Resource efficiency impacts of future EU bioenergy demand (ReceBio) – An analysis commissioned by DG Environment of the European Commission

Background Paper for 6 October 2014 - Workshop on developing and reviewing assumptions and scenarios on bioenergy demand and biomass use

CONTENTS

1 SUMMARY

The aim of the "Resource efficiency impacts of future EU bioenergy demand" (ReceBio) project[1] is to help better understand the potential interactions and impacts resulting from increased EU demand for bioenergy, and specifically the implications for resource efficiency. To achieve this, the study as a whole will build on the best available data and understanding of biomass resource at present, and model projected use of biomass for energy and materials up to 2050. The intention is to understand the consequences on resource efficiency and the environment of pursuing different bioenergy pathways.

To date, the project team has conducted detailed analysis of the availability of biomass resources and current use of biomass in the EU. In parallel, a detailed assessment of literature reviewing the impacts of biomass use on natural resources and the global environment has been made. The outputs of these assessments will provide key inputs to the model-based assessment of the implications of biomass resource use. These will be presented in the workshop for comment and critical review.

The main focus of the workshop is to present and discuss the initial findings of the project and the model-based assessment that will be undertaken within the framework of the project. **The core purpose of the workshop is to understand your views, as a stakeholder, on the basis for the modeling (i.e. the scenarios to be assessed) and the assumptions upon which these will be based.** The scenarios selected and the assumptions on which they are based will be presented during the day, and we welcome an open debate on this selection and the findings reached this far.

The starting point for the analysis under ReceBio is the EU 2020 climate and energy targets and the proposed EU 2030 package. In this context, the baseline and GHG emission reduction scenarios are based on the EU Reference Scenario[2] used in the 2014 EU Impact Assessment[3]. The analysis focuses on biomass use for heat and electricity, hence excluding biofuels. It is proposed that the analysis would be based on the scenarios briefly presented in the table below. All the scenarios are discussed in further detail within this paper and will be presented for discussion at the event.

[1] http://www.iiasa.ac.at/web/home/research/researchPrograms/EcosystemsServicesandManagement/Resource_Efficiency.html

[2] European Commission. EU Energy, transport and GHG emissions trends to 2050. Reference scenario 2013. (2013).

[3] European Commission. Impact Assessment: Accompanying the Communication A policy framework for climate and energy in the period from 2020 up to 2030. (2014).

Table 1. Overview of the scenarios for analysis and key differences from the reference scenario

		Main model parameters		
		Bioenergy demand in EU28	Bioenergy demand in RoW	Biomass import to EU28
Baseline	Baseline Scenario	As in EU Reference Scenario	As in EU Reference Scenario	Estimated by model
Policy scenarios	EU Emission Reduction Scenario	**As in GHG40/EE (increased level compared to baseline)**	As in baseline	Estimated by model
	Constant EU Bioenergy Demand Scenario	**As in GHG40/EE until year 2020, then constant**	As in baseline	Estimated by model
	Increased RoW Bioenergy Demand Scenario	As in GHG40/EE	**As in Global Action Scenario (increased level compared to baseline)**	Estimated by model
	Increased EU Biomass Import Scenario	As in GHG40/EE	As in baseline	**Enhanced import (estimated by model)**

2 INTRODUCTION

2.1 Purpose of the workshop

This meeting offers an important opportunity to input to and review assumptions and scenarios to be used as a basis for assessments under the 'Resource efficiency impacts of future EU bioenergy demand' (ReceBio) project. These will critically influence the outcomes of the work and the conclusions reached. The results of the work will provide new insights into two fundamental questions resulting from increasing bioenergy demand:

- What are the potential effects of increased bioenergy demand on the environment?
- How would an increased bioenergy demand impact other sectors that also use biomass resources?

The purpose of the day is to present initial analysis from the study for stakeholders' comments. We will then focus on how this can be developed into assumptions and scenarios that will be used as a basis for modelling work to be completed later in 2014 and 2015. Understanding stakeholders' questions and issues regarding the nature and appropriateness of the assumptions and scenarios is critical to the effective development of the modeling work on EU bioenergy demand and its consequences.

With work of this nature there will be a need for the team to present, later on, the analysis completed, however, the emphasis of the day is very much on communication and discussion. **It is vital to the work that we understand your thoughts, concerns and perspectives. Comments on the analysis are, therefore, welcomed at any point in the meeting and additionally after discussions have taken place**.

2.2 Key questions for discussion on the 6th October

Please consider the following questions during the day:

- Do you feel the storylines and conceptualization of the different world situations depicted in the scenarios are appropriate? Are there some issues or dynamics that should be added?
- Are there potential scenarios or model analysis that should be considered in addition to those presented? What might these encompass and why?
- Are there any additional dataset or sources of information that should be taken into account for the storylines considered here?
- Do you feel that the assumptions applied are appropriate to the different scenarios?
- Do you feel there are areas where the analysis or approach might be improved and how?

2.3 Introduction to the ReceBio Project

In the European Union, biomass use for electricity and heat production is expanding. This is happening within a context of increased use of renewable energy intended to contribute to reduce greenhouse gas emissions and increase energy security. In general, the impact on resources and competing sectors of the EU bioenergy demand is not sufficiently well understood. This study, therefore, seeks to develop understanding of the various interactions and impacts that can arise as a result of an increased EU demand in bioenergy, and their implications for resource efficiency.

