USE OF FOREST BASED BIOMASS FOR BIOENERGY IN EU-28

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Abstract
Europe’s future wood demand for energy is expected to increase by 10 million to 200 million m³ in the period 2010-2030. This will be supplied by both domestic sources (forests, industrial residues post-consumer wood waste), but also from sources outside Europe. The EU-28 predicts a near future (2020) gap between solid biomass supply and demand for renewable energy: 21.4 million tonnes of oil equivalents (MTOE). This is estimated via preliminary renewable energy action plans (NREAP’s) per country. The EU-28 expects wood pellet import will merely complete this gap of 21.4 MTOE, with more than 50 million tonnes of pellets. This implies a feedstock need of 125 million m³ of wood from forests and other sources outside the EU-28.

Introduction
As renewable energy sources (RES), forest biomass and other biomass provided about 10% (54 EJ equivalent with 1,300 MTOE) of global total primary energy demand (TPED) in 2011. This is supplied by about 3,100 million dry tonnes of biomass, equal to 7.5 billion m³ wood and other biomass (Note: 1 EJ = 23.9 MTOE and is equivalent with 57 million tonnes of wood pellets or 138.5 million m³ with moisture content of 20%). In 2011, traditional use of wood, straw, charcoal, and manures for cooking, space heating etc. in buildings accounted for about 64%. Another 15% occurred in industrial sectors, like the use of pulp waste (black liquor) in the paper industries. Biomass use for electricity and transport fuels was 5% and 6% respectively. The remaining is estimated at about 6% (IEA 2013). Total future demand for bioenergy across all those global sectors is expected to increase from 54 EJ in 2011 to about 78 EJ in 2035, which is about 11% of the future TPED. This is referred to as the IEA’s New Policies scenario (which is in between a current policies scenario and a ‘450 ppm’ scenario with high renewable energy use). The largest proportion of demand for bioenergy is related to the building sector, including traditional use. This will decline in absolute terms throughout 2011-2035 (Outlook period). Driven by government support policies, the demand by the transport sector grows at the fastest rate over the Outlook period. The feedstock for those liquid biofuels is primarily covered by agricultural sources. The demand for bioenergy for power and heat generation has the largest increase, from 5.7 EJ in 2011 to 17.6 EJ in 2035 (Figure 1).

Assuming that this type is merely covered by woody biomass (i.e., biomass with 20% moisture content), the increase equals to about 1,650 million m³ wood.

According to the IEA forecasts, the demand for bioenergy increases significantly in the power sector in developing countries such as China, India and Brazil. This growth is mainly driven by policies to reduce air pollution, boost the use of domestic agricultural residues and speed deployment of renewables. Over 90% of the world demand is met from domestic resources throughout the Outlook period. To meet the remaining demand, some regions will increasingly turn to international supplies of solid biomass for power generation, most commonly in the form of wood pellets. Wood pellets are processed products that have a relatively high energy density, are fairly uniform and easier to transport than untreated biomass feedstock. A few regions are expected to supply any external needs, next to their domestic demand. Brazil, Canada and the United States stand out in this group, but also their natural resources are limited. For other regions, it will be difficult for the domestic supply to keep pace with the growing demand. In the New Policies scenario (IEA 2013), the European Union already imports large volumes of wood pellets and will continue to do so. The EU-28 is expected to be the largest importer of biomass for power generation by 2035, importing about 6.7 MTOE or 16 million dry tonnes biomass, equivalent with almost 40 million m³ harvested wood. In India, the demand for solid biomass in power generation reaches 1.5 EJ, almost three times the current level, and requiring 90 million tons of pellet equivalents. While a similar
order of magnitude of agricultural residues is available, it will be difficult to collect and transport them to the Indian power plants at reasonable costs. As for many fuels in the power sector, China will become the largest consumer of biomass for power generation and heat by 2035. It also has one of the highest supply potentials, when agricultural, and forest biomass are combined (IEA 2013).

So far, wood sector models merely lack a full picture of the growing future bioenergy demand. The main aim of this paper is to inventory which approach(es) to integrate energy in wood sector models are interesting and promising.

