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Biomass for heat or as transportation fuel? A comparison between two model-based studies

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Abstract

In two different energy economy models of the global energy system, the cost-effective use of biomass under a stringent carbon constraint has been analyzed. Gielen et al. conclude that it is cost-effective to use biofuels for transportation, whereas Azar et al. find that it is more cost-effective to use most of the biomass to generate heat and process heat, despite the fact that assumptions about the cost of biofuels production is similar in the models. In this study, we compare the two models with the purpose of finding an explanation for these different results. It was found that both models suggest that biomass is most cost-effectively used for heat production for low carbon taxes (below 50–100 USD/tC, depending on the year in question). But for higher carbon taxes, the cost-effective choice reverses in the BEAP model, but not in the GET model. The reason for this is that GET includes hydrogen from carbon-free energy sources as a technology option, whereas that option is not allowed in the BEAP model. In all other sectors, both models include carbon-free options above biomass. Thus, with higher carbon taxes, biomass will eventually become the cost-effective choice in the transportation sector in BEAP, regardless of its technology cost parameters.

Keywords: Energy scenarios; Energy systems modelling; Biomass; Transportation fuels; Liquid biofuels; Hydrogen; Carbon dioxide emissions; Carbon tax

1. Introduction

Due to the expected increase in global energy demand, the supply of carbon dioxide (CO_2)-neutral energy may have to grow to levels similar to or even larger than the present global total fossil fuel use, if we are to avoid venturing into a future with a doubled, tripled or even quadrupled pre-industrial atmospheric CO_2 level. Among several candidates capable of supplying large amounts of CO_2-neutral energy, biomass ranks as one of the few options already competitive in some markets. It is a low-cost renewable fuel, and it is near penetration into new applications as policies, markets and related technologies develop.

There are large uncertainties about the potential for biomass, but it is nevertheless clear that the potential supply is low compared with the future required levels of climate neutral energy, almost regardless of whether one is optimistic or pessimistic about the global bioenergy potential [1,2]. Biomass will thus not be available for all possible energy applications, and it is therefore important to discuss where to best use the scarce biomass resources for climate change mitigation.

In their study of cost-effective fuel choices in the transportation sector, Azar et al. [3] find that it is more cost-effective to substitute biomass for fossil fuels in power and heat production. Oil-based fuels remain in the transportation sector for the next four–five decades and thereafter solar hydrogen or hydrogen produced from fossil fuels with carbon capture and storage enters. However, in another study, Gielen et al. [4,5] conclude that most of the biomass is cost-effectively used as biofuels[1]

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[1]In this paper, "biofuels" always means liquid biofuels in the transportation sector.

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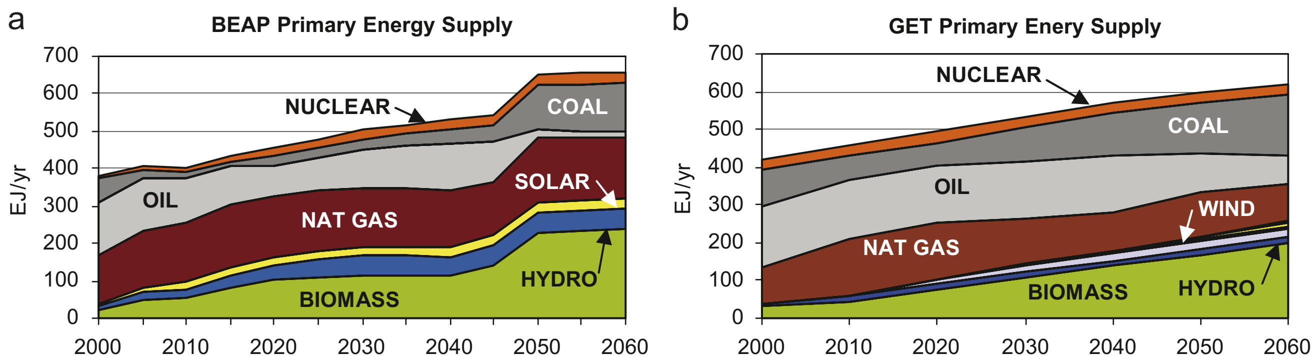

Fig. 1. Results on global primary energy supply as presented in (a) the BEAP paper and (b) the GET paper. In both models, there is an increasing use of biomass to meet the stringent CO_2 constraints. These are referred to as the reference scenarios of the models.

