AVAILABILITY OF WOOD BIOMASS FOR BIOREFINING

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Biorefining is an emerging industry that will use increasing volumes of biomass as a raw material. This paper presents the estimates of global forest biomass resources for biorefining, based on the available global forest statistics and literature. The focus is on the large-scale production facilities, such as liquid biofuel production. The raw material sources were divided into three categories, namely, reallocation of current raw material flows to biorefining, mobilization of the existing biomass resources not utilized today, and boosting of biomass production, particularly in plantation forests.
By the year 2020, the potential of woody biomass for biorefining will amount to 780 million m^3 (327 dry tonnes) annually, corresponding to 147.5 million tonnes of oil in terms of energy content. Assuming that 50% of the energy content of the feedstock can be recovered as liquid biofuel, 73.8 million tonnes (3.1 EJ) of liquid biofuels could be produced, which will represent, in the year 2020, 2.6% of the global forecasted transportation fuel consumption (117 EJ).

Keywords: biorefining, biomass resources, woody biomass

INTRODUCTION

Background

Global energy consumption has doubled since the early 1970s and increased by about 20% since the beginning of this millennium.[1] Renewable fuels have kept their share (10%) over the decades, while fossil fuels (oil, coal and natural gas) account for over 80% of the global energy consumption (Fig. 1). Areas particularly dependent on imports of fossil energy, such as the EU and US, are very vulnerable to any international crisis that might affect supplies. Liquid biofuels derived from biomass are a potential means to reduce the dependency on crude oil imports and thus increase the stability of national fuel markets.[2]

In addition, the emissions from burning fossil fuels are the main source of greenhouse gas emissions, and thus a significant contributor to global warming.

The global use of roundwood for industrial processing and energy generation amounted[3] to 3.7 billion m^3 in 2007, of which 1.9 billion m^3 was used for fuel and 1.8 billion m^3 for feedstock for industrial uses. In 1970, the cuttings were markedly lower (2.6 billion m^3).

A decrease in greenhouse gas emissions is an essential national and international goal to meet the commitments of climate change mitigation. The efficient use of woody biomass, as a renewable energy resource or as a raw material for industrial processes – including biorefining – can notably replace the non-renewable resources.

Dependency on oil, mainly from foreign sources, as well as geopolitical instability and environmental issues are energy and raw material security aspects that have made biomass an increasingly important element of the energy, environment and agriculture policy, particularly in the EU and US.

Forest residues, wood industry residues and short-rotation biomass crops are the most important and largest available sources for increasing the use of biomass. In industrialised countries, the conventional use of fuel wood has decreased over the decades, while the use of stemwood, residues from the forest industries, recovered wood and demolition waste for refining and energy purposes has increased. While, in some countries, felling residues once used to be left on the site, in Finland and Sweden residues have been for years collected for energy purposes; today, this practice has started to spread to other countries too, especially in Central Europe.

The so-called first-generation liquid biofuels are already commercially installed. However, their raw material basis is limited to vegetable oils, grain and other scarce resources. Second-generation liquid transport fuels use more abundant biomass, such as agricultural residues and woody forest biomass.[2] Forests are thus among the largest raw material sources for biorefining, both as energy carrier and for biomaterial production.

Objectives

Estimates of global forest biomass resources for biorefining are presented, with focus on large-scale production facilities, such as liquid biofuel production. The estimations are mainly based on FAO's forest statistics, on Finnish Forest Research Institute's own studies and other available reports. The aim of this paper is to provide rough estimates of the forest resources for biorefining on a global scale, as well as the pinpoint areas where the availability of feedstock for biorefining seems most promising.

FOREST RESOURCES AND CURRENT USE OF FOREST BIOMASS

Globally, forests form a vast source of biomass, covering 4 billion hectares – representing[3] about 30% of the total landmass (Fig. 2). Globally, between 2000 and 2005, the forest area decreased by 13 million hectares per year. In Europe, North America and Asia, the forest area is increasing, while in Africa, South America and Oceania, it is decreasing. The global growing stock totals 434 billion m^3 of stemwood measured over bark.[3]

As already mentioned,[3] the current global use of wood is of about 3.7 billion m^3 *per annum* over bark, more than a half being used as a fuel mainly in developing countries. About 45% of the material is used by forest industries, but 40% of it ends up[4] in energy production. Thus, currently, over 60% of the wood is used for energy production. Additional resources for woody biomass are logging residues, stump wood and surplus forest growth. Moreover, plantation forestry has intensified wood production globally. These sources represent a large potential of renewable feedstock for biorefining. In the Northern hemisphere, forest resources are increasing, with maybe the most positive development in the EU. The net annual increment in the EU is of about 600 million m^3, while the annual rate of change (net annual increment – current harvest) in the region is of approximately 240 million m^3 per year or 35% of the net annual increment. The annual rate of change has clearly been positive for several decades, and thus an increasing amount of wood has been accumulated in forests, which made them denser, older-age class structures.

