BIOMASS FUTURES

Biomass role in achieving the Climate Change & Renewables EU policy targets. Demand and Supply dynamics under the perspective of stakeholders . **IEE 08 653 SI2. 529 241**

Non-technical introduction to the Biomass Futures modelling framework

Biomass Futures Policy Briefings

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Contents

Preface

This publication is part of the BIOMASS FUTURES project (Biomass role in achieving the Climate Change & Renewables EU policy targets. Demand and Supply dynamics under the perspective of stakeholders - IEE 08 653 SI2. 529 241, www.biomassfutures.eu) funded by the European Union's Intelligent Energy Programme. It forms part of a series of policy briefings prepared under Work Package 6 of the Biomass Futures project ('Support Policy Makers'), deliverable D6.4. The policy briefings are intended to translate the results generated within Biomass Futures to a wider group of stakeholders, most notably policy makers at EU and Member State level.

The work of all project partners in further developing their respective models for the purposes of Biomass Futures is recognised.

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1 Introduction

The Biomass Futures project assesses the role of bioenergy in meeting Europe's renewable energy targets as spelled out in the Renewable Energy Directive (RED)[1]. It does so by conducting sectoral market analyses, estimating the availability of biomass for the energy sector and by modelling the demand and supply of bioenergy within the energy system. These insights will play an important role given the anticipated strong contribution of bioenergy to meeting the EU's renewable energy targets. According to analyses of the Member States' National Renewable Energy Action Plans (NREAPs), biomass will make up 19 per cent of total renewable electricity in the year 2020, 78 per cent of total renewable heating and cooling in 2020 and 89 per cent of total renewable energy in transport. Altogether, bioenergy is expected to make up over 50 per cent of total renewable energy use[2]. Underpinning the analysis of bioenergy supply in the context of renewable energy demand is the identification of sustainability criteria for all forms of bioenergy going beyond the existing criteria of the Renewable Energy Directive for biofuels and bioliquids. Where feasible, sustainability constraints are included in the quantitative analyses.

Various methodological approaches are used within the Biomass Futures project and a range of models are employed in order to capture the dynamics and interactions in energy and agricultural markets including trade relations between the EU and third countries. This briefing gives a non-technical introduction to the Biomass Futures modelling framework. A parallel Biomass Futures briefing introduces the three different scenarios that will be run by the modelling framework[3].

2 Framing the analysis: Stakeholder engagement and scenario definition

The engagement of different groups of stakeholders is an integral part of the Biomass Futures project. In the context of the development of models, scenarios, potential estimates and sustainability criteria this implies consulting stakeholders from the policy arena, civil society, industry and researchers working on similar projects so as to validate necessary assumptions and initial findings of our work. The stakeholder consultation along with extensive internal discussions among all Biomass Futures partners have fed into the definition of three main scenarios that are run by the here presented modelling framework. These scenarios include:

1) a *reference scenario* (based on renewable energy demand as derived from the National Renewable Energy Action Plans and existing sustainability criteria for biofuels/bioliquids),

2) a s*ustainability scenario* (with sustainability criteria strengthened and extended to solid and gaseous biomass) and

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[1] Directive 2009/28/EC of the European Parliament and of the Council of 5 June 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. The RED requires the EU to generate 20 per cent of energy from renewable sources by 2020, and each Member State to achieve a 10 per cent share of renewable energy sources in the transport sector.

[2] These figures are taken from http://www.ecn.nl/docs/library/report/2010/e10069_summary.pdf. Another valuable Biomass Futures report based on the 23 NREAPs available at the time of drafting is Atanasiu (2010), The role of bioenergy in the National Renewable Energy Action Plans: a first identification of issues and uncertainties, (http://www.biomassfutures.eu/work_packages/WP8%20Dissemination/D8.4%20bioenergy_in_NREAPs-final_08_12_2010.pdf), which focuses on analysing the bioenergy information contained in the NREAPs.

[3] Available soon on http://www.biomassfutures.eu/work_packages/work_packages.html.

3) a *'biomass max' scenario* (that will be finalised once the results from the first two scenarios are fully validated).

The scenarios are described in detail in an accompanying policy briefing[4].

The scenarios are implemented by changing the scenario characteristic assumptions on sustainability criteria and other parameters within the Biomass Futures modelling framework that is described in Figure 1 and in the following sections. The schematic overview in figure 1 together with the legend explain the integration of demand for and supply of bioenergy and the interaction between models and hence between the different work packages (WPs) of the project. The following sections explain the various linkages illustrated in Figure 1 in more detail.

