

U.S. Biomass Opportunities for Value-added Biomass Exports based on the European Union Renewable Energy Share Targets

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World energy demand is expected to continue increasing in the coming years. This situation has created a worldwide pressure for the development of alternative fuel and energy sources, pursuing a more environmentally friendly usage of biofuels. The EU has the target of generating 20% of its energy consumption from renewable sources by 2020. Member States have different individual targets to meet this overall target. Meanwhile in the United States, there are about 750 million acres [300 million hectares] of forestland, with slightly more than two-thirds classified as timberland or land capable of producing 20 cubic feet per acre [1.4 m³ per hectare] annually of roundwood. Given these circumstances, this research aimed to understand the U.S. opportunities to export woody biomass based on the targets that the European Union has imposed to its Member States. The data collected allowed several scenario developments by identifying the possible EU's biomass deficits and U.S.'s capacity to supply the gaps. Considering the physical availability, the U.S. would be able to satisfy between 42 and 48% depending on the energy efficiency scenario. Nevertheless, when considering reasonable biomass prices, only a small portion of the EU demand could be covered by the U.S.

Keywords: Woody Biomass; U.S. Biomass Availability; EU Biomass roadmaps; US export opportunities

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INTRODUCTION

World energy demand has been continuously increasing, and there is no indication that the trend will change in the coming years (U.S. Department of Energy 2013). Moreover, there is a worldwide pressure for the development of alternative fuel and energy sources, pursuing a more environmentally friendly oriented usage of biofuels (Council on Foreign Relations 2013). In this matter, Europe 2020 is the EU's growth strategy for the 2010 - 2020 decade. The European Commission wants the EU to become a smart, sustainable, and inclusive economy (European Commission, 2013).

The Europe 2020 strategy aims to create jobs, encourage 'green' economic growth, and create an inclusive society (CIVITAS 2012). The EU has the target of generating 20% of its energy consumption from renewable sources by 2020. Member States each have different individual targets to allow this overall target to be met, and they are obliged to provide detailed roadmaps describing how they will meet their legally binding target. The roadmaps contain sectorial targets, the technology mix they expect to use, and the trajectory they will follow (European Environment Agency 2012).

Each European Member State has provided a National Renewable Energy Action Plan (NREAP) to the European Commission, detailing projections for renewable energy

development up to the year 2020. By that year, the cumulative consumption of renewable energy in all European Member States should result in an overall share of renewable energy of 20% across the European Union (Beurskens *et al.* 2011).

The National Renewable Energy Action Plan (NREAPs) for the European Union divides the demand for Renewable Energy in the Following Sectors:

Renewable Electricity

According to the NREAPs, more than one third of the EU's electricity consumption will come from renewable energy sources in 2020. The share of renewable energy sources in electricity is forecast to increase from 14.9% in 2005 to 34.3% in 2020. According to the national RES industry roadmaps, renewable electricity can reach a higher share of 42.3% electricity consumption in 2020. Biomass is expected to represent 6.5% of the total energy required in the European Electricity Sector in 2020 (Zervos *et al.* 2011).

The increasing demand for industrial pellets in northern/western European countries such as Netherlands, Belgium, UK and Denmark has been driven by the availability of feed in premiums for green electricity and the relative cost competitiveness of biomass with the cost of coal plus CO₂ emission allowances (Goh *et al.* 2013).

Pellets for co-firing are mainly imported from Canada and U.S., and partially from Russia, Baltic states and other EU countries (Goh *et al.* 2013).

Renewable Heating & Cooling

More than one fifth of the EU's heating consumption is expected to come from RES in 2020. The share of RES in heating and cooling will increase from 10.2% in 2005 to 21.3% in 2020. Biomass should represent 17.2% of heating and cooling consumption, heat pumps from aerothermal and hydrothermal energy will be 1.6%, solar thermal energy will be 1.2%, and geothermal energy will be 1.3%. According to the national RES industry roadmaps, renewable heating and cooling can reach the share of 23.5% of heating and cooling consumption in 2020 (Zervos *et al.* 2011).

The biggest heat markets will be Germany, Italy, the United Kingdom (UK), and Sweden. According to the NREAPs, biomass heat production will reach 88.8 Mtoe in the EU in 2020 (compared to 63.8 Mtoe in 2008) instead of 124 Mtoe as the European Biomass Association AEBIOM had projected (Zervos *et al.* 2011).

Germany and Austria are practically fully consumed for residential heating. Both countries have large feedstock availability, resulting in excess production for export. France follows a similar trend but with a smaller excess in production. Likewise in Italy, the large majority of pellets are used for space heating in the residential sector; nevertheless, the domestic production can only fulfill approximately half of the total demand (Goh *et al.* 2013).

Renewable Transport

The share of renewables in transport is projected to reach 11.27% of diesel and gasoline consumption in 2020, overtaking the binding transport target of 10%, up from 3.1% in 2005. Looking at the transport sector, biodiesel is the first contributor to the target for RES in transport in 2020, followed by bioethanol. Renewable electricity in transport will contribute toward achieving the target, while almost no contribution of hydrogen is expected so far. Taking into account the national RES industry roadmaps, renewable energy in transport would amount to 12.2% by 2020 (Zervos *et al.* 2011).

Forest biomass will not contribute to a significant difference in the EU's energy requirements in 2020 for the transport sector, and this is the reason why this sector's demand is not being considered in the study.

European Union Demand and Domestic Supply

According to the NREAP's, the majority of the biomass required towards the 2020 targets can be produced within the EU. This goal seems slightly optimistic when several reports state that the increase in EU biomass production will not occur without the introduction of significant additional supporting policies and measures. Renewables Action Plan (RESAP) estimates that some of the required biomass must be imported from outside the EU. This statement and analysis is supported by projects such as, "Biomass Imports to Europe and Global Availability" carried out by Pöyry Energy Consulting (EURELECTRIC 2011a).