The specific objective of the work under ReceBio is to understand the resource efficiency implications of different future trajectories of increased EU use of bioenergy for electricity and heat, under different scenarios, and including indirect impacts. To this end, the team have so far reviewed the “state of play” to understand in detail the bioenergy potential available from multiple different resource streams and reviewed extensively the existing literature regarding the consequences of biomass use on natural resources and the global environment. Summaries of key findings from this work are presented here and will be further presented and discussed at the meeting. The purpose, however, of this first stage of the work is in essence to provide a sound basis for a systematic modeling based analysis.

Comments and interventions made today will help to focus and improve the basis for the modeling exercise. It will commence within 2014 and run into 2015 with a further workshop to present findings taking place in autumn 2015.

The team conducting the work consists of:

- International Institute for Applied Systems Analysis (IIASA) – Project lead, coordinating modeling efforts;
- INDUFOR – experts in woody biomass, coordinating input on the state of play;
- Öko-Institut (OEKO) – lead on natural resource and environmental impacts;
- European Forest Institute (EFI) – experts in biomass trade and analysis; and
- the Institute for European Environmental Policy (IEEP) – lead in stakeholder engagement and experts in biomass for energy

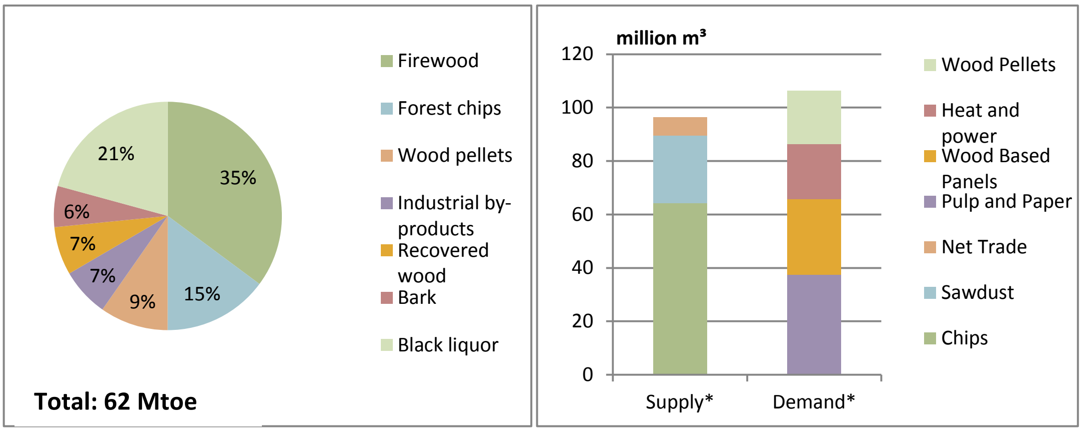
3 AVAILABILITY AND USE OF BIOMASS: THE STATE OF PLAY – PROVIDING A BASIS FOR UNDERSTANDING BIOENERGY POTENTIAL

In 2012, bioenergy constituted two-thirds of the primary production of renewable energy in the EU. The largest source for bioenergy was solid biomass, which provided almost half of the final energy consumption from renewable energy sources, the rest being constituted of municipal waste, biogas and liquid biofuels. The latter are not studied in the context of this project as they are already extensively studied elsewhere. Task 1 of the project portrays development and trends of biomass use in the EU and the links between biomass use for material and energy purposes.

The uses of wood and agricultural biomass and biogenic waste are largely separate from each other. However, for wood, material purposes are an essential use although interaction and dependencies between non-energy and energy use are also highly evident within this sector. Agricultural biomass is first and foremost produced for food and feed. Non-energy uses of biogenic waste are still much limited and strongly dependent on effective ways to sort, decontaminate and treat waste.

As for wood biomass, material and energy use in the EU will be increasingly interconnected. Already today different proportions of felled trees and consequent by-products of industrial processing are directed to various end uses, depending on the needs and paying capabilities of buyers (often local wood consuming industries). Over 50% of the wood used for energy in EU comes either from the wood products industry or pulp and paper industries (Figure 1). This includes industrial by-products, certain wood pellets, recovered wood, bark, black liquor and part of forest chips. In practice, all available industrial by-products are being used, and practically no unused volume is available unless production volume of sawmilling and other round wood consuming industries increases. Outside industrial uses, firewood represents a significant type of wood biomass consumption for energy. Currently about a third of all wood-based energy is estimated to derive from firewood and it is the largest single source of wood energy in the EU (see Figure 1).

