biomasspolicies

IINAS
International Institute
for Sustainability Analysis
and Strategy

Scientific Director:
Uwe R. Fritsche uf@iinas.org

Administrative Director:
Thomas Stetz ts@iinas.org

Office:
Heidelberger Str. 129 ½
D-64285 Darmstadt, Germany
ph +49 (6151) 850-6077
fax +49 (6151) 850-6080
info@iinas.org

Scientific Advisory Board:
Joseph Alcamo, Chief Scientist, UNEP
Suani Coelho, CENBIO (BR)
Teresa Pinto Correia, ICAAM (PT)
Maria Curt, UPM (ES)
Marina Fischer-Kowalski, IFF (AT)
Bundit Fungtammasan, JGSEE-KMUTT (TH)
Alan Hecht, EPA (US)
Eva Heiskanen, NCRC (FI)
Alois Heißenhuber, TU München (DE)
Edgar Hertwich, NTNU (NO)
Jorge Hilbert, INTA (AR)
Tetsunari Iada, ISEP (JP)
Thomas B. Johansson, Lund Univ. (SE)
Lev Nedorezov, INENKO RAS (RU)
Martina Schäfer, ZTG TU Berlin (DE)
Udo Simonis, WZB (DE)
Ralph Sims, Massey University (NZ)
Leena Srivastara, TERI (IN)
Helen Watson, UKZN (ZA)
Sir Robert Watson, Tyndall Centre (UK)

Bank Account:
Volksbank eG Darmstadt
IBAN DE54508900000055548609
BIC GENODEF1VBD

Company Register:
HRB 90827 District Court Darmstadtt

VAT ID:
DE 282876833

www.iinas.org

Biomass Policies

Task 2.4: Sustainable Imports

Cost supply curves for medium- to longer-term potentials for sustainable biomass and bioenergy (pellets, biomethane, liquid biofuels) imports to the EU-28.

Deliverable 2.5 – Explanatory note

prepared by

Uwe R. Fritsche, Leire Iriarte

Darmstadt, Madrid, March 2016

This note aims to clarify the interactions between deliverable 2.5 of the Biomass Policies project (Sustainable imports) and other related on-going projects:

Interactions with BioTrade2020plus project:

Biomass Policies started in March 2013 while BioTrade2020plus project kickoff was in March 2014. The first version of the Deliverable 2.5 of Biomass Policies was in November 2014 when relevant progress in BioTrade had not ocurred yet.

The work in Biomass Policies has focused on having an overview of sustainable biomass potentials and to develop respective cost-supply curves for several feedstocks in selected countries all around the world. Given the limited resources in Biomass Policies and the complexity of the analysis, not all countries currently exporting to the EU were examined. Thus, the approach focused on the potential sustainable availability in the **two most promising export countries** assuming that these countries could play a relevant role as exporters to the EU. In contrast, the BioTrade2020plus project has focused on **six selected countries** (or regions) in order to determine the different sustainable production of **lignocellulosic** feedstocks cost-supply curves. For the six cases studies selected in BioTrade2020plus, a deeper analysis of the sustainable resources available to be exported was carried out.

Biomass Policies addressed 1st and 2nd generation ethanol, biodiesel, wood pellets and wood chips as well as biomethane, while in BioTrade2020plus, only lignocellulosic feedstocks were considered.

Also, there are some differences in the methodology. While in BioTrade2020plus specific and detailed assessments of sustainable biomass potentials have been carried out in Biomass Policies more general assumptions had to be taken into account. The research in Biomass Policies was based on literature review and expert opinion while BioTrade undertook primary analysis (in most cases by GIS tools). Nonetheless, the authors consider that the assumptions taken in Biomass Policies for D2.5, even if general, give a good understanding of the magnitude of the sustainable biomass potential available to be exported to the EU-28.

The only overlap in scope of Biomass Policies and BioTrade2020plus concern sugarcane EtOH from Brazil, and wood pellets from the US. When possible, the teams of both projects have been in touch, have exchanged information including the participation in different teleconferences (e.g. IINAS participated in the Telco organized within the BioTrade2020plus project to present and discuss the draft of the Brazilian Case Study, organized the 19 of January 2016). Nonetheless, the final version of D2.5 of Biomass Policies have been produced before the final version of the BioTrade2020plus case studies were published.

Other interactions:

BiomassPolicies Task 2.5 built on various previous work such as e.g.. BioBench[1], and project results of the Netherlands Programmes for Sustainable Biomass[2].

BiomassPolicies Task 2.5 was fortunate to draw information and data directly from work of IEA Bioenergy Task 40, especially on sustainable woody biomass import potentials from Russia, and the US Southeast[3].

1 VITO et al. (2011): BIOBENCH - Benchmarking biomass sustainability criteria for energy purposes. EC DG ENER contract ENER/C1/495-2009/SI2.572581. Mol http://ec.europa.eu/energy/renewables/studies/doc/2014_05_biobench_report.pdf

2 http://english.rvo.nl/topics/sustainability/sustainable-biomass/publications-results

3 See Iriarte, Leire; Fritsche, Uwe & Pelkmans, Luc (2014): Impact of promotion mechanisms for advanced and low-iLUC biofuels on biomass markets: Wood Pellets from the US to the EU. Prepared for IEA Bioenergy Task 40 by IINAS & VITO. Darmstadt, Madrid, Brussels http://www.bioenergytrade.org/downloads/t40-low-iluc-pellet-august-2014.pdf and Thiffault, Evelyne; Lorente, Miren; Murray, Jessica; Fritsche, Uwe; Iriarte, Leire; Endres, Jody & McCubbins, James (2014): Ecological sustainability of wood bioenergy feedstock supply chains: Local, national and international policy perspectives. IEA Bioenergy Task 40. http://www.bioenergytrade.org/downloads/t40-sustainable-wood-energy-2014.pdf

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Administrative Director:
Thomas Stetz ts@iinas.org

Office:
Heidelberger Str. 129 ½
D-64285 Darmstadt, Germany
ph +49 (6151) 850-6077
fax +49 (6151) 850-6080
info@iinas.org

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Teresa Pinto Correia, ICAAM (PT)
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Alan Hecht, EPA (US)
Eva Heiskanen, NCRC (FI)
Alois Heißenhuber, TU München (DE)
Edgar Hertwich, NTNU (NO)
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Tetsunari Iada, ISEP (JP)
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Lev Nedorezov, INENKO RAS (RU)
Martina Schäfer, ZTG TU Berlin (DE)
Udo Simonis, WZB (DE)
Ralph Sims, Massey University (NZ)
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Helen Watson, UKZN (ZA)
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Uwe R. Fritsche, Leire Iriarte