In the RESAP report, the primary interest concerns solid and gaseous biomass used in the electricity and heat sector, rather than liquid biofuels used in the transport sector. In order to evaluate the amount of primary biomass required to fulfill these ambitions, it is necessary to use some assumed efficiency figures for conversion of biomass into useful final energy (EURELECTRIC 2011b).

Analyses made by Hewitt (2011) also reveal that the quantity of wood required to satisfy the 2020 targets is likely to be too large to be met by increased production within the EU. Instead, Member States will have to rely on importing wood products from elsewhere, at the risk of damaging ecosystems in other parts of the world, while actually increasing the EU's own carbon footprint.

Assuming that the mix of wood product types remains the same, EU's Member States will need to use between 50 and 100% more wood than what is currently consumed as fuel. Most of the increase in imports is likely to be for electricity generation, probably in the form of wood pellets supplied to a small number of large power stations. The most likely sources are Canada and the U.S., and perhaps Russia, if the risks associated with imports from Russia do not become prohibitive (Hewitt 2011).

EU's biomass requirements have encouraged countries with large raw material and small domestic consumption to establish an export-oriented pellet industry, mostly eastern and southern European countries. Approximately half of the pellet mills are located in Northwest Russia, which is geographically closest to Europe, and therefore facilitates the export to the main European commodity markets. Major internal consumers are private customers, but recently some municipal boiler-houses have been transferred from gas to pellets (Goh *et al.* 2013).

Portugal and the Baltic States are also major exporters in Europe, with little or negligible domestic consumption. The Baltic States mainly export wood pellets to Sweden and Denmark. Spain, the Czech Republic, Slovakia, Romania, Hungary, Ukraine, Lithuania and Croatia, each produced approximately 0.1 to 0.2 Mt in 2010 (Goh *et al.* 2013).

However, the option to import is surrounded with uncertainty, especially about the sustainable potential of other regions, and competition from other wood importing regions, such as China. There should be assurance that supplies are truly from sustainable sources, and do not unfairly endanger European producers (Mantau *et al.* 2010).

There are several regions with the capacity to supply woody resources, including fast growing plantations in tropical regions or the southern United States, or the extensive

natural and semi-natural forests in Russia and Canada. However having a large forest resource is no guarantee for having a dynamic export development. (UNECE/FAO 2011).

Furthermore there are numerous causes of uncertainty, including whether these sources would be considered sustainable according to emerging EU rules (EU 2009), and the strength of demand from other regions, especially China and other Asian countries, which would compete with possible European importers. In Europe, however, large biomass burning power plants are already being brought into production, which are almost entirely dependent on biomass imported from outside Europe.

Another possibility is to import wood energy from outside Europe in the form of chips, pellets, or biofuels. There are already significant imports of wood for energy by Europe. In 2009, the EU27 imported about 1.8 million tonnes of wood pellets, mostly from the US, Canada, and Russia (UNECE/FAO 2010), and several large power stations have been built or are under construction, with plans to use imported biomass.

U.S. Feedstock Considerations

Woody biomass from forests is primarily fuel wood used in the residential and commercial sectors, and residues generated in the manufacture of forest products. There is also a relatively small amount of MSW (municipal solid waste) wood that is recovered for energy (Smith *et al.* 2009).

Fuel wood is wood that is harvested from forests and combusted directly for useable heat in the residential and commercial sectors, as well as power in the electric utility sector. Combined, these sectors account for 30% of the current consumption of forest biomass and about 20% of total U.S. biomass energy consumption (Smith *et al.* 2009).

The forest products industry consumes three major sources of primary and secondary mill residues generated in the processing of roundwood, roundwood products, and pulping liquors (Smith *et al.* 2009)

In the United States, there are about 750 million acres (303 million ha) of forestland, with slightly more than two-thirds classified as timberland or land capable of producing 20 cubic feet per acre (28 m³/ha) annually of roundwood in natural stands (Smith *et al.* 2009).

In order to manage this available woody biomass and recognize U.S. export opportunities, several limitations regarding energy regulations must be understood. The Energy Independence and Security Act (EISA) 2007 law contains a number of provisions to increase energy efficiency and the availability and use of renewable energy. One key provision of EISA is the setting of a revised Renewable Fuels Standard (RFS). The revised RFS mandates the use of 15 billion gallons per year (68.2 billion liters per year) Advanced Biofuel, enclosing woody biomass, by 2022 and approximately 11 billion gallons per year (50 billion liters per year) by 2020.

The production of power and heat from solid biomass is one of the most important and direct bioenergy generation pathways, experiencing an average increase of 2.7% of the total bioenergy production sector since 1990 (Silveira 2005). Hence, it is important to understand and improve the process design, economics, and biomass sources for solid biofuels production. According to Hoadley (2000), the calculations for the potential use of woody biomass for combustion have two basic considerations: the stove efficiency and the moisture content of the material. Additionally, in the use of biofuels for bioenergy, is important to properly design systems to handle biomass and feedstocks.

Transportation, handling, and utilization of solid biofuels can be highly improved through a densification process, such as pelletizing. Pelletized particles are defined as

compressed cylindrical particles of biomass, with a diameter of 6 to 12 mm, a length of approximately four times the diameter, and a moisture content lower than 8% (PiR 2006). This process produces a fuel that has a volumetric density between 800 and 1200 kg/m³, resulting in an energy density of around 0.05 m³/GJ. The process involves a particle reduction of the biomass to less than 3 mm, and material drying (often an obligatory step). The material is then densified using (typically) the natural waxes and extractives of the biomass in order to bind the material together in a high pressure system of dies, and with a high mass and energy production efficiency of at least 95% (Overend 2004). Pelletized biomass has an enhanced volumetric density and calorific value per unit of volume, improving the material handling and combustion efficiency (Moran *et al.* 2004).