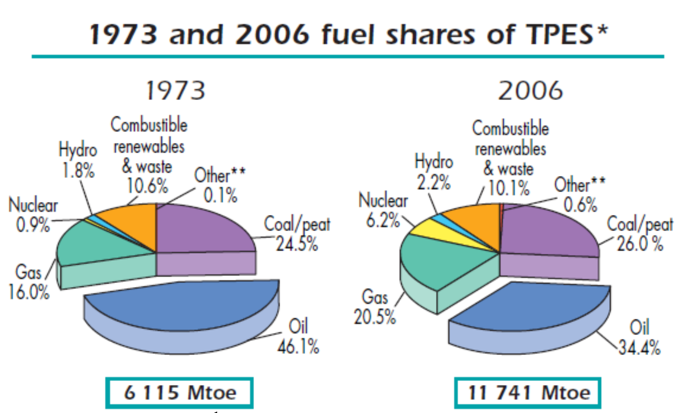

Figure 1: Evolution[1] (1971-2006) of world total primary energy supply (TPES)* by fuel (Mtoe)

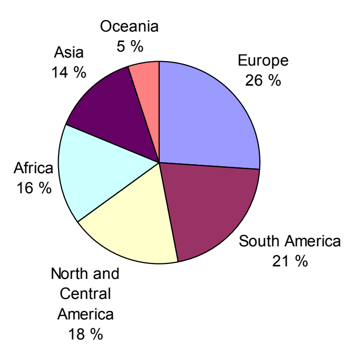

Figure 2: Distribution of forested areas[3]

ESTIMATION METHODS OF BIOMASS AVAILABILITY FOR BIOREFINING

Currently, the woody biomass used in saw mills, pulp and paper industries and panel industries can be *reallocated* for other biorefining purposes. This can be done if the values of the new products or the net profits of their manufacturing overpower the traditional uses. If an increased net use of woody biomass is aimed at, other sources have to be *mobilized*. This additional biomass resource can be divided into two main components: primary residues of current logging operations and surplus of forest growth (net annual increment – current wood drain from the forest). The first component includes felling residues and biomass from the stump and root system. The second component also includes the stemwood. *Reallocation* and *mobilization* are based on the existing forest resources, while *boosting* of the woody biomass production calls for its intensification on the existing forest land, or the establishment of new plantations. In recent decades, for example, the production of wood for pulp and paper industries has shifted to plantations. In addition, large plantations have been established for energy cultivation.

As most biomass components of the tree can be used for a number of products, as well as for heat, power and biorefining purposes, the estimation is based on a "what if" principle: what volumes can be directed to biorefining if a chosen level of selected biomass is utilized?

The potential of *reallocation* as a raw material source was based on the simple assumption that 10% of the current raw material use of wood would be reallocated for biorefining purposes.

The potential of *mobilization* of the existing biomass resources not currently used can be quantified based on global growth figures and utilization statistics. Anttila *et al*.[5] estimated the volumes of logging residues and surplus forest growth at a global level. FAO's statistics provides the volume of merchantable stemwood (Fig. 3), while the volume of branches and unmerchantable stemwood was added using biomass expansion factors.[5]

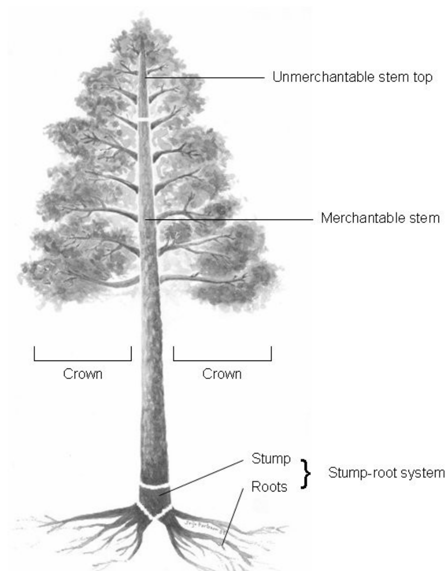

Figure 3: Biomass components of a tree[6]

Based on stemwood statistics and on the factors affecting biomass expansion, the mobilization potential of the biomass for biorefining was calculated. It was assumed that 25% of the total annual surplus forest growth could be used for biorefining.[5]

Finally, the potential for *boosting* the biomass production for biorefining was quantified by assuming that a third of the future production increase in tree plantations would be directed towards biorefining purposes. The prognosis published by the International Tropical Timber Organization suggests that, in 2020, plantations could annually supply 1.8 billion m^3 of wood, covering the current industrial use of wood.[7] The plantation area would cover almost 450 million hectares. The change in terms of woody biomass from current (about 1 billion m^3/a) production would be of 810 million m^3 annually.