Darmstadt, Madrid, February 2016

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Acronyms

bbl	barrel
CENBIO	Centro Nacional de Referência em Biomassa
CIF	Cost, Insurance and Freight
DBFZ	Deutsches BiomasseForschungsZentrum gGmbH
EC	European Commission
EIA	U.S. Energy Information Administration
EMBRAPA	Brazilian Agricultural Research Corporation
ETSAP	Energy Technology Systems Analysis Programme
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FOB	Free on Board
FNR	Fachagentur Nachwachsende Rohstoffe e. V.
GRFA	Global Renewable Fuels Alliance
IC	Imperial College
IEA	International Energy Agency
IINAS	International Institute for Sustainability Analysis and Strategy
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
lde	Liter of diesel equivalent
lge	Liter of gasoline equivalent
LNG	Liquefied Natural Gas
M	Million
MME	Ministério de Minas e Energia - Brazil
MS	Member States
NRC	Natural Resources Canada
NREAP	National Renewable Energy Action Plans
NREL	National Renewable Energy Laboratory
OECD	Organisation for Economic Cooperation and Development
RED	Renewable Energy Directive (EU 28/2009)
REN21	Renewable Energy Policy Network for the 21st century
SNG	Substitute Natural Gas
SRC	Short rotation coppice
t	tonnes
toe	tonnes oil equivalent
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development

Preface

This paper was prepared within the Biomass Policies project[1] and is based on work of IINAS in WP 2. While working on Task 2.4, IINAS received valuable inputs from project partners (Imperial College, Alterra, ECN, Port of Rotterdam), and outside colleagues, particularly the consortium of BioTrade2020plus project (CENER, Utrecht University and Imperial College).

It represents Deliverable 2.5, and the authors hope that it will provide orientation and beneficial information to those within the Biomass Policies project and beyond working towards sustainable bioenergy production and use.

This document is the final version of Deliverable 2.5.

The sole responsibility for the content of this publication lies with authors.

It does not necessarily reflect the opinion of the European Communities. The European Commission is not responsible for any use that may be made of the information contained therein.

Darmstadt, Madrid, February 2016 The Authors

[1] "Biomass Policies: Strategic Initiative for Resource Efficient Biomass Policies" (www.biomasspolicies.eu) funded by the Intelligent Energy Europe programme of the European Commission, DG Energy.

1 Introduction and Objectives

The goal of Task 2.4 of the Biomass Policies project is to determine realistic cost-supply curves for medium- to longer-term potentials (2020 and 2030) for bioenergy **imports** (pellets, biomethane, liquid biofuels) to the EU28. The results of this task will help determine import shares per Member State in the scenarios.

Various studies assessed the bioenergy potentials in Europe, concluding that given the current market uptake the bottleneck is not resources availability but the capacity to mobilize the resources (e.g. IC et al. 2013; Hetemäki 2013). In this context the costs of the resources and sustainability requirements will be of particular importance to determine when domestic or imported bioenergy can be used.

Currently, 62 countries all around the world have passed biofuels mandates or targets (GRFA 2014) so a global increasing demand for biofuels might be expected in the short and medium-term. Nonetheless, the demand of biomass for liquid biofuels in the longer term will depend on a long list of issues (including technology developments and policy willingness) and complex interactions. With regards to solid bioenergy, most of it is domestically produced and locally consumed in the EU being wood pellets the most relevant solid bioenergy carrier imported from abroad.

Contrary to what occurs with **bioethanol** that is extensively produced outside the EU (94 billion liters produced globally in 2014), the biodiesel production (29.7 billion liters produced globally in 2014) is mainly concentrate within the EU (REN21 2015).

In 2014, the largest **bioethanol** producer countries were USA and Brazil (see Table 1). In the case of **biodiesel**, dominant countries are: EU28, USA, Argentina, Brazil, Indonesia and Colombia. In America (US, Argentina, and Brazil) biodiesel is almost purely soy-based SME while in South East Asia (Indonesia and Malaysia) it is almost exclusively palmoil-based PME (Lamers et al. 2011).

Table 1 Biofuels Global Production in 2014 (billion litres)

Country	Bioethanol	Biodiesel	HVO	Total	Change relative to 2013
United States	54.3	4.7	1.1	60.1	+3.9
Brazil	26.5	3.4		29.9	+1.6
Germany	0.9	3.4		4.3	+0.6
China	2.8	1.1		3.9	+0.3
Argentina	0.7	2.9		3.6	+0.8
Indonesia	0.1	3.1		3.2	+0.9
France	1.0	2.1		3.1	+0.1
Netherlands	0.4	0.7	1.7	2.5	+0.2
Thailand	1.1	1.2		2.3	+0.4
Canada	1.8	0.3		2.1	+0.1
Belgium	0.6	0.7		1.3	+0.2
Spain	0.4	0.8		1.2	+0.1
Singapore	0	0	1.0	1.0	+0.1
Poland	0.2	0.8		1.0	+0.1
Colombia	0.4	0.6		1.0	No change
Australia	0.2	0.1		0.3	-0.1
EU28	**5.2**	**11.6**	**1.8**	**18.6**	**1.9**
World	**94**	**29.7**	**4**	**127.7**	**10.4**

Source: REN21 (2015); only the top 16 countries plus EU28 are shown

Regarding solid bioenergy, pellets are the most tradable product due to favorable technical characteristics (e.g. energy density). This, coupled with the increasing demand in some EU MS with limited domestic production capacity (e.g. UK, NL, BE or DK) are relevant reasons why international trade is increasing rapidly.

Table 2 shows the main international pellet flows in 2013 and 2014. Although the numbers provided could be in the low range, USA, Canada and Russia dominate the pellet export to the EU, which is the largest market. Other countries have minor import demands, e.g. Japan, South Korea but significantly increased their imports in 2014 (in comparison with 2013).