This solid biofuel has several applications for commercial, industrial, and domestic heating and power generation. With many high-efficiency stoves and boilers on the market, solid biofuel provides a competitive heating source as compared to oil or natural gas (Overend 2004). Specifically, pelletization has become a proven technology for conversion of biomass into heat and power, becoming an increasing, mature energy market in several European Union countries, Canada, and the U.S. The main reason for the increase in pellet utilization resides in it being an attractive fuel for power stations, since pellets are composed of small particles that can be readily crushed and used in fuel burners in the same sense as coal (Hoque *et al.* 2006).

Wood pellets have become a successful internationally traded biomass (Junginger *et al.* 2008) with a market size that was projected to double from 2007 to 2010 (Savolainen 2007). Hess and Jacobson (2009) indicated that from 2002 through 2006, the internal demand of wood pellets in the United States increased by 200 percent. Moreover, production forecasts for 2012 were set at 6.0 million metric tons (10% moisture content) per year in the U.S.; however, by the year 2009 the market capacity increased faster than forecasted, with an approximate production of 6.2 million metric tons (Mani 2006; Spelter and Toth 2009).

Ryu *et al.* (2006) stated that a critical element for biomass fuels to successfully compete with other energy sources is densification; in this sense, wood pellets provide an enhanced heating value of wood per unit of volume, a low moisture content, a more complete and efficient burning, with low ash and particulate emissions content, optimized transportation over long distances, and a variety of applications, from small-scale residential heating to large-scale co-firing in coal power plants (Wahlund *et al.* 2004; Junginger *et al.* 2008; Spelter and Toth 2009). Additionally, pellets can be easily produced from wood waste, forest-thinning, other biomass ingredients, and wood production by-products (Bergman and Zerbe 2008; PFI 2009). Furthermore, Pirraglia *et al.* (2010) showed the technical and economic feasibility of producing wood pellets for the U.S. domestic market and discussed the main variables and scenarios for making a profitable business.

In 2010, 20% of pellets produced in the US were exported to Europe (0.4 MT). New mills have been built recently to process chipped round wood, especially in the southeast US. Their independence from the sawmill industry has allowed a focus on export of wood pellets, and many of the newer plants have capacities of several hundred kt per year. A combination of factors such as a large availability of feedstock at competitive prices, as well as a sound and sustainable forest management system, relatively easy logistics, and cheap transport has rapidly attracted investment in the southeast USA from American as well as European companies. As a result, new additions have brought the total capacity to around 6 Mt in 2010 and several new projects are in process. A large share of the US pellets from the southeast USA has been exported to Europe, exports to EU reached

over 0.75 Mt in 2010, driven mainly by the demand for industrial pellet by co-firing plants in northern EU countries and to a much lesser extent by the increasing demand for residential heating in Italy (Goh *et al.* 2013).

Objective

Given the EU's biomass considerations as well as U.S. biomass availability, the main objective of this research is to quantify and analyze U.S. biomass export opportunities. The targets and regulations that the European Union has imposed will drive this possible export opportunity. This project assesses and describes market trends (consumption and capacity) for woody biomass in the U.S. as well as the opportunities for new markets in Europe based on the European Union Targets and Regulations.

METHODS

Current and future targets and regulations imposed by the European Union to its members were identified and quantified from different European Renewable Energy Council Reports. The data collection was prepared by searching databases and reports that the European Commission has available for their members. For this study, the renewable energy demand was divided into different sectors, as specified by The National Renewable Energy Action Plan (NREAPs) for the European Union. This was done to identify the specific biomass needs to fulfill the demand in each of those sectors.

Once the energy requirements for the EU were quantified in terms of energy, the following energy scenarios were considered to calculate the final energy requirements:

1. Current average efficiency of plant ("Current")
2. Efficiency of plant in 2020 under "business as usual conditions" ("BAU")
3. Efficiency of plants in 2020 with additional efficiency efforts ("Improved Efficiency")

Table 1 shows the conversion efficiencies used to calculate the final energy requirement for each scenario.

Table 1. Assumed Plant Efficiencies for Solid Biomass

| Current Scenario | | BAU Scenario | | Improved Scenario | |
|------------------|---------|--------------|---------|-------------------|---------|
| Electricity | Heating | Electricity | Heating | Electricity | Heating |
| 30% | 85% | 34% | 85% | 37% | 85% |

Source: EURELECTRIC 2011

Then, the amount of biomass the EU has projected to produce by 2020 was quantified in order to identify possible shortfalls. The forestry sector was used for this purpose. Table 2 shows the forest sector's projections used in this study.

Table 2. Biomass Availability in the Forestry Sector within the EU, 2015 and 2020

| Projection 2015 | Projection 2020 |
|-----------------|-----------------|
| 63.7 Mtoe | 71.4 Mtoe |

Source: EURELECTRIC, 2011

Later on, the available U.S. inventory for 2020 was identified and summarized, assessing forest biomass and waste resources. This includes all of the resources not currently used listed under primary forest resources and unused mill residues and urban wood listed under secondary residues and waste. This resources mix is presented in Fig. 1. Sources circled in red were the ones selected for the study.