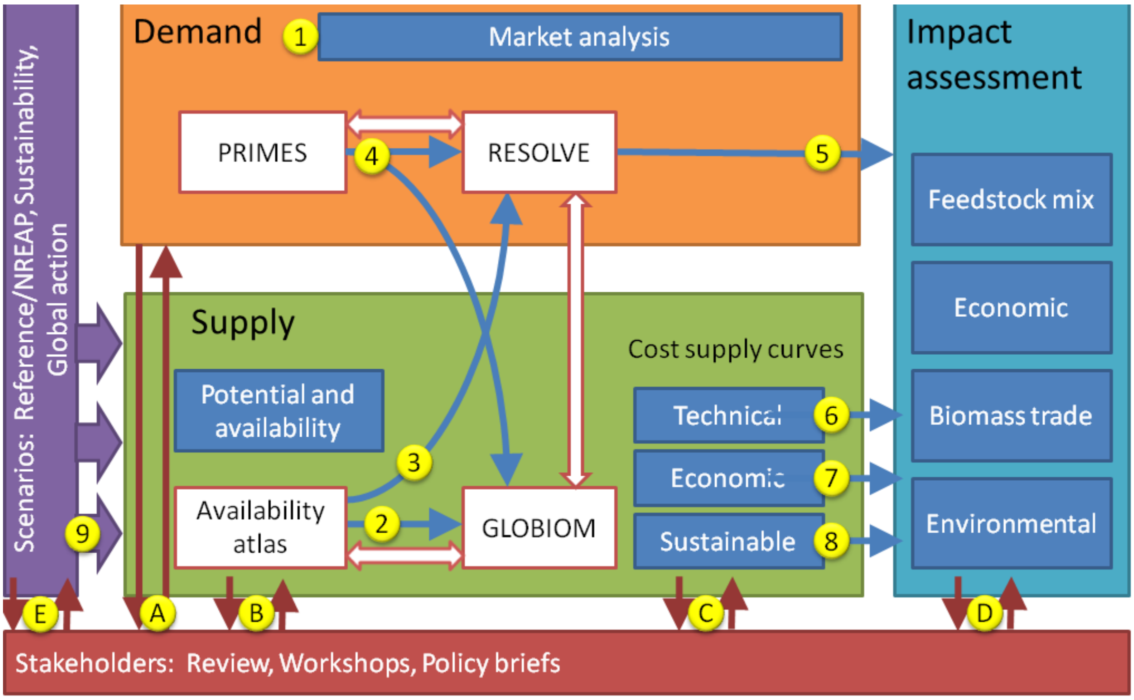

Figure 1: Flow chart of Biomass Futures modelling framework. *Legend to the steps of the analysis*: 1.Market and demand analysis (WP2), 2.Availability maps and technical potential (WP3.4), 3.Cost supply curves for biomass feedstocks (WP3.4), 4.Demand projection by feedstock (WP 5), 5.Assessment of technical impacts of technology mix (WP 5), 6.Assessment of technical potential (WP 3.4), 7.Assessment of economic potential (WP 3.5), 8.Assessment of sustainable potential (WP 4, 3.5). 9.Scenarios of bioenergy use (WP 5) are applied to the entire modelling framework, Exchange with stakeholders on model assumptions in workshops (WP6, 7) includes the topics Demand (A), Availability (B), Sustainability (C), Supply (D), and Scenarios (E). *The broad white arrows between the models symbolise the harmonisation of model assumptions. Harmonisation includes exchange of information on conversion factors, energy contents, consistent mapping of feedstock and technology categories as well as assumptions relating to trade flows*.[5]

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[4] Ibid.

[5] Taken from Böttcher, Elbersen and Alexopoulou and updated (2011, p5).

3 Biomass demand

The main elements of the Biomass Futures demand side related work are 1) a qualitative demand analysis and 2) the use of the energy sector models RESolve and PRIMES.

The qualitative market analysis consists of identifying the most promising market segments for bioenergy in the heat, electricity (including CHP) and transport sectors along with the key factors influencing future penetration. The identification of key factors and market segments is undertaken by a combination of literature review and consultation of over 40 stakeholders from the respective industries and forms part of WP 2. The conclusions derived from the qualitative analysis of promising market segments are used to validate the technology mix as predicted by the modelling outcomes and hence function as a kind of internal review process.

EU bioenergy demand feeds into the WPs modelling biomass supply as an input to the land use model GLOBIOM which incorporates the bioenergy demand projections of the PRIMES biomass model. Consistency between GLOBIOM and PRIMES is facilitated by using a common base year (2000) along with common exogenous macroeconomic drivers, ie population and GDP growth. Bioenergy demand outside of the EU is taken from the POLES model, a global energy model[6]. While we will vary biomass supply by changing sustainability criteria to be met across scenarios, EU bioenergy demand is assumed to be the same for at least the reference and sustainability scenarios.