Figure 1. (left) Consumption of wood biomass in energy production in EU27; (right) Supply and demand of industrial by-products in the EU27

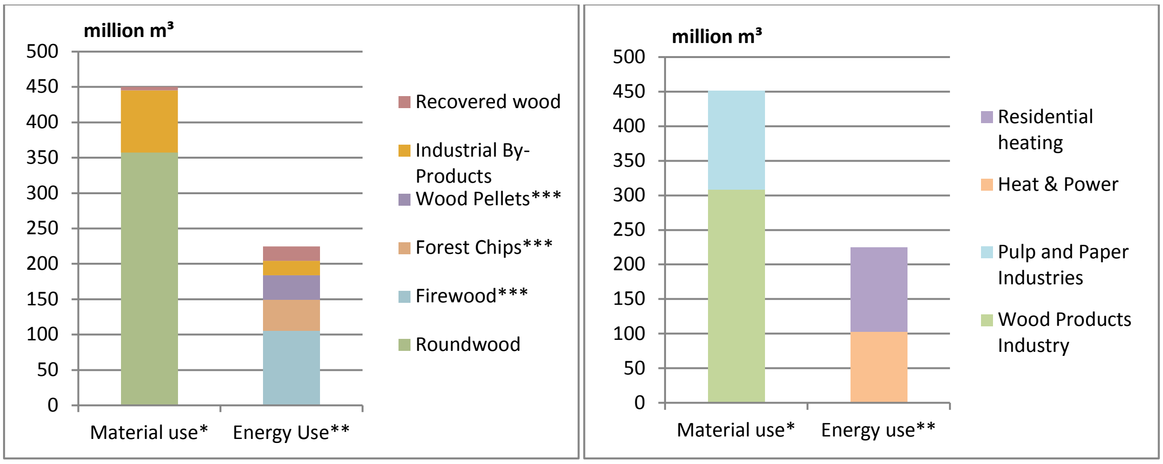


*Supply and demand numbers cannot be combined well due to the variable conversion factors used in several sources as well as the difference between the actual supply and volume of stock within a calendar year.

Source: ReceBio – Task 1 Report: Joint Wood Energy Enquiry, FAOSTAT, National Statistics, Holzmarktbericht, Indufor, Study on the Wood Raw Material Supply and Demand for the EU Wood-processing Industries 2013, European Panel Federation, AEBIOM European Bioenergy Outlook 2013, CEPI, VDP – Germany, Austropapier, EPF, COST 31, Wood Recyclers' Association UK, BAV Germany

Virgin wood by-products and recycled wood consumed in material use is estimated to be approximately double the amount of wood consumed in energy production. Figure 2 shows the wood consumption between material and energy use per raw material type and by consumer.

Figure 2. Consumption of wood biomass for material and energy use in the EU27 per type (left) and sector (right)



* Excludes recovered paper and imported pulp used in pulp and paper industry. ** Excludes bark and black liquor. Figure shows aside wood material that, at least in theory, could be switched from material use to energy use. *** For these products, roundwood is partly used as raw material, however exact figures for this amount is difficult to estimate.
Source: ReceBio – Task 1 Report: Joint Wood Energy Enquiry, FAOSTAT, National Statistics, Holzmarktbericht, Indufor, Study on the Wood Raw Material Supply and Demand for the EU Wood-processing Industries 2013, European Panel Federation, AEBIOM European Bioenergy Outlook 2013, CEPI, VDP – Germany, Austropapier, EPF, COST 31, Wood Recyclers' Association UK, BAV Germany

Presently within the EU, 89 Mtoe of agricultural residues and 9 Mtoe of short rotational and perennial crops are produced. Due to the fact that the markets are largely unaccounted, few estimates of available energy potentials exist. Based on several sources, however, trends and developments can be estimated indirectly. In bioenergy production, the main uses of agricultural biomass today are biofuels in the transport sector, and biogas for heat and power production and feeding to the gas grid. Biomass from ligno-cellulosic energy crops can contribute to primary energy supply in the short term in heat and electricity applications, in the long term for biofuels. Cropping areas of cellulosic energy crops have been fluctuating. From a global point of view, an increasing demand for agricultural products increases competition for land. Therefore, to avoid land pressure and food price increases, global supply should be moved towards increased utilization of agricultural residues and wastes

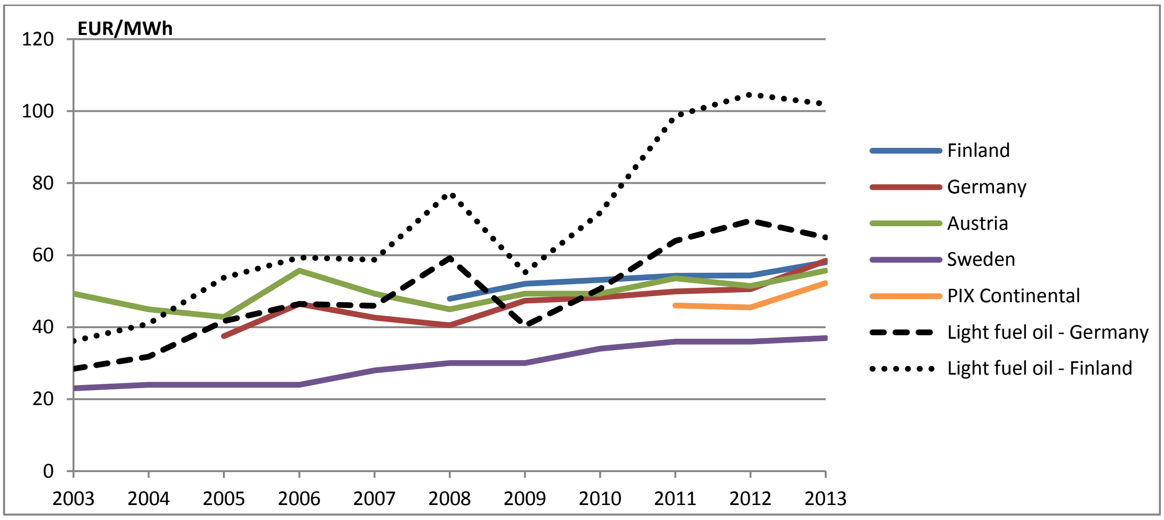
The greatest amount of available biogenic waste comes from food waste (81 Mt), followed by municipal solid waste. Other sources include sewage sludge, waste textiles and green waste. A major part of municipal solid waste is paper and cardboard waste (17.5 Mt). Given the increasing recycling rates for most of municipal waste sub-categories considered and the downward pressure to prevent generation of, for example, food waste; it is estimated that the availability of waste for energy production will decrease over time.