Table 2 Global Trade in Wood Pellets in 2014

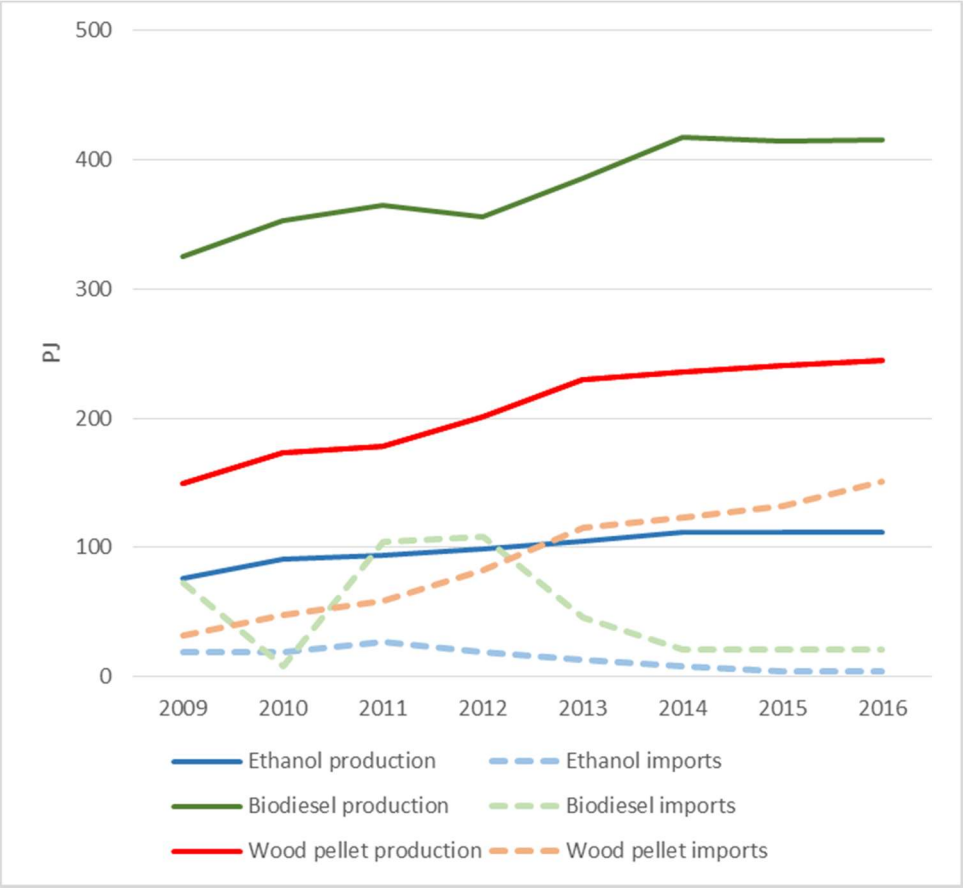
Exporter	Importer	Volume (kilotonnes)	
		2013	2014
United States	EU28	2,776	3,924
Canada	EU28	1,963	1,166
Russia	EU28	702	821
Ukraine	EU28	165	137
Belarus	EU28	116	126
Bosnia and Herzegovina	EU28	171	178
Serbia	EU28	70	71
Australia	EU28	31	0
Norway	EU28	48	18
Egypt	EU28	17	20
Other	EU28	23	33
EU28	Switzerland	87	59
EU28	Norway	30	27
EU28	Japan	6	6
Canada	South Korea, Japan	250	503

Source: REN21 (2015)

Figure 1 shows bioethanol, biodiesel and pellets production in the EU as well as imports during the period 2009-2014 (and forecasts for 2015 and 2016). The production of bioenergy carriers has increased during last years being biodiesel the one showing highest production, followed by bioethanol and pellets. With respect to imports, biofuels for transport have decreased during last years due to various reasons, among others antidumping measures. However, imports of wood pellets have steadily increased during last years and are expected to continue increasing. Wood chips consumption was estimated to be about 15 Mt in 2014 and it is expected to grow to 28 Mt in 2020 (USDA FAS 2015).

The EU28 also export bioethanol, biodiesel and pellets to third countries. While in 2012 none of the exports of these bioenergy carriers from the EU was higher than 10 % (with respect to imports), it is expected that in 2015 bioethanol exports are higher than 50 % of the imports, about 18 % for biodiesel and less than 3 % for pellets.

Figure 1 Production and Imports of Main Bioenergy Carriers into EU28 in 2009-2016



Source: own compilation based on USDA FAS (2015). Original data provided in liters or tons. Conversion factors used in LHV: biodiesel: 33 MJ/l; bioethanol: 21,3 MJ/l; pellets: 18,83 MJ/kg

Note: data for 2014 are estimated and for 2015 and 2016 forecasted

1.1 Current Markets and Technologies

There are several technologies at a commercial scale to produce the so called **1st generation (1G) biofuels**. These commercial technologies include: sugar/starch ethanol, transesterfied diesel, and HVO diesel. Other technologies such as fermentation to jet or biomass to liquid present different levels of readiness (see SQ Consult & IINAS 2015).

Due to sustainability concerns, however, future increases in OECD countries are expected to mainly come from advanced - so-called **2nd generation (2G) biofuels** (see e.g., IEA 2011). Nowadays while advanced biodiesel options are not well developed, there are 690 Ml of ethanol installed capacity worldwide and an additional 470 Ml capacity is expected in the short term (SQ Consult & IINAS 2015). Due to economies of scale, large 2G projects in Europe might use

woodchips as feedstocks since wood pellets are not suited for chemical/fuel production, given their costs and biomass quality (cellulose is not adequate in pellets for these processes).

Pelletization of wood feedstock has gained momentum, given the growing biomass demand for heat and power generation either for heating at household level or for co-firing in large scale units. It is expected that new technological developments (such as **torrefaction**) become commercially available in the next years.

Biomethane production is also a promising technology. The production of biomethane can be based on biochemical conversion of feedstocks into biogas (i.e. anaerobic digestion, followed by upgrading to biomethane) or on thermo-chemical conversion of woody biomass (i.e. gasification and upgrading of syngas to Bio-SNG). Relevant developments of waste to syngas are also expected.

While anaerobic digestion (AD) is a technology commercially available for more than three decades, biogas upgrading to biomethane is a development of the last 10 years. Gasification of biomass, followed by methanization of syngas, is in the demonstration stage, i.e. Bio-SNG is a pre-commercial technology. It is expected that Bio-SNG will become commercial by 2020, though (DBFZ 2012a).

Once biomethane is produced, it is fully equivalent to natural gas, i.e. it can be transported through existing gas pipelines systems, or even processed further to Bio-LNG for international sea transport[2].

1.2 Bioenergy Demand and Resource Availability

Apart from the EU renewable energy targets (EU 2009; 2030 Energy Strategy[3]), other countries that have introduced biofuels mandates[4], have specific goals for advanced biofuels, are promoting co-firing or are well positioned to implement it[5].

