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**

Biomass Futures scenario set-up and the methodology for analysis

Deliverable D5.2

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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.

Within WP 5 of the BIOMASS FUTURES project three scenarios are developed to illustrate the alternative bioenergy futures for Europe. Each scenario includes a comprehensive set of measures, which reflect the announced policy ambitions- the National Renewable Energy Action Plans, and the sustainability criteria with a varying degree. This report presents these scenarios.

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Introduction

Biomass is a key renewable energy source, representing more than 65% of the total renewable energy consumption in Europe. The National Renewable Energy Action Plans (NREAPs) suggest that the energy production from biomass will increase 1,5 folds in 2020, when compared to 2010.

One of the most important arguments behind bioenergy use is that it can avoid greenhouse gas (GHG) emissions. On the other hand, there is an on going debate concerning the environmental and socioeconomic consequences of biomass use for energy purposes. Renewable Energy Directive includes sustainability criteria for biofuels to tackle these concerns. However, it is questionable to what degree the NREAPs recognize the implications of sustainability criteria on supply and demand.

In the framework of the Biomass Futures project, it is deemed useful to analyse scenarios and sensitivity cases to address the question "***how*** and ***to what extent*** biomass can contribute to a sustainable energy future ***without*** causing negative impacts". The renewable energy and the GHG emission targets the European Union is committed to are the main objectives of the scenario formulation. The key EU policy targets that are relevant to our scenarios are listed below.

- The renewable energy targets (specific renewable energy targets for each Member State to ensure an EU 20% renewable energy share in the overall final energy consumption by 2020),
- The road transportation target (10% of the final energy consumption from road transport to be met from renewable resources),
- The GHG emission targets (20% GHG emission reduction target by 2020).

In this deliverable we present the bioenergy scenarios that provide a framework for exploring sustainable and realistic bioenergy futures in the EU27 for 2020 and 2030.

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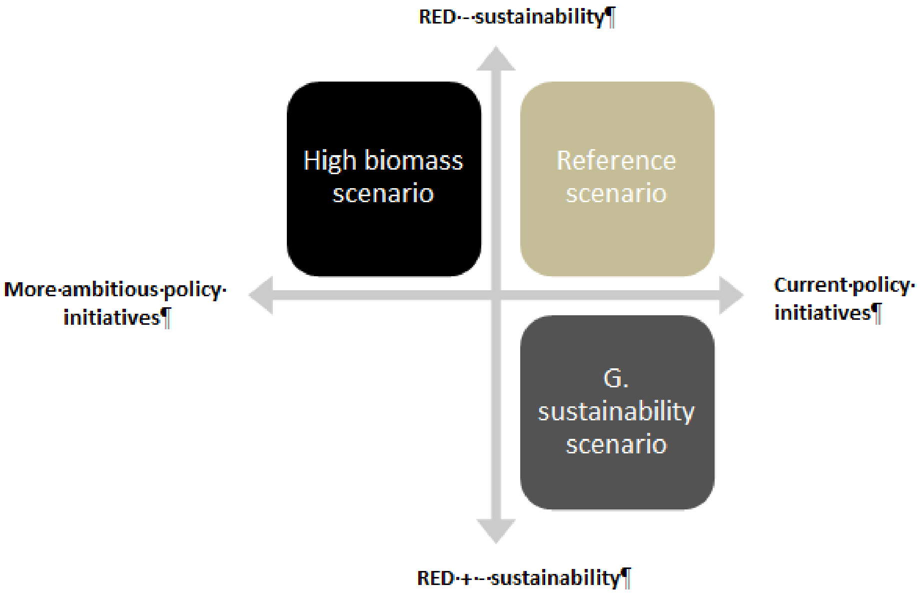
Definition of the Biomass Futures scenarios

The Biomass Futures scenarios are designed according to two important aspects; sustainability concerns around the production of biomass resources and use, and the policy ambitions of the Member States. Figure 1 illustrates the scenarios constructed to carry out the bioenergy modelling of the Biomass Futures project.

Figure 1: Illustration of the scenarios



2.1 Sustainability dimension

Sustainability issues with regards to biofuels have been heavily debated for many years and the EU policy directive recognized the need to demonstrate the sustainability of biomass for energy. The EU Renewable Energy Directive adopted in 2009 (EC, 2009) sets up sustainability criteria for biofuels for transport. The Commission also recommends that Member States that either have, or who introduce national sustainability schemes for solid and gaseous biomass used in electricity and heating and cooling, ensure that these in almost all respects are the same as those laid down in the Renewable Energy Directive.

