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Future perspectives of international bioenergy trade

Julian Matzenberger [a,*], Lukas Kranzl [a], Eric Tromborg [b], Martin Junginger [c], Vassilis Daioglou [c], Chun Sheng Goh [c], Kimon Keramidas [d]

[a] Energy Economics Group, Vienna University of Technology, Gusshausstrasse 25–27, AT-1040 Wien, Austria
[b] Norwegian University of Life Sciences, Høgskoleveien 12, NO-1430 Ås. Norway
[c] Copernicus Institute, Heidelberglaan 2, NL-3584 Utrecht, The Netherlands
[d] Enerdata, Global Energy Forecasting, 47 Av. Alsace Lorraine, F-38000 Grenoble, France

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ABSTRACT

According to the IEA World Energy Outlook 2012, primary demand for bioenergy will strongly increase up to the year 2035: the demand for biofuels and biomass for electricity is expected to triple. These changes will have an impact on the regional balance of demand and supply of bioenergy leading to both increasing trade flows and changes in trade patterns. The GFPM, TIMER and POLES models have been selected for a detailed comparison of scenarios and their impact on global bioenergy trade: In ambitious scenarios, 14–26% of global bioenergy demand is traded between regions in 2030. The model scenarios show a huge range of potential bioenergy trade: for solid biomass, in ambitious scenarios bioenergy trade ranges from 700 Mt to more than 2,500 Mt in 2030. For liquid biomass, the ambitious scenarios show a bioenergy trade in the range of 65 - > 360 Mt in 2030. Considering the currently very small share of internationally traded bioenergy, this would result in huge challenges and require tremendous changes in terms of production, pretreatment of biomass and development of logistic chains.

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1. Introduction

According to IEA World Energy Outlook 2012, primary demand for bioenergy will strongly increase up to the year 2035, the

* Corresponding author. Tel.: +436505854266.
E-mail address: matzenberger@eeg.tuwien.ac.at (J. Matzenberger).

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demand for biofuels and biomass for electricity is expected to triple. Moreover, the patterns of bioenergy use are expected to change substantially. Power generation and production of biofuels for transportation will constitute a larger share of biomass use compared to the currently dominating traditional biomass. These changes will have an impact on the regional balance of demand and supply of bioenergy leading to a change in trade patterns as well. Studies in accordance with the IEA Bioenery show that world bioenergy production has grown exponentially in the past: from below 30 PJ in 2000 to 572 PJ in 2009 for biodiesel; from 340 PJ in 2000 to over 1540 PJ in 2009 for fuel ethanol. World net biofuel trade reached 120–130 PJ in 2009 [22] and increased from about 56 to 300 PJ between 2000 and 2010 for solid biofuel trade [23].

The IEA foresees that international trade of solid biomass for power generation and biofuels for transport increases about seven-fold from 6 Mtoe (251 PJ) in 2010 to about 40 Mtoe (1675 PJ) in 2035, or about one-tenth of bioenergy supply in the power sector [1]. The volumes, routes, fuels, logistics of bioenergy trade will hence look quite different as we are used today. However, different scenarios and models of the global bioenergy sector show a diverging picture of the future development of bioenergy use. The perspectives of bioenergy trade depend on the anticipated development path which is influenced by impacts regarding energy markets, technological development, energy and climate change policies. This publication discusses perspectives of international bioenergy trade in the coming decades, based on assumptions and results of models that cover international bioenergy trade An excerpt based on the presented results can be found in the International Bioenergy Trade Handbook [35].

The objectives of this article are (1) to assess how bioenergy trade is included in different energy sector models covering bioenergy, (2) to analyse the implications on bioenergy trade of different energy market scenarios and (3) discuss different perspectives of international bioenergy trade in various scenarios. The article is structured as follows: First, a brief overview of reviewed studies is given. Second, a more detailed description of models that have been identified as suitable for bioenergy trade analysis is presented. Third, a comparison of scenarios in selected models is presented, leading to an analysis of model based drivers of bioenergy trade. Finally, perspectives of bioenergy trade are discussed and conclusions regarding important bioenergy trade regions in the mid- and long-term time horizion are drawn.