Materials and Methods

Approach to include bioenergy markets

In autumn 2013, the European Commission adopted a new EU forest strategy which responds to the new challenges facing forests and the forest sector (European Commission 2013). The strategy highlights that forests are not only important for rural development, but also for the environment, especially biodiversity, for forest based industries, bioenergy and in the fight against climate change. The new strategy underlines that forest-linked EU policies should fully be taken into account in national forest policies. It calls for a Forest Information System of Europe (FISE) to be set up and for Europe-wide harmonized information on forests to be collected. Within FISE, the Joint Research Centre (JRC) is setting up a Forest-based bio economy modelling framework (see Figure 2), for policy impact analysis that will be capable of addressing policy relevant issues and EU targets affecting the Forest Sector (EUTR, LULUCF, biodiversity, renewable energy, etc.). The framework should allow the assessment of: i) market dynamics, not the least the competition for wood and energy uses; ii) response analysis, i.e., the impact on Europe’s forest resources of different EU policies and targets. Actually, two types of wood models will be integrated: iii) the future supply of forest biomass, together with industrial residues and post-consumer wood; iv) the future demand by the traditional forest industries and the energy sector.

Next to the traditional forest-industry sector, the bio-energy sector is the main user of woody biomass. Following an extensive European inventory on wood markets for energy (Sikkema et al., 2011), inclusion of the bioenergy market can best be approached via their different market segments (Figure 3): 1. large scale power production (mostly industrial wood pellets, next to post consumer wood waste); 2. medium scale combined heat and power (CHP) (mostly wood pellets and wood chips); 3. residential heating (mostly wood pellets and low quality logs). Note that EU’s 2010 Communications (European Commission 2010) about a framework for solid biomass for energy (including wood) is directing towards energy installations with a minimum capacity of 1 MWth (heating) and 1 MWe (power) respectively. As such, large scale power and medium scale CHP’s are above this limit and as such could be to future sustainability requirements for woody biomass sourcing.

Large scale

Most of the large scale cofiring of biomass in Europe depends on feed-in tariffs for electricity production (Mir-Artigues and del Rio, 2014). Feed-in tariffs guarantee a certain price for produced kWh electricity. If the prices are low, the utilities will be
refunded by public funds etc; with high prices, the utilities will have to pay the surplus to the public funds. It is not yet clear whether feed-in tariffs will remain. At least environmentally or economically harmful subsides, including for fossil fuels, are expected to be phased out (Client Earth, 2014).

The Pöyry modelling (Mergner 2014) has designed demand and supply curves for wood pellets. However, this modelling effort is not publicly documented and cannot be consulted. Also, the modelling approach regarding the solid biomass trade in Northwest Europe (Lamers et al., 2014) is relevant, however, the market analysis consists of both woody and agricultural biomass sources, mixed together in one model. The economic viability for cofiring in Germany has been evaluated, following price scenario’s for biomass, coal and CO₂ certificates (Lüschen and Madlener, 2013). The economic feasibility of biomass co-firing will depend on relative cost of coal and biomass and CO₂ emission certificates (Hansson et al., 2009). However, this kind of modelling lacks the existing feed-in tariffs for electricity, a common financial structure for the energy sector in Northwest Europe.

Finally, the analysis of the Global Biosphere Management model (GLOBIOM) is of interest. GLOBIOM is a partial equilibrium model, dealing with the forest and the agricultural sectors (Lauri et al., 2014). Also, the energy production markets (demand) are incorporated to some extent. This model explicitly considers the competition between alternative uses of woody biomass through the market mechanism. However, it includes complex interactions of supply and demand, which makes the model less transparent compared to other models that consider woody biomass use for energy in terms of different (theoretical, technical, sustainable) potentials.

Medium scale heating and power production (CHP’s)

Also, medium scale CHP’s (like those established by forest and paper industries) are more or less depending on feed-in tariffs for any surplus of electricity production. Feed in tariffs should guarantee a certain price for produced kWh electricity, which is not needed for their own needs. Note that these feed-in tariffs are generally determined by the power utilities. For using their electricity distribution networks, the feed-in may be subject to relative low prices (in comparison with consumer prices). In case of district heating, owned by power companies or by municipalities, other feed-in tariffs are applicable, depending on the kind of (long term) contracting.

Different principles are valid for the delivery of any heat surplus, as this type of energy (e.g. steam) is transported within a limited distance to nearby customers (in case of public CHP’s) or via bilateral contracts to neighboring intensive industries.