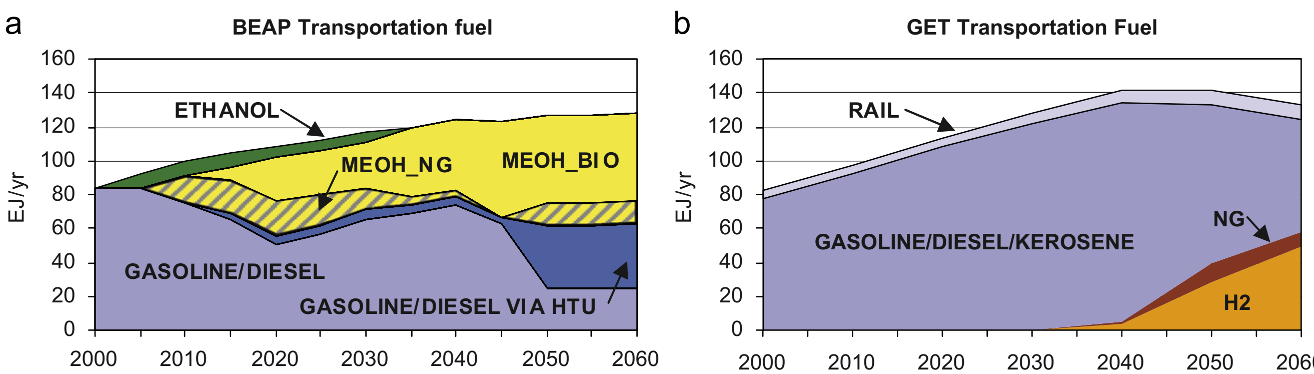

Fig. 2. Transportation fuels as presented in (a) the BEAP paper and (b) the GET paper. In the BEAP model, there is an increasing use of biofuels, i.e., ethanol, methanol from biomass and diesel/gasoline from biomass via HTU oil (Hydro Thermal Upgrading). In the GET model there is no biofuels in the base case run. These are referred to as the reference scenarios of the models.

for transport. These two studies base their results on global energy system models developed especially for these studies. Gielen et al. developed the Biomass Environmental Assessment Program (BEAP) model and Azar et al. the GET 1.0 (Global Energy Transition) model. The two models are in many ways similar to each other, and both models are run under ambitious constraints on CO_2 emissions.

The aim of this paper is to compare the two models with the purpose of finding an explanation for the differing results.

The paper is structured as follows: in Section 2, we summarize the results by Azar et al. and Gielen et al. In Section 3, we briefly describe the two models and present main input data assumptions and in Section 4, we identify four key reasons for the differing results by testing assumptions similar to the GET model in the BEAP model. In Section 5, we analyze how the GET model changes when using assumptions similar to the BEAP model and in Section 6, we present an explanation for the differing results. Finally, in Section 7, we discuss the results and offer some conclusions for modellers and policy makers.

2. A summary of the two different model results

In this section, we summarize results from the two models.[2] When presenting the results from the GET model, we have used an updated version of the GET 1.0 model; thus, the graphs shown are very similar, but not identical, to the results presented in Azar et al. [3]. Details of GET 5.0 can be found in Azar et al. [6]. The graphs for the BEAP model have been generated by running version BEAP2100 with GLOB-policy (the runs were carried out by Maria Grahn). In Figs. 1a and b, the global primary energy supplies are shown. Figs. 2a and b show the transportation sectors and Figs. 3a and b show the biomass use in the two models. Both models are run under stringent CO_2 constraints. In the BEAP model a global carbon tax of approximately 300 USD/tC is applied from the year 2020 onwards. The cumulative emissions during this century amount to approximately 450 Gt C. This emission level corresponds roughly to an atmospheric CO_2 concentration target of 400 ppm by the year 2100. In the runs with the

[2]Results from the BEAP model and from the GET model have been published in [3–5].