4 Bioenergy supply and sustainability

Underpinning the supply side of bioenergy markets is a detailed analysis of biomass potentials that has been performed as part of WP 3. A 'Biomass Potential Atlas' (Elbersen *et al*, 2011) has been produced that takes into account various bioenergy feedstocks, including main products, by-products and residues from the agricultural and forestry sectors as well as biomass waste[7]. This analysis is done at NUTS 2 level where data are available and otherwise at national level covering the EU27 and produces biomass availability estimates in table and map format for all bioenergy feedstocks considered.

Regarding sustainability, two alternative packages of criteria are applied: 1) The present RED criteria applied to feedstock for biofuels only; 2) Stricter sustainability criteria applied to all bioenergy feedstock, including solid and gaseous biomass (see Table 1). Furthermore, competing uses of agricultural residues are excluded from the final potential as an energy source. The potential maps are combined with information on feedstock costs to yield cost-supply curves.

[6] The POLES scenarios used in Biomass Futures are described in the Impact Assessment of the Roadmap for moving to a low-carbon economy in 2050, http://ec.europa.eu/clima/policies/roadmap/documentation_en.htm.

[7] Biomass waste includes primary (such as prunings), secondary (such as solid and wet agricultural residues) and tertiary (including biodegradable/organic wastes from households and industry) residues and waste biomass in the form of sewage sludge.

Table 1: Sustainability criteria applied in reference and sustainability scenarios applied to estimate the EU wide 2020 biomass potential

	GHG mitigation	**Other constraints**
Reference scenario	Mitigation target for biofuels of 50% as compared to fossil alternatives, excluding compensation of iLUC[8] related emissions. No mitigation target set for bioelectricity and heat.	No use of biomass for biofuels cropped on biodiverse land or land with high carbon stock.
Sustainability scenario	Mitigation target for bioenergy (fuels, heat and electricity) of 70% as compared to fossil alternative, including a compensation of iLUC related emissions.	No use of biomass cropped on biodiverse land or land with high carbon stock. For forests strict biomass harvesting guidelines apply.

In order to implement the GHG mitigation criteria in the final potential an estimate of the GHG payback time of 20 years is chosen (in line with the RED) and the mitigation ability of different bioenergy pathways including iLUC effects was calculated. Major studies estimating iLUC effects were consulted and an average iLUC emissions factor was calculated to estimate the GHG mitigation ability per bioenergy pathway[9].

To calculate the full life-cycle emissions and mitigations a distinction was made between the land based up-stream part of bioenergy processes (eg feedstock cultivation and harvesting) and the downstream part. The land based up-stream emissions were calculated by the Miterra-Europe model (Velthof, 2009) for every bioenergy crop in every EU region (Nuts 2). The emissions of the downstream part of the bioenergy pathways and of the fossil comparators are based on GEMIS, which refer to full life-cycle emissions. GEMIS 10 is a life-cycle analysis program and database for energy, material, and transport systems[10].

In the reference scenario the RED criteria are followed which implies that only for biofuel production the loss of highly biodiverse areas or areas with a high carbon stock should be prevented. This means that tropical rain forests, savannahs, permanent semi-natural grasslands, protected nature areas (eg Natura 2000 areas) and highly biodiverse agricultural land (eg High Nature Value farmlands), could still potentially be used for bioelectricity and heat production. This is changed in the sustainability scenario: For the estimation of the potentials at EU level both the Natura 2000 (farmland) and the High Nature Value farmland (Paracchini *et al*, 2008) areas were regarded as good proxies for highly biodiverse areas and agricultural areas of high carbon stock, and were therefore taken as no-go areas for biomass

[8] Emissions related to indirect land use changes (iLUC).

[9] The estimation of this average GHG iLUC factor was done as part of an EEA study executed by the European Topic Centres on Climate Change (ETC-ACC) and Land use (ETC-SIA). This study is expected to be published by the end of 2011.

[10] GEMIS includes the total life-cycle in its calculation of impacts - ie fuel delivery, materials used for construction, waste treatment, transports/auxiliaries and includes by-product allocation (based on energy value). The GEMIS database offers information on 1) fossil fuels, renewables, nuclear, biomass and hydrogen, 2) processes for electricity and heat, 3) materials and 4) transports. A further description of GEMIS and the calculated GHG emissions is given in EEA (2008) in Annex 2 and 3.

cropping. Outside the EU27 more coarse information based on WCMC (Kapos *et al*, 2008) data is used to identify hot spots of biodiversity.