2 Due to comparatively high cost of producing LNG and limitations of EU unloading capacity, this option is not analyzed here.

3 http://ec.europa.eu/energy/en/topics/energy-strategy/2030-energy-strategy

4 See REN21 (2015)

5 See IINAS, CENBIO (2014); IEA-ETSAP, IRENA (2013b)

This situation raises the question whether there are enough biomass resources to meet all the needs (not only for bioenergy but also for chemicals, products or other purposes), with land availability of particular concern.

Globally, a 70 % increase in global food demand is expected by 2050 (FAO 2009) leading to a net land expansion of 70 Mha. From this total, a net expansion by about 120 Mha is expected in developing countries and a decline of around 50 Mha in industrialized countries. However, changes in future agricultural productivity, increase in efficiency in food chains and changes in diets may alter this estimate.

On the other hand, degraded and abandoned land can contribute to bioenergy generation through the cultivation of energy crops, showing various potentials depending on the assumptions (IINAS & IFEU 2012), but at higher cost. In particular, IPCC (2011) estimates around 120 EJ (30 EJ – 200 EJ) coming from energy crops by 2050.

Many studies have attempted to narrow down the various biomass potentials (i.e. technical or economic) at various levels (from international to local assessments) with tremendously diverse results due to the variables taken into account and respective assumptions[6]. Most realistic results provide a range from 100 to 300 EJ/a by 2050 (IPCC 2011).

In the demand side, the IEA (2014) reports a global total primary biomass demand in 2011 equivalent to 55 EJ which could range from 83 EJ to 107 EJ in 2030 for the 6 degree scenario and 2 degree scenario respectively.

1.3 Costs

Generally speaking, biofuels are not yet economically competitive with fossil fuels at present prices, with the sole exception of sugarcane ethanol from Brazil (IEA ETSAP & IRENA 2013a). 2G biofuels are currently quite expensive (1.0 -1.2 $/lge) but it is expected they become competitive with crude oil prices above 60-70 $/bbl due to technology improvements by 2030 (IEA-ETSAP & IRENA 2013a).

Thus, a cost reduction of 30 to 60 % is expected in the longer-term (de Witt et al. 2010). Adequate carbon pricing policies, operating cost reduction, reduced

6 See e.g.: IPCC (2011)

feedstock costs and higher fossil fuel prices will contribute to introduce 2G biofuels.

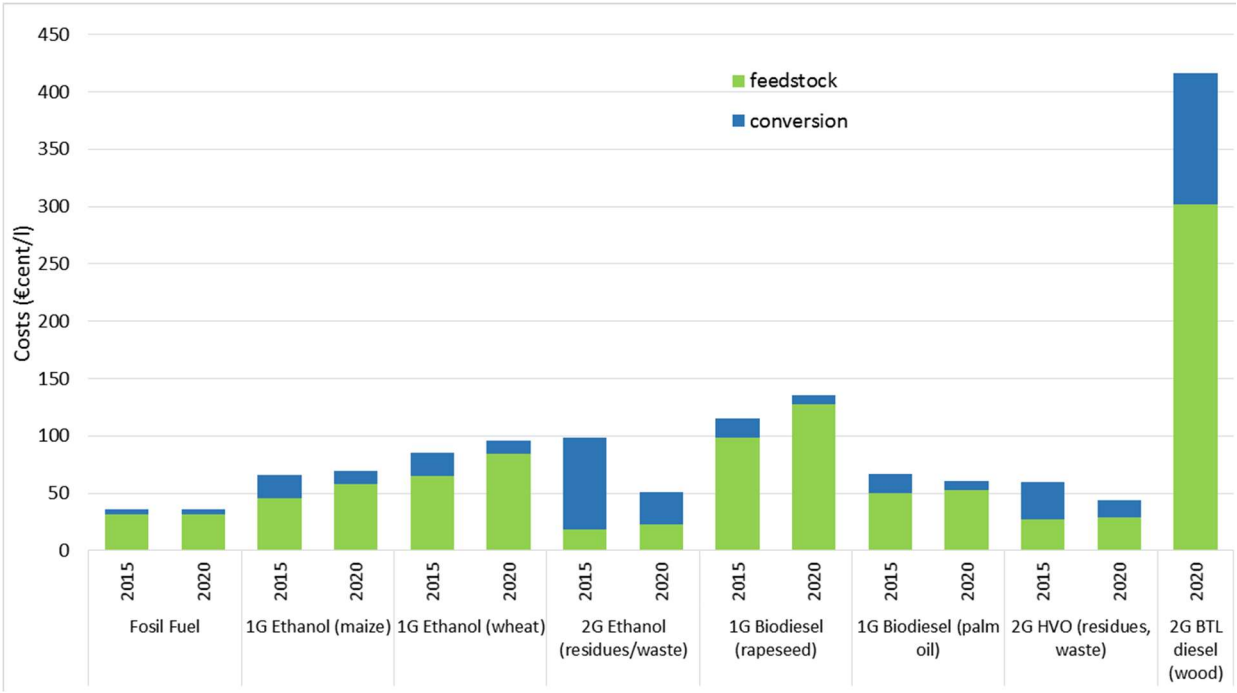
The costs of bioenergy trade are determined by many factors such as the feedstock (e.g. wastes, residues or dedicated plantations) the type of biomass transported ("raw biomass", intermediate energy carriers or high-quality energy carriers) and other parameters in the bioenergy chain (e.g. pre-treatment operations, transport distances and scale, see Hamelinck et al. 2005).

Several modelling exercises have been carried out to investigate production costs of biofuels in the short- to longer-term (e.g. IPCC 2011; IEA-ETSAP & IRENA 2013a).

Figure 2 shows current 2015 and expected 2020 costs for different biofuel pathways. **Feedstocks** represent up to 50-60 % of the final cost of Brazilian sugarcane and 80-90 % of palm and rapeseed biodiesel, and maize ethanol (IEA-ETSAP & IRENA 2013a).

Conversion costs are only of relatively minor importance for 1G biofuels, while relevant for 2G ethanol, HVO, and especially BTL, particularly by 2020 assuming larger production scales. The competitiveness for 2G biofuels is expected to increase in the mid- to long-term due to learning curve effects.