The biofuels must be sustainable in order to be counted towards the mandatory renewable energy targets and in order to be eligible for 'financial support'. Article 17 of the Directive defines two sets of sustainability criteria, which must be fulfilled cumulatively.

(i) greenhouse gas (GHG) emission savings and,
(ii) land-use requirements.

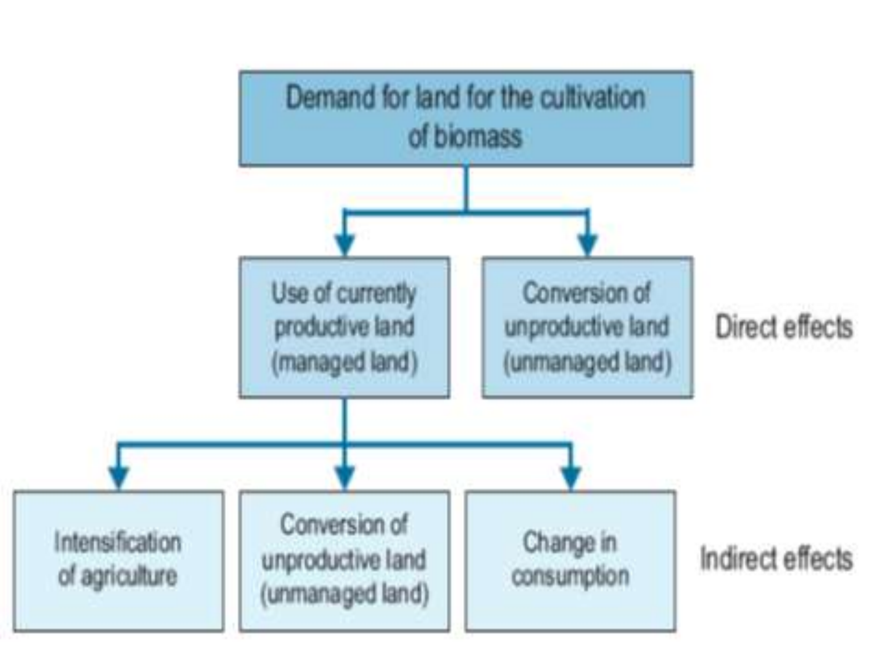
GHG emission savings
In comparison to the use of fossil fuels in the transport sector biofuels shall have a minimum GHG emission saving rate of 35% . However, there is a grace period for installations that were in operation before 23 January 2008. From 1 January 2017, the greenhouse gas emission saving from the use of biofuels and bioliquids shall be at least 50 % and from 1 January 2018 the threshold will increase to 60%, but only for installations that started operating in 2017 or later.

While the GHG emission calculation methodology includes all stages of biofuel production (extraction and cultivation of raw materials, land-use change, processing and transport and distribution) the land-use requirements do not consider so called indirect land-use change (iLUC) effects. However, the European Commission is committed by the Renewable Energy Directive to review the potential impact of GHG emissions from iLUC and, if appropriate, develop a methodology to address iLUC emissions. A public consultation was launched in 2009 on potential policy approaches to iLUC.

BOX 1 Definition of indirect land use change (iLUC)

iLUC is generated by the elevated demand for agricultural commodities as a consequence of biofuel consumption. The cultivation of agricultural commodities for biofuels require land. Currently productive land can be used to produce the extra demand. However, unproductive land such as nature areas can also be used to produce energy crops for biofuels. The land use change from the current use into use for biofuel crops is called direct land use change and the effects that arise from that direct land use change are called direct land use change effects. With the option of cultivating currently productive land, the original production would have to be realised elsewhere either through the conversion of land into agricultural use or through intensification of agriculture to increase yields. This 'displacement' of agricultural production is called the iLUC

effect (see below Figure). When biofuels are grown on existing arable land, which will often be the case, iLUC can occur elsewhere, either in the same country or in other parts of the world. This is because current demand for food and animal feed may well remain unchanged and cannot be assumed to fall. As a consequence pre-existing agricultural production can be displaced into new areas. This displacement will cause some new land to be brought into arable production, possibly far from the area in which the biofuel feedstock is being grown, potentially impacting grasslands, forests or other natural habitats.