2. Global energy models and the role of bioenergy trade

2.1. Literature and model overview

Many studies have been undertaken to assess the biomass potential to contribute to future energy supply. A limited number of studies is dealing with the gap between regional bioenergy demand, supply and bioenergy trade. Conclusions from these studies vary significantly. We have indentified 28 models which contain bioenergy trade in some form. The models are heterogenous with some focusing specifically on the trade of biomass products, while others are more general energy or trade models which also include bioenergy trade. A three-stage review process was carried out in order to identify models suited for in-depth analysis of biomass trade. Out of the 28 identified bioenergy trade models, 22 models were selected according to their potential to model global bioenergy trade on a sufficient regional resolution, data availability and explicit trade modelling.

The models identified for further analysis ("long-list") were characterised according to specific criteria regarding bioenergy trade, based on available literature and, where not specified in sufficient detail, a questionnaire was sent out to the respective modelling groups. The following criteria for model selection have been analysed: the extent to which the model does cover biomass trade and if regional or global trade patterns are assumed, sectoral coverage, geographical regional aggregation and scenario time frame. The summarised results of a selected model review are shown in Table 1. In most models a scenario timeframe until year 2100 is considered.

We have selected specific models to be analysed in terms of status of development and activity, assumptions regarding trade, scenario families, scenario assumptions, demand coverage, demand drivers and data availability.[1] Three models have been chosen for a detailed comparison of scenarios and model results: GFPM, TIMER and POLES, which will be described in the following sub-secrion. All three models are currently used in global policy analysis and are under continuing development and have sufficient spacial resolution to allow for a common aggregation. TIMER and POLES are global (bio)energy models with comparable scenario assumptions, whereas GFPM is a renown model, that offers a perspective from forest sector modeling (Table 2).

2.2. Selected models for bioenergy trade analysis

2.2.1. Timer

The TIMER model is a dynamic energy system model developed by the Netherlands Environmental Assessment Agency (PBL) [12]. It has bottom-up engineering information as well as top-down investment behaviour rules and technological change. It is part of the larger integrated assessment model IMAGE, from which it gets its biophysical data and in turn provides energy and industry related emissions. The simulation process is dynamic recursive on a year-by-year basis. Energy demand is determined from economic activity and population increase and is calculated over five sectors: Industry, transport, residential, services and 'other'. This energy demand can be met from a number of energy carriers which compete with each other on a relative cost basis. Thus demand for energy carriers including bioenergy is price elastic. Key elements of the model dictating the demand and supply of energy carriers include:

- Autonomous and price induced changes in energy intensity. Thus the demand of final energy is elastic to energy prices, simulating behavioural changes.
- Depletion costs of energy resources dictated by supply curves. In the case of biofuels supply is limited from land constraints and decreasing marginal crop yield due to use of lower quality land. These act as positive feedbacks on the price of energy carriers with increased (cumulative, in the case of non-renewable sources) use.
- Stock turnover of capital limits the rate of change of the energy system as installed capital has to completely depreciate.
- Technological learning reduces the cost of a conversion technology with cumulative use. This is based on the learning curve principle. This dynamic acts as a reductive force on the price of energy carriers.
- The Multinomial Logit function is used to determine the market shares which fuels take to meet the energy demand of each sector. Thus multiple fuels can be used in each sector where the

[1] The most actual version of the GLUE model that has been published in international scientific literature does only cover trade on a two region basis and has therefore not been considered in this study. The GLUE II model has, however, been recently improved in terms of regional resolution, but was not considered in the scope of this study due to availability of more recent publications. The analysis by Lamers does only take into account trade of liquid biofuels. The models by Heinimö and Hofnagels have a special resolution limited to a few countries or regions.