Figure 2 Production costs for selected biofuels pathways

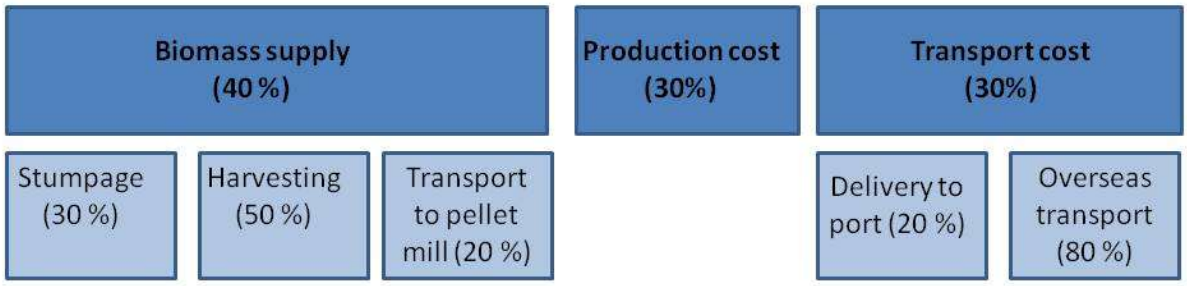


Source: Adapted from Festel et al. (2014); data given for 50 €/bbl crude oil price

For wood pellet, the typical US Southeast cost breakdown is given in Figure 3. Biomass supply represents about 40 % of the total costs while production costs and transport costs are 30 percent each for wood pellet.

Typical ocean shipping cost is 0.1 c_{US}/t*km and 10 c_{US}/t*km for road transport (IEA-ETSAP & IRENA 2013a). Logistics play a relevant role in the delivery cost of any bioenergy carrier (Goh & Junginger 2013).

Figure 3 Typical Cost Breakdown for US SE Wood Pellets



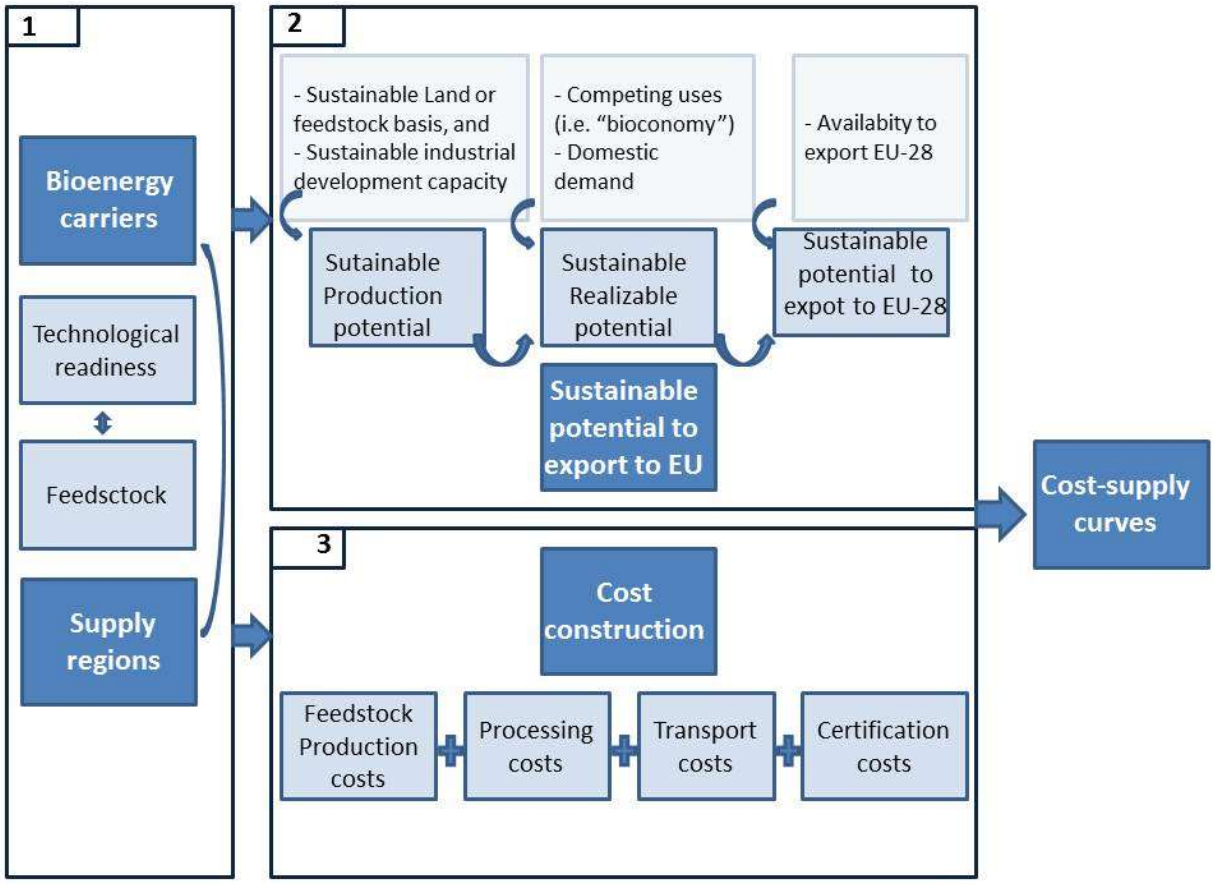
Source: own elaboration based on Qian, McDow (2013) and Bradley et al. (2013)

2 Methodology

The development of the cost-supply curves for the bioenergy carriers selected has taken into account three steps, as depicted in Figure 4:

- First, the relevant bioenergy carriers and regions of production were determined.
- Next, the sustainable potential available to be exported to Europe was evaluated.
- Finally, costs were determined for each bioenergy carrier in the given time horizons, and regions.

Figure 4 Overview of the methodology for the cost-supply curves



Source: own elaboration

Annex 1 shows detailed assumptions and clarifications regarding the methodology applied for each bioenergy carrier and country.

2.1 Bioenergy Carriers and Supplying Regions

Commercially available technological pathways will determine the bioenergy carriers to be internationally traded. Table 3 shows the various bioenergy carriers and technologies by 2020 and 2030 as assumed within this study. This report covers the most likely feedstocks to be used in selected countries, given current trends.

Pyrolysis oil and BtL are not expected to be introduced in significant amounts by 2030 so these routes are not included here. Processing residues such as those from palm oil processing for biodiesel production are not taken into account because in general, they are needed to improve soil quality of plantations[7].