Source: PBL (2011)

The European Commission is considering four policy options for addressing the iLUC impacts of biofuels under the RED and FQD:

- Option 1. Take no action for the time being, while continuing to monitor
- Option 2. Raise the minimum greenhouse gas saving threshold for biofuels
- Option 3.Introduce additional sustainability requirements on certain categories of biofuels
- Option 4. Attribute a quantity of greenhouse gas emissions to biofuels reflecting the estimated iLUC impact

Land- use requirements

According to the Article 17 (3) of the Directive biofuels shall not be made from raw material obtained from land with high biodiversity value, which includes primary forest and other wooded land, areas designated for nature protection or the protection of rare, threatened or endangered ecosystems or species, and highly biodiverse grasslands. According to Article 17 (4) biofuels shall not be made from raw material obtained from land with high carbon stock, namely wetlands, continuously forested areas, or land spanning more than one. hectare with a certain minimum canopy cover. Article 17(5) indicates that biofuels shall not be made from raw material obtained from peatland, unless evidence is provided that the cultivation and harvesting of that raw material does not involve drainage of previously undrained soil.

The implications of sustainability criteria on the supply of biomass and the associated costs are however unknown.

2.2 EU Member States policy ambitions

NREAPs indicate that by 2020 production of energy from biomass sources will increase around 60% compared to 2010, and contribute to approximately 12% of the final energy demand in 2020. While biomass electricity is expected to double renewable heating and cooling from biomass sources is assumed to increase approximately 60% compared to 2010 and contribute 81% of the renewable heating and cooling by 2020 (ECN, 2011). Table 1 presents the bioenergy targets set by the Member States.

Table 1: Member States NREAP bioenergy targets in 2020

Country	AT	BE	BG	CY	CZ	DE	DK
Biomass electricity (GWh)	5	11	871	143	6	49	9
Biomass heat (ktoe)	4	2	1	30	3	11	3
Country	EE	EL	ES	FI	FR	HU	IE
Biomass electricity (GWh)	354	1	10	13	17	3	1
Biomass heat (ktoe)	607	1	5	7	16	1	486
Country	IT	LT	LU	LV	MT	NL	PL
Biomass electricity (GWh)	19	1	334	1	136	17	14
Biomass heat (ktoe)	6	1	83	1	2	938	5
Country	PT	RO	SE	SI	SK	UK	EU27
Biomass electricity (GWh)	4	3	17	676	2	26	232
Biomass heat (ktoe)	2	4	9	526	690	4	90

In their NREAPs Member States also present how they plan to support energy production from biomass resources. The policy support measures consist of varying combinations of feed-in tariff, feed-in premium, quota obligation, investment grants, tax incentives and other fiscal incentives. Table 2 and Table 3 present the type of policy measure each Member State applies to support bio-electricity and heat.

Table 2: Bio-electricity policy measure per Member States

	AT	BE	BG	CY	CZ	DE	DK	EE	FI	FR	EL	HU	IE	IT	LV
Feed in tariff	■	■	■	■	■	■		■		■	■	■	■	■	■
Feed in premium							■	■			■				
Quota obligation		■												■	
Investment grants		■		■	■				■			■			■
Tax incentives		■							■		■				
Fiscal incentives			■			■		■							

	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE	UK
Feed in tariff	■	■	■			■		■	■	■		■
Feed in premium				■					■	■		
Quota obligation					■		■				■	■
Investment grants	■	■	■									
Tax incentives				■	■			■		■	■	■
Fiscal incentives			■	■	■							

Table 3: Bio-heat policy measures per Member States

	AT	BE	BG	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT
Feed in tariff/feed in premium									■					
Quota obligation										Building obligations				Building obligation
Investment grants	■	■		■	■			■		■		■	■	
Tax incentives	■					■		■	■		■			
Fiscal incentives (soft loans)		■	■				■		■	■				

	LV	LT	LX	MT	NL	PL	PT	RO	SK	SI	ES	SE	UK	
Feed in tariff/feed in premium														
Quota obligation														
Investment grants														
Tax incentives														
Fiscal incentives														

2.3 Reference scenario: Re-analysis of bioenergy contributions to national renewable energy targets

The starting point of this scenario is that while the implications of sustainability criteria on biomass supply and the associated costs are unknown there is a significant demand for these resources driven by the current policies. In this scenario we aim at re-analysing the contribution of bioenergy in reaching the national renewable energy targets. In their NREAPs Member States illustrated the total contributions expected from bioenergy to electricity, heating and cooling, and transport up to 2020. However it was uncertain to what degree they incorporated the sustainability criteria for biofuels into their estimates. Therefore, the objective of this scenario is to provide a refined basis for assessing sustainable bioenergy supply based energy demand per Member States.