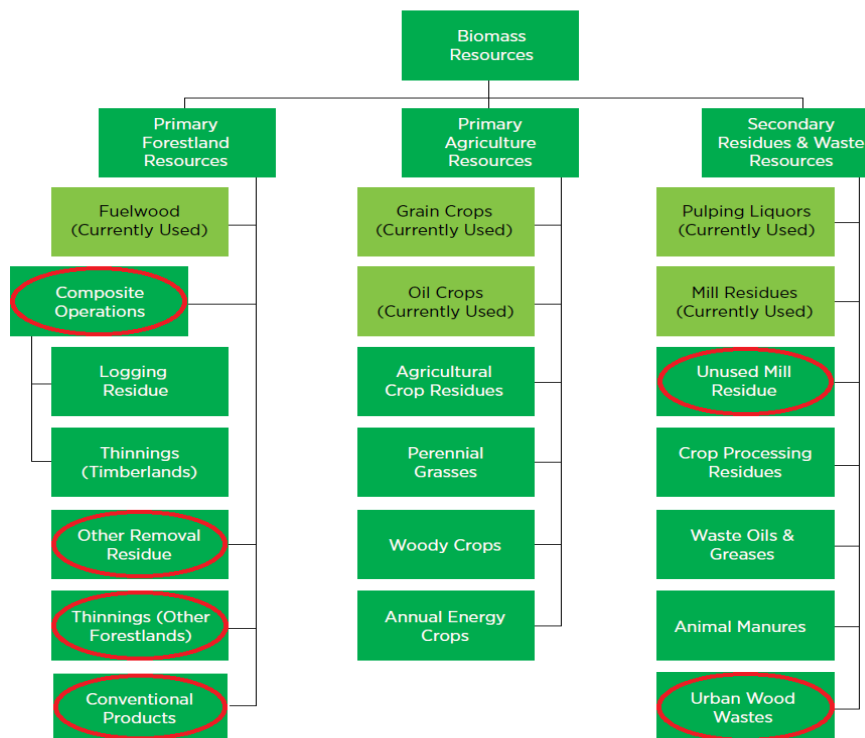


Fig. 1. Biomass resources considered (Source: U.S. Department of Energy 2011)

In order to summarize the available biomass, a tool developed by the Bioenergy Knowledge Development Framework (KDF) was used to obtain custom data subsets from the Billion Ton Update for the specific year required. This model allowed viewing data from the desired available biomass resources (forest and residues) and the production projections in 2020 for all the biomass available at any price as well as for specific prices in USD (\$40, \$50, and \$60). A price of \$60 per dry ton represents a realistic, reasonable price (based on U.S. Department of Energy 2011) for discussion purposes.

Additional data was collected in order to understand the future U.S. export opportunities. To perform the comparison based on energy parameters, among the European Union's needs and the U.S.'s inventory, several conversion assumptions were established to demonstrate standardized results.

For the comparison analysis, a conversion rate of 15 million Btu was assumed per dry ton, with a heat rate of about 13,000 Btu per kWh (U.S. Department of Energy 2011). Finally, 11,630 kWh were considered equivalent to 1 Ktoe (International Energy Agency 2013).

Several scenarios were developed to identify the EU's possible biomass deficits and U.S.'s capacity to supply that gap. A final analysis was conducted comparing and discussing each of the possible scenarios.

RESULTS AND DISCUSSION

Biomass Requirement of the European Union Members

Through a literature review, a breakdown from the renewable energy requirements for every EU member was performed to identify the specific biomass needed for each state in 2020. The data identified were the following:

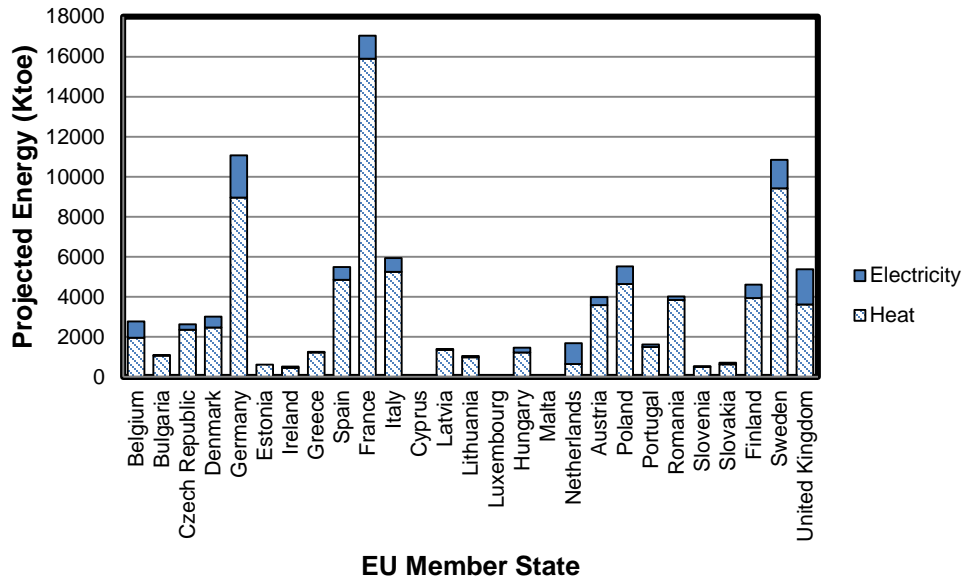


Fig. 2. Projected solid biomass energy for 2020 by EU member state (Source: Beurskens *et al.*)

The major markets for Biomass will be France, Germany, and Sweden. These biomass requirements are mainly intended for heating consumption. The total amount of energy from biomass the entire European Union is going to require by 2020 is approximately 94.31 Mtoe.

Future Projections in the EU's Market

In quantifying the current and projected use of biomass, it is necessary to make a distinction between the final and primary energy for biomass use. The amount of primary biomass is defined as the energy content of the primary input fuels to the energy conversion process, whereas final energy expresses the gross amount of useful energy (Union of Electricity Industry – EURELECTRIC 2011).