Table 3 Technology Readiness by 2020 and 2030

Bioenergy carrier by technology	Feedstock	2020	2030
1G bioethanol	Sugarcane, maize	✓	✓
1G biodiesel	Palm oil, soybeans, rapeseed (including HVO)	✓	✓
2G ethanol	Cereals straw and sugarcane residues (bagasse and straw)	✓	✓
Pellets/chips(1)	Wood (roundwood, primary or secondary wood residues)	✓	✓
Torrefied pellets	Wood and lignocullose		✓
Biomethane	Manure, energy crops, lignocellulose	✓	✓

Source: own compilation based on IEA (2012) and IEA-ETSAP & IRENA (2013)

(1) the various woody feedstocks analyzed in this study could be imported as wood chips or wood pellets. This study has considered the total amount of wood feedstocks that could be traded either as pellet or wood chips.

2.1.1 Country selection

This study has focused on those countries with significant resources (raw materials, land availability) to produce and export bioenergy carriers, based on

7 The BioTrade2020plus project (www.biotrade2020plus.eu) focusses on sustainable biomass export potentials of various types of residues all around the world.

current and expected trade figures at the international level. In addition to countries with high export potential, only those countries that might be oriented to EU markets have been considered.

Given these circumstances, this study distinguishes:

- 1G biofuels (EtOH and biodiesel) - despite that currently there are other countries than those selected playing a role in trading bioenergy carriers and more particularly in exporting to EU28, we focused on countries with most promising contexts (availability of land, forest or agricultural resources, infrastructure readiness, favorable conditions to develop infrastructure, etc.).
- Wood pellets (either torrefied or "normal" pellets) from a comprehensive list of most promising countries to produce and export pellets.
- 2G biofuels - only countries with relevant resources available were taken into account. The US has not been considered given the ambitious domestic targets for 2GEtOH, which limits export options.
- For biomethane only EU neighboring countries (Ukraine and the western part of Russia) were considered since these countries have significant biomethane potentials from agricultural residues, energy crops, and forest biomass, and also have access to the existing high-pressure natural gas pipeline system for international transport to the EU (Thrän et al. 2014).

2.2 Sustainable potentials to be exported to EU28

This report has considered a comparable approach to that indicated in the Deliverable 2.3 of the Biomass Policies project (Outlook of spatial biomass value chains in EU28; Elbersen et al. 2015) to determine sustainable bioenergy availability for exports to the EU:

Availability = Presence - T1 - T2

Where:

Availability = Availability under certain sustainability requirements and competing use assumptions and within a certain time period (2020 & 2030).

Presence = Presence of biomass now and in future (2020 & 2030)

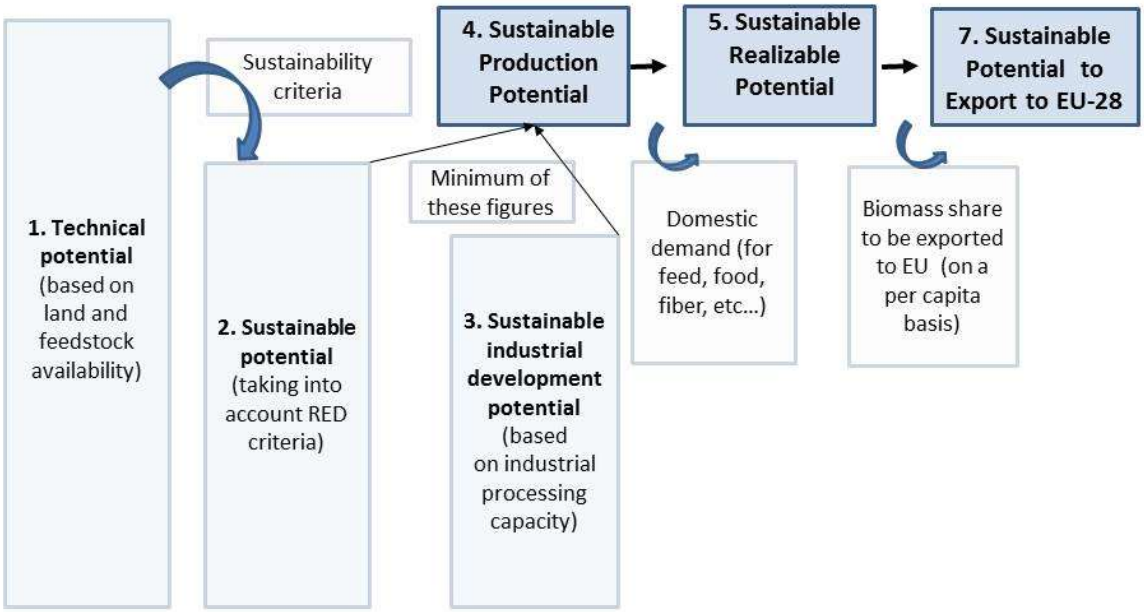
T1 = has to be left behind for soil conservation/biodiversity/erosion control

T2 = conventional competitive uses (feed, bedding, fiber, materials etc.)

This study has been based on average figures for the Business as Usual (BAU) Scenario (see Section 2.4). Biomass demand and supply for other domestic uses

than for bioenergy and biomaterials (e.g. food or feed) were taken into account when necessary (i.e. for bioethanol or in forestry sector where demand of wood products was considered in the cases for which data were available). The results for 2020 and 2030 are given in PJ. An overview of the steps taken to assess bioenergy potentials is shown in Figure 5.

Figure 5 Overview of the steps taken to assess bioenergy potentials.



Source: own compilation by IINAS

Technical potentials (step 1) for bioeconomy were estimated based on a literature review (see Annex 1). For this both land availability to grow feedstocks, primary feedstocks and residues (mainly primary residues) and waste were considered.

From technical potentials, **sustainable potentials (step 2)** were estimated taking into consideration the sustainability issues stated in the RED:

- Minimum greenhouse gas (GHG) emission reduction (Art. 17.2), by at least 35% (50% in 2017) and 60% in new installations from 2017.
- Protection of land with high biodiversity value (Art. 17.3). Primary forests, areas designated by laws, and other highly biodiverse areas (recognized by international agreements or IUCN) and natural and non-natural highly biodiverse grasslands should be excluded.
- Protection of land with high carbon stocks (Art. 17.4). Wetlands, continuously forested areas and lightly forested areas with this status in

January 2008 but no longer have it should be avoided (not applicable if the status in January 2008 is maintained)

- Protection of peatlands (Art. 17.5).

This report assumes that **same sustainability criteria** should be considered when biomass is produced for domestic purposes or for exports in third countries. This report is based on a **precautionary approach** (conservative estimates of biomass availability) so additional narrowing down from the sustainable potentials estimated in the literature was taken into account.