As this scenario looks into the current policy process sustainability criteria is only applicable to biofuels for transport sector. An important dilemma within the sustainability criteria-the indirect land use change issue- is not tackled. The main reason behind is that EC has not yet recommended a specific methodology to deal with indirect land use change. Table 4 presents the sustainability criteria considered in this scenario.

Reference scenario presents a bioenergy future, where the implications of sustainability criteria for biofuels and their impacts on electricity and heat sector are illustrated. It not only presents the utilisation of biomass resources but also the respective costs and the greenhouse gas emissions. Moreover this scenario analysis the policy measures Member States proposed in their NREAPs in terms of whether they are ambitious enough to reach the targets set or not.

Table 4: Sustainability criteria applied to EU domestic biomass potential (REF)

	2020	2030
GHG mitigation criteria	Applied only to biofuels and bioliquids consumed in the EU. Biomass supply is calculated using a GHG mitigation of 50% as compared to fossil fuels. Compensation for iLUC related GHG emissions are excluded	Applied only to biofuels and bioliquids consumed in EU Biomass supply is calculated using a GHG mitigation of 50% as compared to fossil fuels. Compensation for iLUC related GHG emissions are excluded

Other sustainability constraints	Limitations on the use of biomass from biodiverse land or land with high carbon stock are applied to biofuels and bioliquids for transport.	Limitations on the use of biomass from biodiverse land or land with high carbon stock are applied to biofuels and bioliquids for transport.

Policy context

European Commission requested Member States to submit a reports on progress in the promotion and use of energy from renewable sources by 31 December 2011, and every two years thereafter. This scenario is expected to be of immediate relevance to policy makers for assessing these reports and providing direct input to Member States to update their NREAP templates. Besides, the results can be used for benchmarking the available info with a coherent harmonised approach of estimating biomass role in the different markets (heat, electricity & transport) for each Member State .

2.4 Sustainability scenario

In the reference scenario there is a risk of pushing the less sustainable and cheaper resources to electricity and heat sector, and ending up increased unsustainable biomass utilisation. Therefore, this storyline considers a more sustainable energy system in which binding biomass sustainability criteria cover all energy sectors (electricity, heating and cooling, and transport sectors) and biofuel imports.
Different than the reference, this storyline foresees higher GHG mitigation targets-increasing to 80% by 2030. Furthermore, it presents a future in which the indirect land use change implications of the biofuels are to some degree compensated through crop specific iLUC factors.
Crop specific iLUC factors are derived from the EEA/ETC-SIA study (Elbersen, et al., 2012) and introduced in BOX 2. Table 5 introduces the sustainability criteria applied in this scenario.

BOX 2 iLUC factors applied in this study

In the EEA/ETC-SIA-ACC study ((Elbertsen, 2012)) an inventory was made of the following studies:
1. IFPRI study: ‘Global trade and environmental impact study of the EU biofuels mandate’ (Al-Riffai et al., 2010).
2. ADEME study: ‘Analyses de Cycle de Vie appliquées aux biocarburants de première generation consommés en France’ (ADEME, 2010).
3. E4tech study: ‘A causal descriptive approach to modelling the GHG emissions associated with the indirect land use impacts of biofuels’ (E4tech, 2010).
4. PBL study: Identifying the indirect effects of bio-energy production (PBL, 2010a) and
a. ‘The contribution of by-products to the sustainability of biofuels’ (PBL, 2010b).
b. ‘Indirect land-use change emissions related to biofuel consumption in the EU based on historical data’ (Overmars et al., submitted).
5. CARB study: Proposed Regulation to Implement the Low Carbon Fuel Standard Volume I. Staff Report: Initial Statement of Reasons (CARB, 2009a; CARB, 2009b).
6. JRC study: Indirect Land Use Change from increased biofuels demand (JRC-IE, 2010).
7. Oeko-Institut: The ‘iLUC Factor’ as a means to hedge risks of GHG emissions from indirect land use change (OEKO, 2010).

Emission factors derived from these studies and the median from these average

values are presented below.

