita of mechanical forest industry products were assumed to be 50% higher than their 2008–2012 averages by 2050. Demand for the printing and writing papers was assumed to decline gradually due ongoing substitution by the electronic media, being globally 18% lower in 2040 than in 2010. Assuming the future textile industries to increasingly favour wood based fabrics, the demand for dissolving and non-paper pulp was assumed to increase rapidly, in particularly after 2025, reaching 55 million tonnes by 2040. For the rest of the final forest industry products, the demand was tied to GDP growth employing the GDP elasticities from the econometric studies and expert estimates. The GDP growths were assumed to follow the IMF's forecast [16] for the regions it was available and then to converge to the OECD's [17] long run forecast by 2030 and stay at that level thereafter. The above assumptions were only used to specify the demand functions over time. The eventual demands projected by the model depend on the markets that are balancing supply and demand.

We also partly capitalized on the energy sector development in Ref. [15], as detailed below and summarized in Table 1. We considered the “Bioinno” scenario to be an interesting reference point for the present analysis because it includes the assumption that the global energy sector adapts to the goal of limiting climatic warming below 2° C. Consequently, the use of biofuels and production of bio-based heat and power increases considerably in Europe and globally. It is of interest to compare the quantities of wood-based heat, power, and biofuels in alternative biofuel and biomass price settings in this study to the quantities projected to be needed for the 2° C goal. Furthermore, because reaching the 2° C climate goal is challenging, we consider it to be somewhat unlikely that wood-based bioenergy would increase even more rapidly than in “Bioinno”. In the EFI-GTM version used in this study, we do not include alternative energy production forms competing with wood-based energy. Hence, it is convenient to use the “Bioinno” quantities as boundaries for wood based heat and power production in the scenarios when we address the biofuel production. In Ref. [15], the projections for the global energy system were made by Lehtilä and Koljonen with the global energy model TIMES-VTT which is based on widely used TIMES modelling framework [18,19]. The model is grounded in microeconomic theory and it mimics forward-looking market behaviour by the market participants in the global energy sector. The model is frequently used to support national energy and climate policy making in Finland [20].

More information on the main data and assumptions used in the modelling can, in addition to what is described below, be found from Refs. [13,15] and from the Appendix.

2.2.1. Setting A: comparing the impacts of varying global demand for wood bioenergy on the forest industry

Here, we compare three scenarios to examine the influence of potential future increases in the global demand for wood in heat, power and biofuel productions on the forest industry in Europe. We calculate two alternative cases to the “Bioinno” scenario [15]. In “Bioinno”, use of woody biomass is growing in all fronts: in the forest industry, in heat and power production, and in production of biofuels. In one alternative, we remove the possibility to increase production of wood-based transport fuels, but assume the heat and power production to increase as in “Bioinno”. In another alternative, we allow no increase in any wood based energy production after 2010, so that the forest industry