National and international trade is well established within wood biomass products, while almost non-existent within agricultural woody/ligno-cellulosic biomass, cropping and livestock residues, and biogenic waste. Agricultural residues can be pelletized and therefore transported for longer distances, however large majority of the global pellet trade is with wood pellets. Due to the bulkiness of the products, transport prices play a central role in all trade of biomass products. Wood pellets are the most important internationally traded biomass commodity and the EU is the largest consumer (13 million tonnes in 2012) accounting for two-thirds of the global consumption. Imports of wood pellets to EU are expected to increase due to increasing demand for industrial wood pellets in combined heat and power production. Import of wood pellets to the EU from was about 3.2 million tonnes in 2012 and in 2013 increased to 5.7 million tonnes. The US and Canada export about 2.7 and 2.0 million tonnes of pellets to the EU respectively, Russia about 0.7 million tonnes/a. Wood pellet imports cover approximately two per cent of the total wood biomass energy use in the EU. In EU's domestic markets, wood pellets consist mainly of residential quality wood pellets. In this sector, residential wood pellet mills are struggling with increasing competition for raw materials, namely industrial by-products (chips, sawdust).

The market price of wood for energy has been steadily increasing. Price development has been stable in comparison to fluctuating price trends of fossil fuels.

Figure 3 shows the example of residential wood pellet price in several markets.

Figure 3. Price of wood pellets in residential markets



Source: Statistics Finland, C.A.R.M.E.N., Propellets Austria, FOEX, Skogsstyrelsen, Destatis.de, Finnish Petroleum Federation

Quality and availability of data used in the study is good for traditional wood based commodities such as sawn wood, wood based panels and pulp and paper products. Forest chips and recovered wood markets are mostly immature or unaccounted due to limited marketability (like firewood), thus lack established data collection protocols. Only a few Member States present good quality data on production and trade. Data related to wood pellets is the most developed because it is a globally traded commodity. In comparison to other wood biomass for energy use, the trade and production statistics for wood pellets are better developed and more transparent, although need for development can be considered in accounting for the type of the used raw materials (e.g. harvest losses, roundwood or recovered wood). For agricultural biomass and biogenic waste, the figures are less reliable as data collection is not as well established as within wood industry, and for some countries and commodities, the figures can only be considered as rough estimates.

4 UNDERSTANDING THE IMPACTS OF BIOMASS USE ON NATURAL RESOURCES AND THE GLOBAL ENVIRONMENT – KEY MESSAGES FROM THE LITERATURE

Impacts of biomass use on natural resources and the global environment are manifold. The project attempts to cover the most relevant impacts in the model framework (Task 3) and assess them in the subsequent analysis of impacts (Task 4). The literature review carried out in the project gives a comprehensive overview of the current knowledge on possible impacts on biodiversity, soil, water bodies, greenhouse gas emissions and other land-use impacts, including indirect effects as well as some aspects on economic impacts. Each impact category was divided into detailed impacts, e.g. soil erosion, soil carbon loss, soil compaction, soil nutrient loss and soil salinization for the category soil. A set of 40 references was considered relevant after categorization from an initial list of 202 references. The selected references were then analyzed for detailed impacts that were reported, as well as the causes of impacts and the responses suggested by the literature. Despite the complexity of the issue, the project also identifies important aspects regarding potential responses to impacts reported in the reviewed literature (see summary in Table 2).

The use of biomass for energy purposes can potentially be a driver of loss of **biodiversity**, linked primarily to direct and indirect land-use change and increasing intensity of land use. The increasing use of biomass is likely to increase this pressure. The screening of literature carried out in this project focused on the following detailed impacts: loss of species, loss of ecosystems, damage of flora and fauna and loss of ecosystem functions. From a biodiversity perspective the review showed that two aspects are of high relevance: a) the protection of areas with high biodiversity value and b) sustainable extraction rates of dead wood, residues, stumps and old trees.

The review showed that most **soil** impacts are very site specific and require respective soil conservation measures. The amount of biomass extraction can be part of the soil conservation measure (e.g. mulching with straw, retaining nutrient cycle by leaving branches and leaves on site) and lead to win-win situations. Other soil conservation methods increase the possible extraction rate but entail higher production costs (e.g. fertilization with ash). Some soil conservation measures may also only cause costs and not necessarily contribute to improved yields (e.g. adaption of machinery, windbreaks). Finally, specific soil conservation measures may lead to a lowering of yields compared to the option without measures (e.g. adoption of crop rotation to allow straw extraction). It is therefore necessary to favor win-win measures that contribute to soil conservation while positively impacting biomass production.