Type of biofuel	Minimum iLUC emission factor (g CO2eq./MJ)		Maxim iLUC emission factor (g CO2eq./MJ)		Median from average values(g CO2eq./MJ)
Biodiesel based on rapeseed from Europe	-33	80	80	800	**77**
Ethanol based on wheat from Europe	-79	79	-8	329	**73**
Ethanol based on sugar beet from Europe	13	33	65	181	**85**
Biodiesel based on palm oil from South-East Asia	-55	45	34	214	**77**
Biodiesel based on soy from Latin America	13	67	75	1380	**140**
Biodiesel based on soy from US	0	11	100	273	**65**
Ethanol based on sugar cane from Latin America	-1	48	19	95	**60**
Bioelectricity based on perennial on arable land	32	32	75	75	**56**

Table 5: Sustainability criteria applied to EU domestic biomass potential (SUS)

	2020	**2030**
GHG mitigation criteria	• Applicable to all bioenergy consumed in EU. • Biofuel/bioliquids: 70% mitigation as compared to fossil fuel (comparator EU average diesel and petrol emissions 2020). • Bioelectricity and heat: 70% mitigation as compared to fossil energy (comparator country specific depending on 2020 fossil mix) . • **Includes** compensation for iLUC related GHG emissions.	• Applicable to all bioenergy consumed in EU. • Biofuel/bioliquids: 80% mitigation as compared to fossil fuel (comparator EU average diesel and petrol emission 2030) • Bioelectricity and heat: 80% mitigation as compared to fossil energy (comparator country specific depending on 2030 fossil mix) • **Includes** compensation for iLUC related GHG emissions
Other sustainability constraints	• Applicable for all bioenergy consumed in EU. • limitations on the use of biomass from biodiverse land or land with high carbon stock.	• Applicable for all bioenergy consumed in EU. • limitations on the use of biomass from biodiverse land or land with high carbon stock.

Policy context

European Commission informed in its 2010 Communication (EC,2010) that a legislation related to the sustainability of biomass for electricity and heat sector is not necessary. However, this communication included recommendation that the Member States wishing to introduce a scheme at national level to use the sustainability criteria that are in line with the binding criteria for biofuels for transport sector. One of the main reasons behind this decision was that the binding criteria may impose substantial costs on the economic actors.

The Commission will report by 31 December 2011 on whether national schemes have sufficiently and appropriately addressed the sustainability related to the use of biomass from inside and outside the EU. Based on this it will, *inter alia*, consider if additional measures such as common sustainability criteria at EU level would be appropriate or not.

On the other hand the vast majority of the respondents (90%) to the stakeholder consultation on this topic indicated that sustainability scheme for biomass for electricity and heating purposes is needed and that an exclusive limitation to sustainability criteria for transport purposes is not reasonable. Many stakeholders called for consistency with the biofuels for transport sustainability scheme to prevent the adverse effects for biodiversity and the wider environment.

The European Commission is also expected to tackle another policy challenge- including iLUC effects of biofuels- through an Impact Assessment study , followed by a legislative proposal.

Taking all these aspects into consideration the sustainability scenario is very relevant to the current policy process. The sustainability scenario in comparison to the reference scenario will provide insights into the implications of expanding the criteria to electricity and heat sector.

2.5 High biomass scenario

While the first two scenarios aim at analysing the biomass role defined by the NREAPs this scenario focuses on stronger policy ambitions. The objective of this scenario is to analyse the role of biomass given the fact that there is quite a large amount of unutilised biomass potential in the EU. As a starting point 25 % higher targets for bioelectricity and heat (in comparison to NREAP figures) are targeted. As a next step it is assumed that the EU Member States are willing to pay the required policy costs as they will replace fossil fuel based conventional energy systems, improve their security of energy supply and at the same time combat climate change. Besides, they will benefit from increased employment opportunities .

This scenario builds on the reference scenario bioenergy potentials and applies national policy measures that are stronger than the current ones. Thus, the sustainability criteria in line with the current RED directive is only applied to biofuels for transport.