Table 3 takes into account the energy conversion efficiencies to estimate the primary biomass requirement for three scenarios; it is important to note that these efficiencies are a broad estimation of the conversions and that specific energy conversion will depend on the type of biomass and energy conversion technologies. The transport sector is not taken into account, as solid biomass will be used mainly in the electricity and heating/cooling sector.

An important energy loss is noticeable for the electricity sector given its lower conversion efficiency when compared with the heating and cooling sector.

Table 3. Primary 2020 EU Energy Requirements Based on Conversion Efficiencies

| | Final Energy of Biomass | Primary Energy Scenarios | | |
|-------------------------|-------------------------|--------------------------|---------|----------|
| | | Current | BAU | Improved |
| Heat and Cooling (Ktoe) | 80,993 | 95,286 | 95,286 | 95,286 |
| Electricity (Ktoe) | 13,319 | 44,397 | 39,174 | 35,997 |
| Total (Ktoe) | 94,312 | 139,683 | 134,459 | 131,283 |

The analysis proceeded by comparing the primary energy of biomass with the energy conversion scenarios (Table 1) for the years 2015 and 2020. One of the comparisons is shown in Fig. 3.

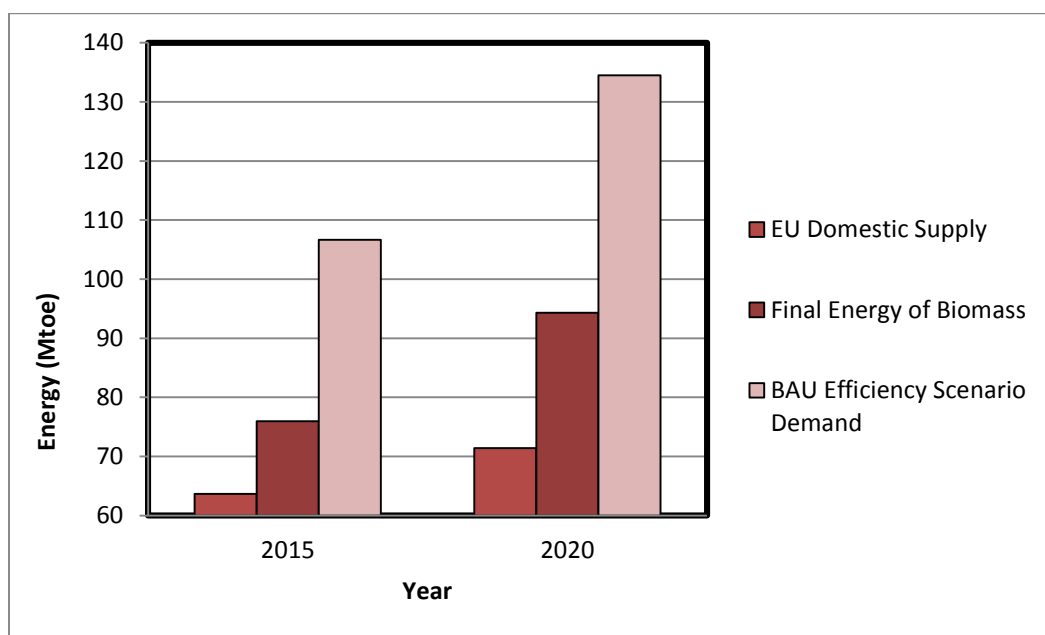
**Fig. 3.** European Union domestic supply and demand for biomass

Figure 3 shows the expected demand and domestic supply considering the BAU (Business as usual) scenario. The figure shows the European domestic supply staying under the final energy as well as the BAU efficiency scenario. The EU will not be able to supply and fulfill their energy requirements with these projections especially considering energy efficiencies. The European Union's domestic supply will not account for the total of amount of useful energy, and the deficiency is much more significant when considering a scenario for the primary biomass energy content.

The same trend was found when analyzing the other efficiency scenarios. The difference between the current efficiency and the improved efficiency scenario is approximately 8.5 Mtoe in 2020 (always higher than the domestic supply). Any plan to be developed to approach the European market should consider this considerable difference between energy requirement projections. The comparison between the EU's domestic supply availability and the demand for all the different energy requirement scenarios is shown in Fig. 4.

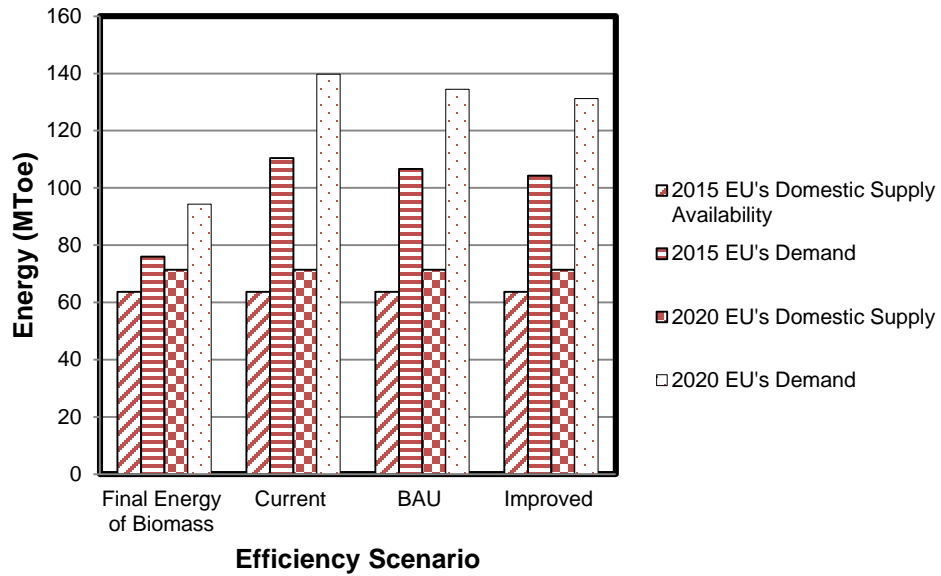


Fig. 4. European Union supply and demand for 2015 and 2020

The biggest demand is given under the current efficiency scenario (no improvement to current conversion technologies), and consequentially the biggest energy gap will also be liable to this scenario.