The identified impacts on **water** are of lower relevance compared to e.g. impacts on biodiversity and soil. This is due to the focus of the literature review on systems producing solid biomass that are largely rain-fed systems in Europe. The most relevant potential negative impacts on water are a) overuse of freshwater resources in water scarce regions, b) pollution of waterbodies from the application of fertilizer and pesticides, and c) pollution of waterbodies from process waste water. However, there can also be positive impacts of biomass production systems, e.g. on ground water supply.

Strong impacts on **greenhouse gas emissions** from biomass production occur when areas of high carbon stock are converted to bioenergy plantations of low carbon stock, but it also occurs from an increase of wood extraction, including whole tree harvest and residue extraction, that can lower the carbon stock of forests. However, there are cases where long-term active forest management can increase biomass and timber production while still safeguarding the forest carbon stock at the landscape level. Examples of such management options range from the promotion of regeneration and silvicultural management to enhancing forest growth (through improved timing of pre-commercial cutting, thinning efforts, fertilization, etc.). When including substitution effects on GHG emissions within the energy and industry sector, managing forests for products and services (materials and energy) can also determine higher GHG savings than suspending the management.

Table 2: Important points identified from the reviewed literature to reduce negative impacts from biomass use on the environment.

Environmental aspect
Biodiversity
▪ The protection of areas with high biodiversity value ▪ Sustainable extraction rates of dead wood, residues, stumps and old trees
Soil
▪ Identification of exclusion areas where (i) no production at all is allowed and (ii) where no residue or stump extraction should occur (e.g. depending on steep slopes, poor soils, wet soils) ▪ Restriction of residue and stump extraction on all remaining areas ▪ Lowering the development of yields, i.e. assuming a lower annual yield-increase rate assuming stronger soil protection measures
Waterbodies
▪ Avoid overuse of freshwater resources in water scarce regions ▪ Reduce pollution of waterbodies from the application of fertilizer and pesticides ▪ Reduce pollution of waterbodies from process waste water
Greenhouse gas emissions
▪ No conversion of areas of high carbon stock ▪ No overuse of forests ▪ Time lag of forest growth and wood use, both for energy and materials ▪ Threshold for the GHG-emission reduction compared to fossil sources

Indirect effects (for all environmental impacts) occur, inter alia, as a consequence of the displacement of a former activity to fulfil a demand. In case that the former demand still exists, meeting this demand may cause impacts elsewhere, especially as further biomass production will tend to extend into less fertile soils (hence requiring more inputs such as fertilizers and/or water) and/or into areas with higher ecological value. Results from the literature review on indirect effects and on economic impacts showed that both aspects are mainly related to competition between different biomass uses (energy, material) for biomass resources such as stem, branches and residues.

Finally a literature review was carried out for the cascading use of biomass, focusing on measures and instruments to incentivize it. The most central issues and proposed methods for increasing cascading mentioned in the covered studies are: the need for clear definitions of cascading use over the whole biomass lifecycle; imposition of taxes, subsidies and legal measures to promote cascading use; and cross-disciplinary dialogue for developing more efficient logistical and technological solutions in different cascading stages.

5 THE MODELLING APPROACH ADOPTED UNDER RECEBIO AND ITS PURPOSE

The starting point for the study is the EU 2020 climate and energy targets and the proposed EU 2030 package. In this context, the baseline and GHG emission reduction scenarios will be specified as close as possible to what has previously been specified in the EU Reference Scenario[2] used in the 2014 EU Impact Assessment[3] (hereafter, "2014 IA report"). Furthermore, this study uses the same modelling framework (e.g. The Global Biosphere Management Model, GLOBIOM[4]) for analyzing the land use implications as the Commission reports, which improves consistency and comparability between the reports.

GLOBIOM is a global model of the forest and agricultural sectors, where the supply side of the model is built-up from the bottom (land cover, land use, management systems) to the top (production/markets). The model computes market equilibrium for agricultural and forest products by allocating land use among production activities to maximize the sum of producer and consumer surplus, subject to resource, technological and policy constraints. The level of production in a given area is determined by the agricultural or forestry productivity in that area (dependent on suitability and management), by market prices (reflecting the level of demand), and by the conditions and cost associated to conversion of the land, to expansion of the production and, when relevant, to international market access. Trade is modelled following spatial equilibrium approach, which means that the trade flows are balanced out between different specific geographical regions. This allows tracing of bilateral trade flows between individual regions.

Biomass used for the production of biofuel for the transport sector is included in the modelling framework. The full range of technological pathways available for production of 1st and 2nd generation biofuels and the various feedstock that the conversion technologies rely upon are considered within the modeling framework. However, since biofuels are outside the scope of this particular study, the implication of changing demand for biofuels will not be analyzed within the framework of this study. Hence, the term "biomass" is to be understood as biomass except biofuel throughout the study.