Stricter sustainability criteria were also applied to forests in the sustainability scenario. We follow the assumptions applied in the 'EU Wood' project's low mobilisation scenario (Mantau *et al*, 2010a/b). These assumptions imply that application of fertilizer after logging residue and stump extraction is not permitted, limited intensification in forest exploitation can be expected and part of the forests are set aside and thus taken out of commercial exploitation to protect biodiversity.

5 Impact assessment of biomass use

Supply maps, technical potential and cost supply curves are brought together with the demand analysis in two different ways that are applied in parallel: a) a detailed integrated assessment of biomass use based on economic and environmental parameters including an assessment of trade and leakage impacts, and b) a detailed feedstock and technology allocation analysis involving the RESolve model.

Following the above described scenarios the analysis provides insights into likely future feedstock mixes, future biomass trade patterns as well as environmental (such as mitigation of greenhouse gas emissions) and economic effects (including changes in food price indices and societal costs of meeting EU renewable energy targets).

5.1 Integrated assessment

Information from the availability assessment on the technical biomass potential is used as input in the GLOBIOM model, a global recursive dynamic partial equilibrium model integrating the agricultural, bioenergy and forestry sectors[11]. Feeding this information into GLOBIOM allows for modelling competition between feedstocks. By doing so the technical potential is transformed into an economic potential. Additionally, the model accounts for a wider scope of sustainability issues, addressing (direct and indirect) land use change, environmental variables (water, nitrogen, GHG emissions), and economic effects (eg food prices). GLOBIOM includes additional biodiversity constraints on highly biodiverse land outside the EU based on WCMC information (Kapos *et al*, 2008). Besides general parameters which limit land use change (no grassland conversion and deforestation in EU27 etc), conversion of cropland and 'other natural vegetation' to short rotation tree plantations is restricted. Through sensitivity analyses by changing assumptions on biofuel trade and other mitigation policies such as avoiding deforestation, GLOBIOM results are used to investigate competition between major land-based sectors (bioenergy, agriculture and forestry), potential leakage effects through land use and land use change as well as effects on food security and GHG emissions in order to give policy advice taking into acount such global impacts.

5.2 Economic assessment

RESolve[12] as the 'biomass allocation model' in the modelling framework takes biomass supply as exogenously given based on the cost-supply information received from WP 3 described above. The

[11] The GLOBIOM model is described by another Biomass Futures policy briefing, 'Modelling biomass supply options with GLOBIOM: A non-technical introduction', available soon on http://www.biomassfutures.eu/work_packages/work_packages.html.

[12] The RESolve model has been extended for the purpose of Biomass Futures by merging several sub-models. RESolve serves as a 'biomass allocation model' determining the amount of bioenergy feedstocks going to the different sectors 'Renewable heat', 'Renewable electricity' and 'Transport'. There is a sub-model for each of these

different sub-models of RESolve calculate biomass demand for the three energy sectors heat, transport and electricity based on *inter alia* capital and operating costs, policy targets and renewable energy support mechanisms and other assumptions including on consumer behaviour. This includes taking into account the demand for other renewable energy sources based on their respective cost structures and potentials. International linkages are taken into account as the RESolve-T framework allows for trade of feedstocks and final products. RESolve then allocates biomass sources to the three sectors by combining their respective demand for biomass and calculating feedstock prices per country, technology and year. The feedstock prices correspond to the marginal feedstock option from the cost supply curves, ie the most expensive feedstock option used so as to have sufficient supply to meet demand. The resulting feedstock prices and available biomass feedstock potentials are fed back to the heat and electricity sub-models, which in turn calculate a new demand distribution over the different technologies, taking into account the other renewable electricity and heat sources and technologies. This iteration continues until equilibrium in biomass demand, potentials and prices in the three market segments is reached. It is possible that existing demand for bioenergy will exceed all available supply as determined in WP 3. The subsequent market response of increasing feedstock prices is mimicked in RESolve by including a 'price adder' that would reduce overall biomass demand until demand and supply match (van Stralen *et al*, 2010).

RESolve makes use of information from the PRIMES model in the following way: In the scenario analysis energy demand and fossil fuel prices from the PRIMES reference scenario are used. While the 2020 bioenergy demand is derived from the NREAPs, the 2030 demand is calculated by applying the relative increase between 2020 and 2030 in the PRIMES scenario to the NREAP figures.

6 Next steps

The application of the here described modelling framework to the three different scenarios mentioned above is on-going. Results will be published as soon as they become available on the Biomass Futures website.

The output of the modelling will be useful for policy makers across the EU for designing suitable renewable energy/bioenergy support policies reflecting economic realities and environmental impacts.

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three sectors, whereby RESolve-T, the transport model, provides the overarching structure and actually integrates the sub-models for heat and electricity as two additional demand segments. RESolve-T is a cost minimisation model, whereas the sub-models for heat and electricity are simulation models.

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