Additional EU’s biomass requirements (deficit) were determined based on the domestic supply and the different scenarios for demand. The import requirement result from this analysis is shown in Fig. 5.

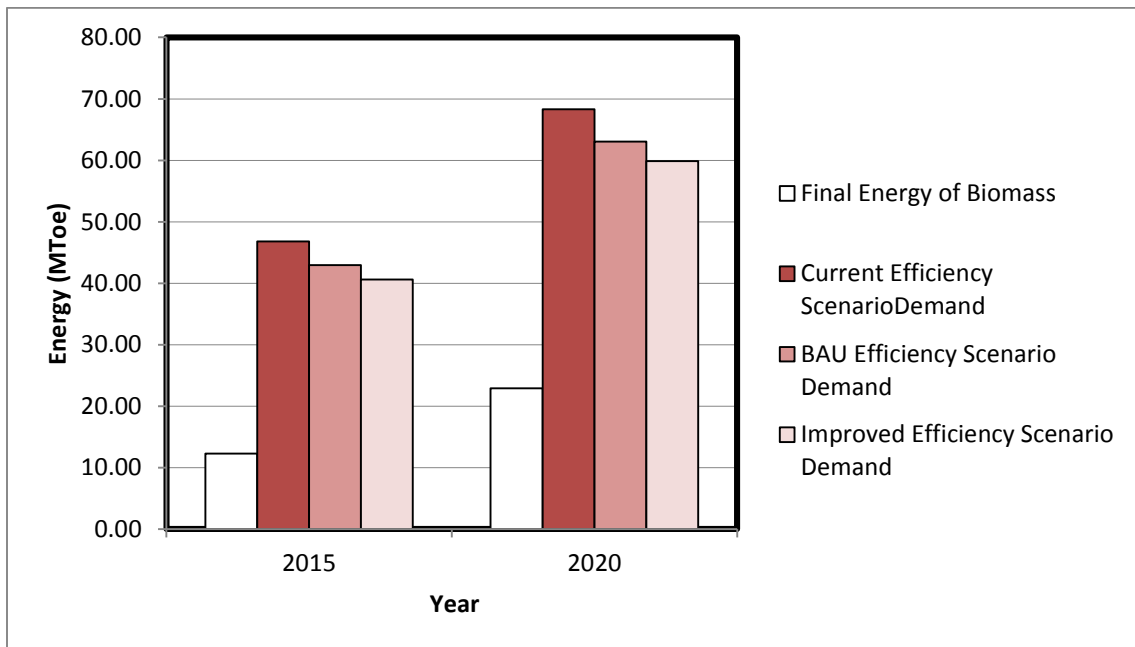


Fig. 5. European Union import requirements

The import requirement when considering energy efficiencies is substantial, as shown in Fig. 5. It represents a gap increase from 12 Mtoe to 48 Mtoe in 2015, and 23 Mtoe to almost 70 Mtoe for the current efficiency scenario in 2020.

U.S. Biomass Availability

After quantifying the EU's future biomass requirement, the next step was to determine U.S. biomass availability. For this study, the amount of primary and secondary forest resources was gathered in weight terms (Dry Tons) and subsequently its equivalent in kilo tonnes (Ktoe) of oil was calculated.

Table 4. 2020 Available Biomass Resources in the U.S. at Specific Prices

| Type | Price (USD) | Amount Available | |
|-----------|-------------|------------------|--------|
| | | Dry ton | Ktoe |
| Primary | 40 | 49,044,000 | 4,866 |
| | 50 | 51,595,200 | 5,119 |
| | 60 | 61,075,800 | 6,060 |
| | Any | 248,577,400 | 24,662 |
| Secondary | 40 | 32,111,500 | 3,186 |
| | 50 | 41,230,800 | 4,091 |
| | 60 | 41,230,800 | 4,091 |
| | Any | 41,230,800 | 4,091 |

Table 4 shows the amount of available biomass in 2020 at different prices, gathered in the different main biomass sources in the US. The price groups are related to the amount of biomass available at a specific price or lower, *e.g.*, the amount of biomass available from Primary Forest Resources at 50 USD or less is 5119 Ktoe.

The amount of biomass available in the primary forest resources is much more than in the secondary forest resources because this last source is limited to unused mill residue and urban wood wastes. There is also no more available biomass in the secondary forest resources at prices higher than 50 USD. This is due to the low commercial value attributed to wood residues. The totals from primary and secondary resources are shown in Table 5.

Table 5. 2020 Total Available Biomass Resources in the U.S. at Specific Prices

| Price (USD) | Amount Available | |
|-------------|------------------|--------|
| | Dry ton | Ktoe |
| 40 | 81,155,500 | 8,052 |
| 50 | 92,826,000 | 9,210 |
| 60 | 102,306,600 | 10,150 |
| Any | 289,808,200 | 28,753 |

After accounting for all the biomass for the desired resources production in Table 5, a total of 289.81 million dry tons will be available (at any price per ton) in 2020, which translate to 28.75 Mtoe available to fulfill the EU's market biomass imports.