In this project, a **baseline** scenario will first be constructed to project future development as a continuation of on-going trends and historical developments. The scenario as such depicts a development trajectory wherein current policies remain unchanged, no new policies come into play, and no major changes from past trends occur. In addition to the baseline scenario, a number of policy scenarios will be constructed to highlight alternative future development and analyze their implications. Each policy scenario is built around a clear storyline and will focus on a single particular issue or aspect of the bioenergy markets. To allow a clear identification of the consequences and trade-offs related to the policy developments analyzed, change in assumptions in a policy scenario only affects part of the modelling framework being used. With this construction, differences in outcomes between the baseline and a policy scenario can be directly attributed to the issue that the policy scenario is reflecting.

Once the baseline and policy scenarios have been created and run using the modelling framework, the impact of different scenarios will be evaluated on 2030 and 2050 time horizons. Comparisons among scenario projections will be made to estimate how policy scenarios impact indicators such as regional production of different types of biomass, forest management strategies, international trade

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[4] http://www.globiom.org

of biomass between countries/regions, and use of biomass resources in relevant sectors (e.g. energy, building, wood-processing industry).

The modelling efforts will also focus on evaluating the environmental and natural resource implications of the policy scenarios. This will be performed in a two-stage approach where scenario-specific results will first be analyzed in order to quantify the impacts on aspects such as biodiversity, soil, land use (including direct and indirect land use change), overall greenhouse gas (GHG)-balance in the LULUCF (land use, land use change and forestry) sector, and forest carbon stocks. In a second stage, and depending on the modelling results obtained in the first step, a set of constraints will be imposed in the model in order to limit the environmental impacts that appeared the most salient ones in the results of the 1^{st} stage of the modeling (this will therefore mimic the introduction of sustainability criteria related to these impacts). Thereafter, the analysis of the impact specific indicators will be re-run.

5.1 Presenting the baseline - a starting point for assessment

The reference point of the assessment is a baseline scenario that is designed to be as comparable as possible to the EU Reference Scenario. The baseline scenario depicts the same development as the EU reference scenario and is based on the same underlying assumptions concerning socio-economic growth, statistical data, and policy targets. The underlying goal of our baseline scenario is to provide a projection of what the world could look like in the future if our policies continue in line with historical trends. For this, the scenario is based upon the latest available statistics, policies in place today, and the latest projections of key parameters such as population growth, energy prices and macro-economic development. The goal of the baseline scenario is to depict a future with continued increasing global population, intermediate economic developments including consideration to EU's economic downturn, and ongoing development of international fuel prices. Moreover, it portrays a future in which consumption patterns of food, fibre, and fuels continue to evolve over time following current trends.

The EU Reference Scenario will be slightly adjusted in this study to provide a relevant baseline scenario that is consistent with the modelling framework used in this study. The main underlying socio-economic information (GDP growth, population development, fossil fuel prices etc.), consumption patterns of commodities, land cover information, trade, and total bioenergy demand will be the same between this study and the 2014 IA report. However, differences will apply due to the use of updated data as collected within Task 1 of the project (state of wood-processing industries, bioenergy production from lignocellulosic biomass, cost and prices of biomass resources etc.) and model developments as performed within Task 3 of the project (disaggregation of wood commodities, separation of bioenergy demand etc.).

Assumptions in line with those in the EU Reference Scenario

- Global population growth and GDP projections.
- Bioenergy demand (heat, electricity, and biofuels) in EU and RoW evolves throughout the projection period in accordance with the EU Reference Scenario.
- Only those sustainability criteria for biofuels, solid and gaseous biomass that were assumed in the 2014 IA report are assumed to affect the development of the bioenergy sector and demand for bioenergy. See the 2014 IA report3 for further details considering the underlying assumptions.
- Land cover for EU28 is based on the CORINE/PELCOM cover maps for the base year of 2000. For the rest of the World, GLC 2000 is used.

- Agricultural and forestry production does not expand into protected areas; however, land conversion can occur on unprotected areas.
- Demand for food and fibre is driven by human population growth and changing GDP. Demand for commodities is price elastic and therefore changes depending on consumers' willingness to pay.
- Trade of commodities between EU Member State and RoW is endogenously estimated by the GLOBIOM modelling framework.
- Current forest management and rotation periods as globally estimated by the G4M model are applied. Rotation periods and management, however, adapt over time to demand changes to maximize forest net present value (NPV) estimates. Age class structural developments are also accounted for both in terms of NPV estimations and potential harvest rates.

Assumptions differing from the EU Reference Scenario

- Data concerning the state of wood based industries as collected within Task 1 of the project will also here be fully integrated within the modelling framework. This allows for more accurate representation of the current state of the industries as well as the biomass sources being used for the production of the various woody commodities.
- Demand for bioenergy will no longer be disaggregated into two sources: energy produced based on biomass from forestry and energy produced based on biomass from short rotation forestry (SRF). A single bioenergy demand will instead be considered that contains biomass from both sources. With this assumption, we allow for complete competition for land and the use of biomass sources. That is, we do not prescribe a certain development for the agricultural nor the forest sector, but instead consider the full competition between these main sources of biomass feedstock as well as between the individual feedstock for each sector (e.g. for forest: stemwood, harvesting residues, industrial residues etc.). This provides information concerning feedstock competitiveness and allows full analyze of the balance depending on feedstock supply assumptions and demand implications (see below section "Analysis of central modeling assumptions").