2.6 Methodology for analysis

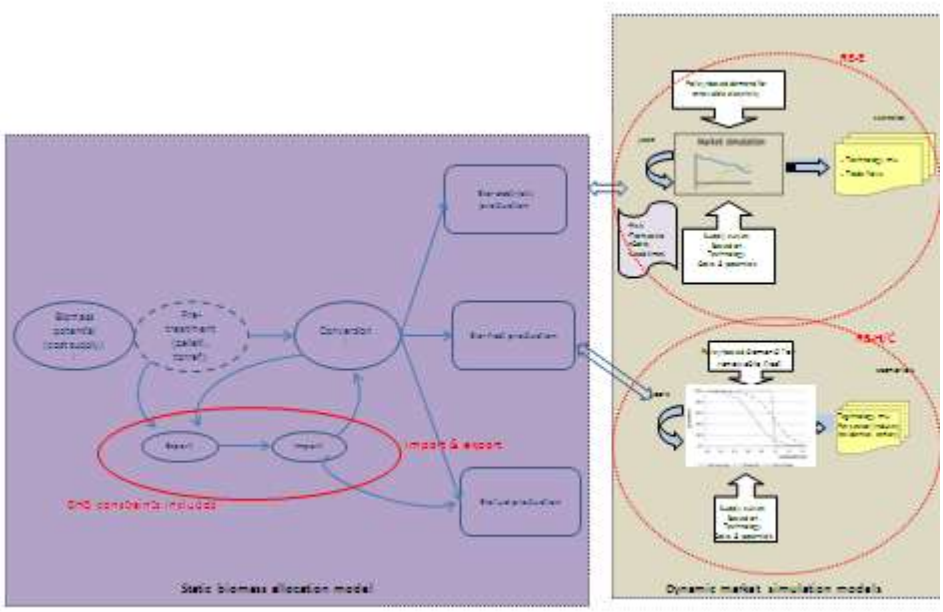
2.6.1 RESolve Models

ECN RESolve models are used to construct the scenarios briefly introduced above. RESolve models consist of sectoral models (renewable electricity(RESolve-E), heating and cooling (RESolve-H)) and a central biomass allocation model(RESolve-biomass that also includes biofuels. The biomass allocation model defines the least cost configurations of bioenergy pathways in the EU (electricity, heat and biofuels), *given potentials, technological progress and projections of demand* - in this case the bioenergy targets set by the Member States.

One of the most important features of the Biomass allocation model(RESolve-biomass) is the ability to link the national production chains allowing for international trade. By allowing trade, the future cost of bioenergy can be approached in a much more realistic way then when each country is evaluated separately. The only costs associated with international trade are transport costs (including handling). For trade between two locations, generalized distances between countries are used.

While biomass allocation model defines the least cost configurations for electricity, heat and transport sector it is not capable of tacking with the complexities of the renewable electricity and heat markets . Therefore this model is coupled with the sector models. The sector models are the market simulation models, in which development of the EU renewable electricity and heating/cooling markets are explored for each year up to 2030. Details of the models and how they interact can be found in D5.1
A simplified illustration of how the models interact is presented in Figure 2.

Figure 2: Illustration of RESolve Model Set



2.6.2 Model input data and assumptions

In order to construct the above presented scenarios an extensive amount of data have been generated and included in the models.

- For the reference and the sustainability scenario EU Member States bioenergy demands for electricity, heat and biofuels are derived from NREAPs for 2020 and increased to 2030 applying the PRIMES reference scenario 2020-2030 bioenergy increase. For the high biomass scenario these figures (bio-electricity and heat for solid biomass) are increased with 25%.

- While the PRIMES reference scenario has been applied to define the conventional fossil fuel mix as the reference for the electricity sector, the required breakdown in final end-user demand sectors for heating has been derived from the ODYSSEE database and extrapolated to NREAP heat demand .

- Policy instruments are updated in accordance with the latest available information and the NREAPs +Progress Report . While the policy measures are kept the same in the reference and the sustainability scenario stronger policy initiatives are applied to the high biomass scenario.

- EU domestic feedstock cost-supply curves calculated including the RED sustainability criteria and the RED+ criteria (the criteria are presented in Table 4 and Table 5) are derived from D3.3 Atlas of EU Biomass Potential (Elbersen et., 2012).

- Biomass and biofuel import cost-supply data are derived from D3.4, Biomass availability and supply analysis (Bottcher et al., 2011). While the biomass and biofuel potentials for import have included the limitations on the use of biomass from biodiverse land or land with high carbon stock the data did not include the GHG emission gaps foreseen in the sustainability scenario due to the technical capabilities of the GLOBIOM model. Therefore , RESolve models included the iLUC emission factors (as presented in BOX 2), and applied the GHG emission gaps through post processing. It is also assumed that 10% of the global import potential is from sustainable feedstocks.

- Life cycle GHG emission data for bioenergy pathways and the conventional energy systems are derived from the Global Emission Model for Integrated Systems (GEMIS) database.

- RESolve models included
    - the GHG emission gap of 35% that is increased to 50% from 2017 onwards. For the installations in which production started on or after 2017 the GHG emission gap of 60% for only biofuels for the reference scenario.
    - The GHG emission gap of 35% is increased to 60% from 2017 onwards. For the installations in which production started on or after 2017 the GHG emission gap of 70% is applied for the sustainability scenario.

3

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