U.S. Opportunities in the EU Biomass Market

To calculate the U.S. opportunities in the European market a comparison was made between EU import requirements and U.S. biomass availability. The comparison was made including the efficiency scenarios. The results are shown in Fig. 6.

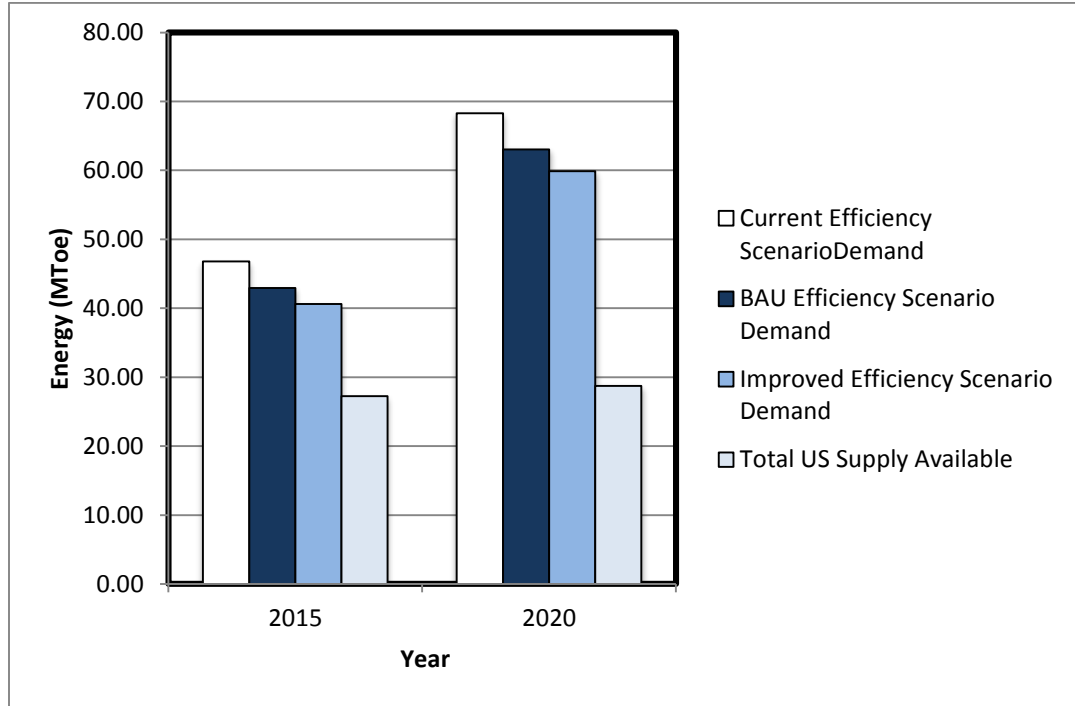


Fig. 6. U.S. opportunities in the EU biomass market

As shown in Fig. 6, the EU’s import requirements after considering their internal supply will be growing at a faster rate than the U.S. biomass inventory (total U.S. supply available). The Total U.S. Supply available shown in Fig. 6 corresponds to all biomass available at any price in the given years. According to this data, the U.S. supply will not be able to satisfy the European Union’s import demand even under the most favorable circumstances.

Additional analysis was made comparing Europe’s import requirements with U.S. available biomass at different prices. The results of this analysis are shown in Fig. 7.

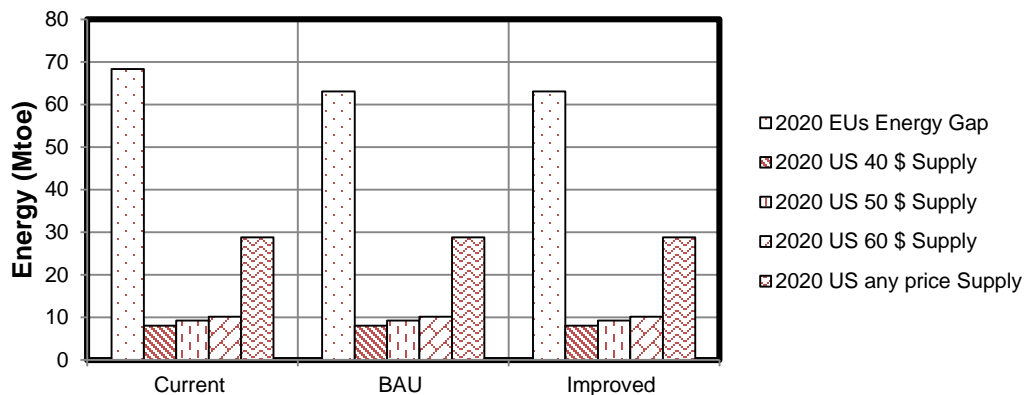


Fig. 7. European Union supply and demand for 2015 and 2020

From analyzing Fig. 7, it seems clear that the U.S. will not be able to satisfy the entire European demand for any of the real energy requirements. Even with the possibility to sell all the biomass available, it will only represent less than half of the European Union’s

import requirements. For the cases in which reasonable biomass prices are considered, only a small portion of the demand could be covered.

The different biomass prices at the different efficiency scenarios are able to supply different percentages of the European biomass import requirements. The different percentages are shown in Fig. 8.