RESULTS

If 10% of the global industrial roundwood utilization were *reallocated* to biorefining, the annual volume would be of 180 million m^3 (71 million dry tonnes), which is roughly one quarter of the wood consumption in chemical and mechanical pulping today. As 25% of the surplus forest growth will be *mobilized* for biorefining, 340 million m^3 (143 million dry tonnes) would be available.

Boosting of the woody biomass production creates a future potential source for biorefining. Assuming that one third of the total production increase (0.81 billion m^3/year), by 2020, will supply the biorefineries, the annual volume is of 270 million m^3/a.

By combining the reallocation volumes of the existing raw material flows, by mobilizing more biomass from forests and by boosting the biomass production of plantations, the potential of woody biomass for biorefining will attain 780 million m^3 (327 dry tonnes) annually, by the year 2020 (Fig. 5). The energy content of 780 million m^3 corresponds[8] to 147.5 million tonnes of oil, in terms of energy content (1 m^3 of wood with a moisture content 40% = 8.2 GJ). Assuming that 50% of the energy content of the feedstock can be recovered as a liquid biofuel, 73.8 million tonnes (3.1 EJ) of liquid biofuels can be produced, which will represent[9] 2.6% of the global forecasted transportation fuel consumption (117 EJ) in 2020.

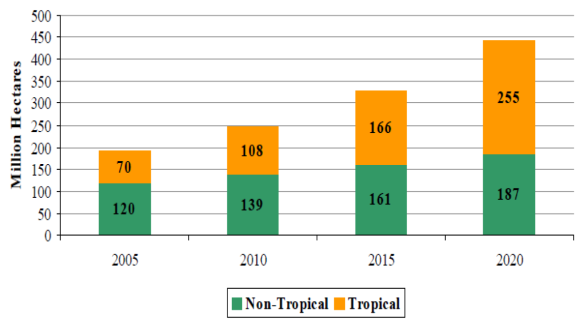

Figure 4: Estimated development of plantation forest area[7]

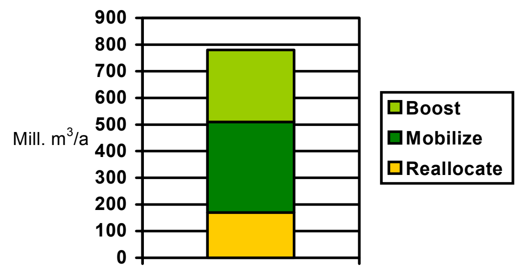

Figure 5: Total availability of woody biomass for biorefining. Note that boosting of biomass production becomes gradually available by 2020

DISCUSSION

A more intensive use of forest biomass for biorefining could add less than 1% to the share of biomass in the global energy consumption and, as already mentioned, wood-based liquid biofuels could supply less than 3% of the forecasted transportation fuel consumption in 2020 (Fig. 1). The figures presented here may appear to be rather limited, but when the volumes are compared with the current harvesting of roundwood for industry and energy, the increase is much higher in relative terms (about 13%).

The competition for the use of wood is likely to increase in the future. Although the consumption of carton and packaging boards has decreased in the US, there is an increasing consumption in China, India, Taiwan, Thailand and Vietnam, and the decline recorded[10] in the US can not make up for it. Similarly, the global consumption of printing paper continues to increase. Additionally, the use of wood as a construction material continues to grow in well-developed economies. For instance, in the EU/EFTA countries, the material use of wood is expected[11] to increase by over 10% (about 60 million m^3) by 2020. The heat and power sectors are considering woody biomass as a potential fuel to replace coal and oil in energy production, especially in the EU/EFTA countries. A scenario study showed[11] that the goals set for the wood-based energy and material use would lead to a 47 million m^3 higher wood demand in the EU/EFTA region in 2020, more than forests can supply.

Thus, at a global level, forest biomass can not markedly replace fossil fuels in liquid fuel production. However, in forested countries, it may play a significant role in the increasing generation of renewable energy or as a feedstock for new refineries of woody biomass. Gross production of forest biomass can also increase in the future. Particularly in the boreal and temperate zones, woody biomass production has increased substantially during the past hundred years. However, due to limited land, water and nutrient availability, as well as to land use restrictions, the development of plantations may be slower than anticipated.

Another question is the borderline between industrial (including biorefining for materials) and the energy use of wood. The market value of paper products has decreased during this millennium, whereas the value of energy generation and energy products has been increasing. If the demand for paper products decreases globally, more woody raw materials could be used in biorefineries.

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