Finally, the approach to include energy in a forest sector model, as done by EFI-GTM (Moiseyev et al., 2011; Moiseyev et al., 2013) is of interest. It has inserted woody feedstock data for medium scale heating and electricity production throughout Europe. Next to the traditional demand by the European forest sector (production of sawnwood, pulp, paper, panels), one overall energy sector is regarded. However, Moiseyev et al., (2013) did not analyze any feed-in tariff (for surplus electricity), due to the incompatibility with their partial equilibrium model. As the feed-in tariffs structure is out of scope, the EFI-GTM is at least not compatible for future electricity markets and possible

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**Figure 2. The JRC model for European forest biomass supply and demand.**
carbon trading (see also section 3.1). The EFI-GTM model assumes the demand for thermal electricity and heat to be inelastic. Following the World Energy Outlook scenarios, the demand for electricity is not inelastic, but will increase between 2011 and 2035. In a similar way, the US modeling of the forest sector is set up (Zhang et al., 2014), although it has another division by including the transport sector, too: i) fuelwood; ii) transportation fuels; iii) electricity and heat.

Further, the global Forests Product Model or GFPM (Raunikar et al., 2010; Buongiorno et al., 2011; Buongiorno et al., 2012) is dedicated to energy markets. However, its price inventory is limited to two types of feedstock: fuelwood, and pulpwood (also defined as industrial round wood) and one type of final product: sawn wood. However, the GFPM modeling is a market simplification by aggregating all fuelwood into one bioenergy market.

Finally, three smaller, more regional, models have been developed. The first study focuses on Germany, and is based on the fuel price for oil (Härtl and Knoke, 2014). The competition with oil is valid for medium scale heating, although most conversion of oil based installations to wood fired installations occurred in the past (at least in most EU member states). Competition of wood with natural gas, rather than oil, will become valid for future developments due to increasing supplies by Russia. In the long term, it can be expected that EU dependency on gas from Russia and the Middle East will increase, which to a large extent will be utilized for power and heat generation (Kjärstad and Johnsson, 2007; Kjärstad, 2011). The second study (Schwarzbauer and Stern, 2010) focuses on Austria: it exists of a simulation model (FOHOW) to analyze the competitiveness between traditional demand for wood by the forest sector and increasing demand for energy by the same forest sector. Any external sector (energy sectors) is not integrated into the model. Again the oil price is inserted as the only feedstock for energy. This may not be applicable for further future, because natural gas shall operate as the main competing fuel. The third study focused on Norwegian forest sector (Bolkesjö et al., 2006). This Norwegian study has the same characteristics (partial equilibrium model) as the EFI-GTM. The advantage of this model is the inclusion of commercial electricity prices, both for large scale consumers and small ones. However, this kind of price may not be applicable, as forest industries will generally receive a lower price for any surplus of electricity. Nevertheless, this model may be relevant to be analyzed as well, as both small scale and medium scale users are included, varying from forest industries to external CHP’s.

Small scale residential heating

It is expected (Esteban and Carrasco 2013) that the number of small heating appliances (capacity lower than 60 kW) in the EU-28 will grow by about 11% (from 4.9 million to 5.5 million boilers), with a major shift from wood chip boilers to pellet boilers. Note that small scale stoves (used for pellets in bags) are left out of this survey. With an average annual pellet consumption of 5 to 6 tonnes for small pellet boilers in Austria (personal communication with Holzforschung Austria), the impact on supply and demand modelling for EU’s markets in 2020 is assumed to be fairly limited (increase by 3 million tonne).

Figure 3. Division on EU’s bioenergy sector in three major markets.
Results and Discussion

The impacts of a growing need for wood for energy, combined with the traditional demand by the forest industries are compiled in global forest product models (Raunikar et al., 2010; Buongiorno et al., 2011; Buongiorno et al., 2012). The GFTM study is linked to the projections of the Intergovernmental Panel on Climate Change (IPCC) for high energy use (maximum fuelwood demand) and low energy use (minimum fuelwood demand) respectively. The maximum fuelwood demand, together with a nearly steady demand for industrial roundwood, leads to a total annual roundwood consumption from 3.55 billion m$^3$ in 2006 to about 4.96 billion m$^3$ in 2030, thus, an extra demand on a global scale by about 1,400 million m$^3$. The economic and demographic assumptions coupled with a scenario of low fuelwood demand, lead to a global harvest of 3.70 billion m$^3$, thus 150 million m$^3$ extra. The share of Europe in these consumption patterns (industrial wood and fuelwood together) is expected (Buongiorno et al., 2012) to increase from 645 million m$^3$ in 2006 to a level of 663 million m$^3$ (minimum demand) and to 859 million m$^3$ in 2030 (maximum demand). The sub share of industrial roundwood remains stable. Resuming, EU’s demand for energy wood is expected to increase from a level of 145 million m$^3$ to about 155 million m$^3$ (low demand) to more than 360 million m$^3$ (high demand), an increase by 10 million to 200 million m$^3$ of wood (about 5 to 120 million dry tonnes).