In addition to sustainable biomass availability in a given region and timeframe, the pace of development at which these sustainably produced feedstocks are mobilized is extremely relevant to avoid negative and unintended effects in related sectors (e.g. agricultural sector for the case of 1G biofuels or forest sector in the case of woody pellets). Here this was called **sustainable industrial development capacity (step 3)** and has been considered as a reference proxy to have into account the market potential as well as avoid indirect unintended impacts in other sectors (competition and displacement of other traditional sectors as in the pulp and paper sector when wood pellets are boosted. Thus, some regions in the world present untapped biomass potentials or high land availability for biomass cultivation for bioenergy, i.e. Africa (e.g. Stecher, Brosowski & Thrän 2013; Batidzirai, Faaij, Smeets 2006). However, this gross technical potential (and respective sustainable potential) cannot directly be extrapolated to “mobilizable” potentials and respective “exportable” potentials in the short term, given the list of efforts needed to make them sustainably available without creating distortions in other spheres.

Then, in addition to the sustainable potentials based on resources availability calculation, sustainable processing capacity was calculated extrapolating for 2020 and 2030 the exported amounts (or the production capacity) of various bioenergy carriers during last years (for most of them the period between 2009 and 2013 was considered). When these data were not available assumptions on sustainable industrial development capacity were made based on literature review. The **sustainable production capacity** was calculated by extrapolating the production capacity or the exports for a given bioenergy carrier from 2009-2012 by means of a linear regression for 1G biodiesel exporting countries or wood pellets exporters. Table 4 shows data for biodiesel in Argentina and Indonesia and Table 5 data for wood pellet.

Brazil, with exceptional forest resources, land availability and technological readiness has been an exception in this approach and particular considerations with regards to the industrial development capacity were taken into account.

Then, a balanced and sound figure of the combination of these approaches was selected as the **sustainable production potential (step 4)**.

Table 4 Biodiesel Production Capacity (2006-2012) and Projections for 2013 and 2014

in Ml	2006	2007	2008	2009	2010	2011	2012	2013	2014
AR	175	665	1500	2300	2800	3800	4200	4600	5200
ID	215	1709	3138	3528	3936	3936	4280	4280	4280

Source: USDA FAS (2013)-AR and USDA FAS (2013)-ID

Table 5 Wood Pellets Imports to EU (2009-2012) by Country

in Mt	2009	2010	2011	2012
US	0.54	0.76	1.03	1.76
CA	0.52	0.98	1.17	1.35
RU	0.38	0.40	0.48	0.64
Others	0.27	0.38	<0.48	0.61
Total	1.71	2.52	3.16	4.36

Source: USDA-FAS (2013)

2.2.1 Domestic demand

Domestic demand (for biofuels and other biomaterials) was taken out from this **sustainable realizable potential** to calculate the available potential to be exported. In those countries with relevant technical potentials (such as CA and RU in the case of wood pellets), only potentials for bioenergy were considered so demand e.g. for industrial roundwood for materials is not affected.

Average projections of domestic demand for the 2 Degree Scenario and 6 Degree Scenario of IEA (2014) have been considered for countries with available data.

This study considers that local demand should be met before starting to explore export options (see the principle "**local demand first**"[8]). This simplified assumption aims to avoid risky competition with local demands, particularly in developing countries. The authors recognize the limitations of this approach, but this consideration was necessary from a conceptual point of view in order not to interfere with the domestic demands.

2.2.2 Available potentials to be exported to EU

Once the most promising countries (or regions) to export to the EU markets were identified, this study has not considered market preferences between destination countries. The available potentials to be exported to EU28 were calculated on a *per capita* basis, considering the demand for same bioenergy carriers in other regions of the world that might have similar paying capacity, as shown in Table 6. The case of 2G biofuels exports from Ukraine to the EU and biomethane exporters were exceptions in this approach.

Table 6 Share of bioenergy carriers available to be exported to the EU28 on a per capita basis

Country	1G Biofuels	2G Biofuels	Pellets
CN*	(1351)	N/A	N/A
JP	128	128	128
KR	50	50	50
US	314	314	N/A
CA	N/A	35	N/A
EU28	506	506	506
Total	**1066**	**1033**	**684**
Share of EU28	**47%**	**49%**	**74%**

Source: compilation from UN-STATS (2014) and Eurostat (2013) for the EU28

**= only 5 % of the total Chinese population considered*

[8] See IINAS & CENBIO (2014) for details

2.3 Costs

This study focuses on costs, disregarding prices which are market driven. Hence, the following issues are not taken into account directly in the cost construction:

- Subsidizing policies: neither promoting policies in the exporting countries nor within the EU are brought to the debate.
- Duties and taxes: exporting and importing duties are excluded.
- Issuance of contracts: some biofuel contracts i.e. for pellets are signed several years in advance, with respective impacts on prices.
- Market barriers such as iodine number or phytosanitary measures

To develop the cost-supply curves four main cost categories have been determined, as follows:

- **Feedstock production costs**: it encompasses land costs, labor costs, fertilizer costs, harvesting, transport to the factory, capital cost & miscellaneous when adequate. Particular production costs categories depend on the feedstocks i.e. crops vs. residues or forest vs. agricultural biomass.
- **Processing costs**: it includes investment costs, operating costs, maintenance, etc. When co-products are obtained from the bioenergy carrier production process their value has been deducted from the total cost.
- **Transport costs**: from the mill to the port and overseas freight to Amsterdam-Rotterdam-Antwerp (ARA), the delivery point.
- **Certification costs**: here it is assumed that all type of bioenergy i.e. biofuels, bioliquids and solid biomass (wood pellet) have to comply with a set of mandatory criteria by 2020. From the literature revision it is assumed that certification costs might be 4 % of the cost of the bioenergy delivered to ARA.

The total costs are given in $€_{2010}$/GJ (see Annex 1 – conversion factors) and a fixed exchange rate of 1.1 $\$_{2010}/€_{2010}$ was used even though exchange rates change and have relevant impact on costs (Sikkema et al. 2011).

Specific feedstock data and disaggregated regional data were acknowledged as long as possible. For biofuels, costs provided were based on van Eijck, Batidzirai & Faaij (2014) and for wood pellets and wood chips on Pöyry (2011).