5.2 Developing Alternative Scenarios for Assessment

The baseline that has been selected for this study forms a point of comparison in terms of the implication of various policies. Within the project, a number of policy scenarios are proposed to be analyzed within the context of the EU proposed climate-energy targets for 2030.

In each scenario, the level of bioenergy demand is determined when defining the scenario, for example in accordance with PRIMES/POLES estimates. During the modelling, change in LULUCF emission due to increased or reduced biomass demand is not accounted for in the efforts needed for reaching an overall EU GHG emission reduction target part of each scenario. Increasing or decreasing forest carbon stocks in relation to the forest management levels are not reflected back to the bioenergy demand, due to the fact that LULUCF emissions are not accounted for in the political targets. In addition, bioenergy demand from POLES/PRIMES was computed with an assumption of carbon neutrality of bioenergy use.

The proposed policy scenarios are the following (see also The information and views set out in this report are those of the author(s) and do not necessarily reflect the official opinion of the Commission.

Table 1):

5.2.1 EU Emission Reduction Scenario

This scenario depicts a development where more stringent GHG emission abatement targets for EU come into play, enhancing the development of the bioenergy sector. Thus, the scenario assumes higher targets for EU in terms of GHG emission reduction in comparison to the baseline scenario. This in turn is expected to increase the demand for biomass for energy purposes, place higher pressure on biomass production, and decrease the amount of biomass available for material production. In short, the scenario will show implications of higher bioenergy production levels for the EU in comparison to the baseline scenario.

For EU, the scenario is based on the same overall targets and policy assumptions as for the GHG40/EE scenario in the 2014 IA report. The same differences as pointed between the reference and the baseline scenario will also be applicable here in terms of differences between the GHG40/EE scenario and the EU Emission Reduction Scenario. Most importantly, the same bioenergy demand level as for the GHG40/EE scenario will be applied for this scenario. However, as in the baseline scenario, bioenergy demand will be considered as one category. The main points of the overall targets and policy assumptions that the scenario is based upon are described below. These are the same assumptions as those in the GHG40/EE scenario.

For the RoW, the scenario assumes the same overall targets and policy assumptions as for the baseline scenario. It is therefore assumed that the enhanced GHG mitigation policies for EU do not entail increasing policy actions for RoW. As such, the same bioenergy demand for RoW will be assumed as for the baseline scenario.

Main underlying assumptions

The same assumptions as for the baseline scenario apply for all aspects as stated earlier for the baseline scenario (GDP projections, global population growth, etc.), except for:

- The bioenergy demand in EU28 evolves throughout the projection period in accordance with levels evaluated as for the GHG40/EE scenario. This implies that demand for biomass for energy is higher than the level assumed for the baseline scenario.
- Demand for first and second generation biofuel within EU28 develop all the way until 2050 according to the levels as assumption for the GHG40/EE scenario.

5.2.2 Constant EU Bioenergy Demand Scenario

This scenario depicts a development where no further action for promoting the development of the bioenergy sector comes into play after 2020 and the focus in achieving the GHG emission reduction target is shifted from the bioenergy sector to the other renewable energy sources. This in turns leads to a reduced pace of development in the bioenergy sector, keeping it stable at 2020 levels. This is based on the assumption that the private sector may prove unwilling to roll back the established conversion capacities, but also unwilling to invest further into the development of the sector. The scenario also assumes that no further policies, regulatory frameworks, legislations or targets are introduced related to the LULUCF sector.

These developments are expected to reduce the pressure on biomass production and to increase the amount of biomass available for material production. In short, the scenario will show the implication of lower bioenergy production levels for the EU in comparison to the baseline scenario

For the RoW, the scenario assumes the same overall targets and policy assumptions as for the baseline scenario. The same bioenergy demand for RoW will be assumed as for the baseline scenario.

Main underlying assumptions

The same assumptions as for the baseline scenario apply for all aspects as stated earlier for the baseline scenario (GDP projections, global population growth, etc.), except for:

- The demand for bioenergy in EU28 evolves until 2020 in accordance with assumptions for the GHG40/EE scenario in the 2014 IA study.
- From 2020 onward, demand for biomass for heat and electricity remains constant in EU28 and does not change over time. Sources and types of biomass used for energy purposes are allowed to change over time in relation to changes in prices and availabilities. Demand for all other commodities evolves over time according to GDP and population growth as expressed for the baseline scenario.
- Demand for first and second generation biofuel within EU28 develop all the way until 2050 according to the levels of the GHG40/EE scenario. This is assumed to single out the effect of biomass utilization of biomass for heat and electricity.

5.2.3 Increased RoW Bioenergy Demand Scenario

This scenario depicts a development wherein joint global efforts are taken to reduce GHG emissions, thereby enhancing the development of the bioenergy sector for the RoW and EU. The scenario assumes higher targets for EU and RoW in terms of GHG emission reduction in comparison to the baseline scenario. This in turn is expected to lead to globally increasing demand for biomass for energy purposes and globally increasing pressure to produce biomass resources. In short, the scenario will show the implication of higher bioenergy targets for the EU and RoW in comparison to the baseline scenario.