The current share of virgin wood (from forest and forest industries) and wood waste in EU’s gross energy consumption (GEC) in 2011 is 3.4 EJ, i.e. 4.8% of total GEC (Eurostat 2012). This is equal to about 195 million tonnes of dry wood with an energy value 17.5 GJ per tonne. The EU Renewable Energy Directive (RED) strives for mobilisation of domestic and imported biomass (including wood) via EU Member State’s National Renewable Energy Action Plans (NREAP’s). The preliminary NREAP’s indicate a total biomass supply (forest, agriculture and waste) starting from 88 MTOE in 2006 to about 131 MTOE in 2020 (Banja et al., 2013). The increase for virgin wood fibres from forests and forest industries is about 11 MTOE or 25 million tonnes (equal to about 45 million m$^3$). The preliminary NREAP’s indicate a growth for wood waste flows of about 4.5 MTOE, equal to about 11 million dry tonnes of post-consumer wood waste. The NREAP gap between supply and demand of biomass within the EU-28 is estimated to be about 21.4 MTOE (0.9 EJ) and expected to be merely completed by wood pellets (DG Energy, 2014). This would implicitly mean an import of about 51 million tonnes of pellets. For comparison: an inventory by the European energy sector (Eurelectric, 2011), stated a relative large import by the EU-28 of about 55 million to 85 million dry tonnes of wood is likely to be needed for meeting EU’s future annual wood demand for heating and electricity in 2020.

All partial equilibrium models depart from the notion of perfect competition, this is, of course, a shortcoming, but one has to deal with it when modelling energy, just as for the traditional wood-based commodities. The state-of-the-art of bioenergy markets (2010) in Europe can be compiled from basic data by (Hendrickx 2010; Mantau 2012; CEPI 2013; Sikkema et al., 2014). For EU-28, the following subdivision in 2010 is applied:

- Small scale residential heating: 91 million tonne
- Large and medium scale CHP’s: 90 million tonne (including black liquor and chips by forest sector)
- Pulp industry feedstock: 70 million tonne
- Panelboard industry feedstock: 32 million tonne
- Sawmills: not yet specified, as there is no interference with energy related feedstock

For future data we suggest relying on the National Renewable Energy Action Plans (NREAP’s). These data are inserted by the Member States of EU-28, for reporting obligations. These obligations are completed via the National Renewable energy Action Plans for the period 2009-2020, like in (Banja et al., 2013). Note that the overview below is a preliminary one, as the data needed for the new modelling has still to be verified. Actually, two major markets of wood (and other) biomass need to be accounted for supply and demand markets.

Future supply of biomass (million ton of oil equivalents) is divided into:

- 2 forest resource categories (forests, forest industries), i.e. woody biomass
- 2 agricultural resource categories (agriculture, agricultural residues)
- 3 waste categories (note that post-consumer wood waste is a part of solid wastes)

Future demand of biomass (markets) is divided into 3 main categories:

- Biomass for electricity and heating except agricultural residues for co-digest / biogas in, for example, Germany, most biomass is related to woody biomass (pellets, chips, low quality logs)
- Biomass for heating and cooling; both biomass from forest and agriculture.
- Biomass for transportation fuels, merely existing of agricultural biomass

Conclusions

- Best practice approaches for including bioenergy markets in wood models are found for medium scale power and heating. Next to the worldwide approach (Lauri et al., 2014), the regional approach
for the United States (Zhang et al., 2014), EU-28 plus some other European countries (Moiseyev et al., 2011; Moiseyev et al., 2013) and Norway (Bolkesjø et al., 2006) are promising. All models are stated to be based on a partial equilibrium model, focusing on the short term wood markets but without any clear long term prospects for others (e.g. CO2 trade certificates).

- A major point of concern is the lack of a feed-in tariff structure in the respective models (GLOBIOM; US-FPM; EFI-GTM; NTM-II). This structure is relevant throughout most EU Member States. It guarantees a certain purchase price per kWh, and this is also valid for the internal electricity production within the forest sector itself.
- Another point of concern is the inelastic demand for electricity (Moiseyev et al., 2011; Moiseyev et al., 2013). This does not comply with 2030 predictions for an increasing electricity use in comparison with current consumption patterns.
- Finally, the interaction of limited available future forest resources and increasing competition between traditional wood markets and the energy sector is a point of attention for integrated models.

References