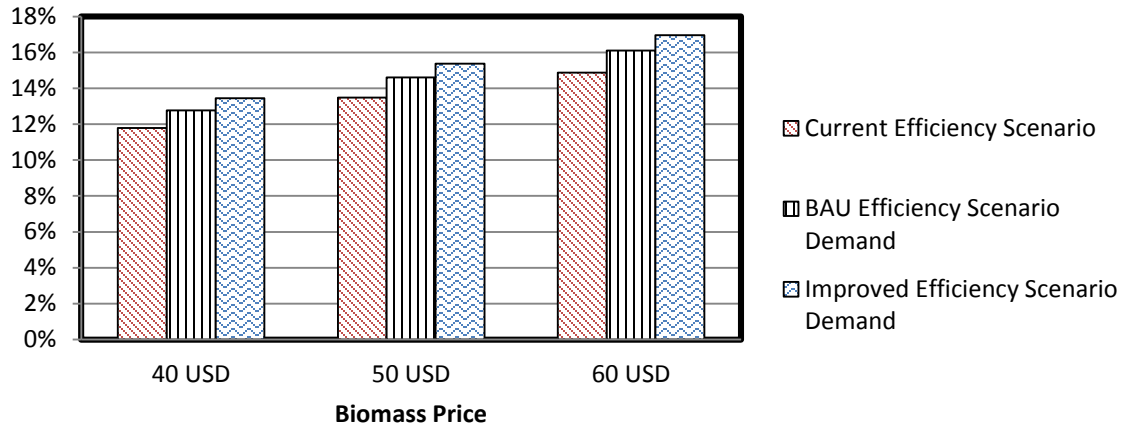


Fig. 8. U.S. export opportunity to satisfy the EU's biomass import requirements at 40, 50, and 60 USD in 2020

Figure 8 shows the amount of biomass the U.S. has available at different biomass prices considering the possible efficiency scenarios. For a 40 USD biomass price, which represents 8.1 Mtoe, the U.S. would be able to satisfy between 11.8% and 13.4% of the European demand. The Current, BAU, and Improved efficiency scenarios will generate a supply deficit for the European Union of 88.2%, 87.2%, and 86.6 %, respectively.

For a biomass price of 50 USD, which represents 9.2 Mtoe available to be supplied, the U.S. would be able to satisfy between 13.5% and 15.4% of the European demand. The Current, BAU, and Improved efficiency scenarios represent a supply deficit of 86.5%, 85.4%, and 84.6%, respectively for the European Union.

Also, for a biomass price of \$60, which represents 10.2 Mtoe available to be supplied, the U.S. would be able to satisfy between 14.9 and 16.9% of the European demand. The supply deficit under current, BAU, and Improved efficiency scenarios would be 85.1%, 83.9%, and 83.1%, respectively.

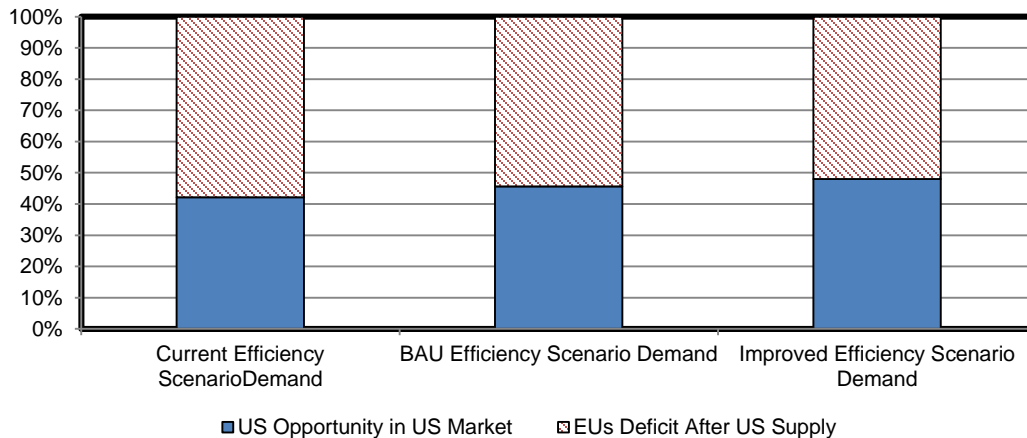


Fig. 9. U.S. export opportunity to satisfy EU's biomass import requirement at any price in 2020

This analysis was also performed considering the total U.S. biomass availability at any price. The total possible U.S. share (available biomass at all prices) in the European biomass import requirement is shown in Fig. 9.

Figure 9 shows that at any biomass price, representing 28.8 Mtoe available to be supplied, the U.S. would be able to satisfy between 42% and 48% of the European demand. The supply deficit for the European Union from the Current, BAU, and Improved efficiency scenarios represent 57.9%, 54.4%, and 52%, respectively.

CONCLUSIONS

This research focused on understanding the U.S. opportunities to export woody biomass based on the targets that the European Union has imposed to its Member States. The main conclusions for this project are:

1. The U.S. could satisfy between 42% and 48% of the European demand at reasonable biomass prices based on the USDA prices estimates.
2. When considering energy efficiencies, there is a significant shortfall of primary biomass within the EU. Studies approaching the European market and U.S. export opportunities should consider different conversion efficiency projections.
3. Improvements to current energy conversion technologies would substantially reduce the EU biomass requirements. The EU could reduce its level of biomass imports dependence by developing more efficient technologies, particularly in the electricity sector.
4. The EU biomass demand, after considering internal supply, will be growing at a higher rate than the U.S. biomass inventory and production. This translates into an increasing deficit in the European market, and this is likely to impact the biomass prices in following years unless new suppliers participate largely.
5. Previous research and technical information from the EU renewable energy roadmaps indicated that biomass is expected to be used to generate 17.2% of the planned EU heating and cooling mix and 6.5% of electricity consumption by 2020.
6. U.S. opportunities in the European Market might be threatened by factors such as the EU's co-operation mechanisms (allowing a limited level of renewable energy sources trading between member states) and competitors including Canada and Russia, and potentially, China and South America.
7. The countries with higher use of biomass in 2020 are expected to be France, Germany, and Sweden. These biomass requirements are distributed in electricity and heating consumption representing with the latter having the largest intended amount.

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