For EU28, the scenario is based on the same overall targets and policy assumptions as the GHG40/EE scenario in the 2014 IA report. The same assumptions for EU28 apply as for the EU Emission Reduction Scenario. Most importantly, the same bioenergy demand level as for the GHG40/EE scenario will be applied.

For RoW, the scenario will be based on an 2014 updated version of the Global Action Scenario from the 2011 IA report "A Roadmap for moving to a competitive low carbon economy in 2050" (Commission, 2011), hereafter referred to as the "2011 IA report". This scenario reflect that joint international actions are taken to reduce global emissions and where non-EU regions put into play actions that leads to further GHG emission reduction than that as assumed for the baseline scenario. This scenario is currently under construction for DG CLIMA both in term of underlying policy actions and analysis of their ensuing implications. Assumptions for the scenario and final bioenergy demand will be described in detail in the final Task 3 deliverable. For RoW, the bioenergy demand will be the same as for the updated version of the Global Action Scenario.

Main underlying assumptions

The same assumptions as for the baseline scenario apply for all aspects as stated earlier for the baseline scenario (GDP projections, global population growth, etc.), except for:

- The bioenergy demand in EU28 evolves throughout the projection period in accordance with levels evaluated as for the GHG40/EE scenario.

- Demand for first and second generation biofuel within EU28 develop all the way until 2050 according to the levels as assumption for the GHG40/EE scenario.
- Bioenergy demand in RoW evolves until 2050 in accordance to updated estimations by POLES as for the Global Action Scenario.

5.2.4 Increased EU Biomass Import Scenario

This scenario depicts a development where more stringent GHG emission abatement targets for EU come into play, but where less biomass of EU origin is used in EU for bioenergy in EU. The scenario represents a situation where trade barriers are lifted and/or more effective nature/forest policies comes into play for EU, therefore leading to increased biomass import to EU to provide feedstock for the bioenergy sector. This is in turn expected to lower the pressure on European forests and agricultural land to produce biomass dedicated to the bioenergy sector. In short, the scenario will show the implication of increasing biomass import for the EU from RoW in comparison to the baseline scenario.

For EU28, the increase in imports is specifically focused on imports from RoW but does not scrutinize the non-EU country from which these imports come. However, specific regions and zones (with high biodiversity, high ecological values, high carbon stocks e.g.) can be excluded from imports. Except for its increased level of biomass import into EU28, the scenario is based on the same overall target as for the GHG40/EE scenario. The same bioenergy demand levels as for the GHG40/EE scenario will be assumed for EU28 RES development over time in the EU is assumed to be the same as assumed for the GHG40/EE scenario.

For RoW, the scenario assumes the same overall targets as for the baseline scenario.

Main underlying assumptions

The same assumptions as for the baseline scenario apply for all aspects as stated earlier for the baseline scenario (GDP projections, global population growth, etc.), except for:

- The bioenergy demand in EU28 evolves throughout the projection period in accordance with levels evaluated as for the GHG40/EE scenario. This implies that demand for biomass for energy is higher than the level assumed for the baseline scenario.
- Demand for first and second generation biofuels within EU28 develops through 2050 according to the levels as assumption for the GHG40/EE scenario.
- Increased import of biomass to the EU is represented in the model through released trade policy
- All final trade of biomass will be estimated endogenously within the GLOBIOM modelling framework.

5.3 Analysis of the central modeling assumptions

After constructing the scenarios, the central modelling assumptions that are expected to have the most significant implications for the results will be further scrutinized to assess the effects of changing assumptions in the modelling outcome. The assumptions that will be analyzed are elaborated in Table 3. Each assumption and its related impacts on the model parameters will be analyzed individually to isolate their specific implications. The results will give an indication of how sensitive the scenario results are to assumptions made within the model.

The focus of the analysis is especially on the policy scenario parameters that were identified in the data and literature reviews to potentially have a major effect on the development of land use sectors, forest industries, and bioenergy sector. Furthermore, special attention is given to parameters whose future development is highly uncertain.

Table 3. Parameters of the central model assumptions that will be analyzed further

		Description of the analysis
Comparison point	EU Emission Reduction Scenario	This policy scenario depicts increased demand for bioenergy, and is chosen as a comparison point because it forms the basis even for the other policy scenarios
Policy scenario parameters for detailed analysis	Linearity of EU bioenergy demand	Investigates if increased or decreased bioenergy demand in the EU has a linear impact on the outcome.
	Biomass feedstock availability	Evaluates how increased or decreased availability of different biomass feedstock impacts the scenario outcome
	Energy crops vs. wood	Evaluates the impact of replacing some energy crops with solid wood, and vice versa, as a bioenergy feedstock
	Pulp and paper sector in the EU	Investigates the effects of demand changes for pulp and paper commodities
	Biomaterials in the EU	Investigates the impacts of increasing new biomaterial production. Three different levels will be discussed: current trend, moderate increase and major increase
	Cascading use of biomass	Evaluates the impacts of different levels of cascading use of biomass: first, by comparing the policy scenarios using cascade factors to quantify cascading, and then, by simulating two additional scenarios aiming to increase cascading use

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