2.4 Scenarios

The scenarios considered for bioenergy imports are those that run across the Biomass Policies work for feedstock assessment, value chain analysis and RESolve modelling. In addition to the Business as Usual (BAU) scenario to which descriptions given in the previous section applies, this report also considered:

- B1 scenario: it involves high bioenergy consumption, strict sustainability and resource efficiency criteria applied at EU scale. This leads to some more imports to the EU. This scenario builds on the Energy Roadmap 2050-PRIMES high RES scenario.
- B2 scenario: it involves strict sustainability and resource efficiency criteria that are not only applicable to the EU bioenergy consumption but also to bioenergy produced globally. This scenario leads to more biomass demand in the world and higher prices. This scenario also builds on the Energy Roadmap 2050-PRIMES high RES scenario.

The assumptions relative to these scenarios are included in this report as shown in Table 7.

Table 7 Biomass availability and costs assumptions depending on the scenario

Scenario	Availability*	Cost
B1	Production capacity + 25 % of the BAU (to the extent that sustainable biomass potential is still available)	+5 % of the BAU cost
B2	Production capacity + 50 % of the BAU (to the extent that sustainable biomass potential is still available)	+10 % of the BAU cost

Source: own elaboration

**= This refers to general assumptions for biofuels; specific assumptions for wood pellets (and chips) and biomethane are given in Annex 2.*

3 Results

This study has applied a **conservative** approach to determine the most promising countries to export available bioenergy carriers to EU. The countries (or regions) selected for each bioenergy carrier are (IINAS & CENBIO 2013; Goh & Junginger 2013; UNCTAD 2014; own compilation):

- 1G EtOH: Brazil, Mozambique
- 1G Biodiesel: Argentina, Indonesia
- Wood pellets (including torrefied ones): Russia (Northwest), US (Southeast), Canada (East), Brazil, Mozambique.
- Biomethane: Russia (Northwest), Ukraine

3.1 Biofuels and bioliquids

The various biofuels export options to the EU has been assessed based on the particular conditions of each country selected, as shown in Annex 1.

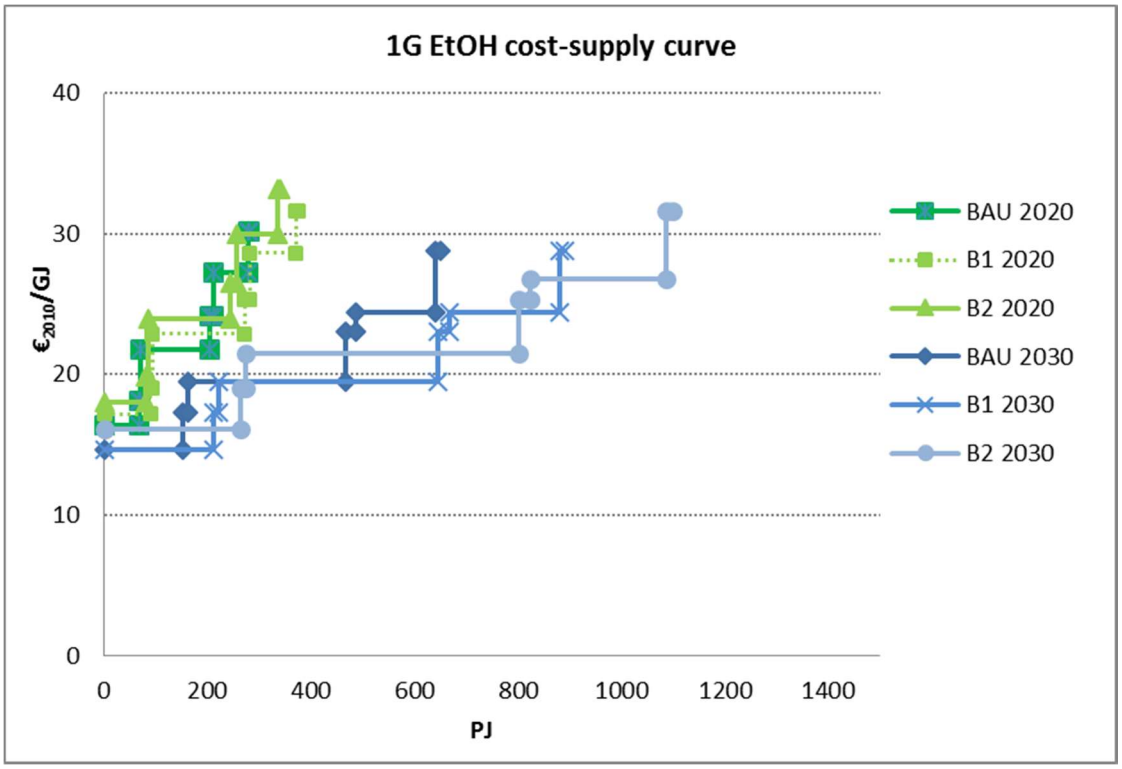
3.1.1 1G Ethanol

The two selected countries are Brazil and Mozambique using sugarcane as feedstock. The cost-supply curve is shown in Figure 6 and details in Table 8. Brazil is able to provide more than 15 times the supply from Mozambique in 2030. This is because of the extensive land resources available in Brazil. The agro-ecological zoning of sugarcane in Brazil showed that 34.2 Mha were lands with agricultural suitability for sugarcane tillage under diverse agricultural usage (EMBRAPA 2009). Moreover, CENBIO (2013) estimated that 25 Mha would be available for crops for energy purposes (sugar cane, oil palm, elephant grass, etc.) by 2030. This enormous land base resource is the basis for sugarcane crops.

The Biofuels Policy of Mozambique has established 0.45 Mha available for biofuels cultivation with various crops but much larger potentials ranging between 7.7 to 16.6 Mha by 2030 have been determined in other studies (e.g., van der Hilst et al. 2012). Also, the Government of Mozambique has developed an agro-ecological zoning to determine the areas where biofuels might be cultivated (Republic of Mozambique 2009). Here a more conservative approach has been taken in place and the sustainable production capacity has been assessed based on the production potential capacity since it seems to be the most limiting factor for the expansion of the sugarcane industry in Brazil.

Delivered (CIF ARA) costs are in the same order of magnitude in both countries and expected to decrease from 2020 to 2030 (while feedstock availability increase).

Figure 6 Cost-Supply Curve for 1G EtOH



Source: own elaboration

Table 8 Cost-Supply Data for 1G EtOH

Scenario	Country	Sustainable availability to export to EU (PJ)		Average costs (€2010/GJ)	
		2020	2030	2020	2030
BAU	BR	267	611	21.8	19.5
	MZ	14	39	24.1	23.0
	Total	**281**	**650**		
B1	BR	357	846	22.9	20.5
	MZ	18	45	25.3	24.2
	Total	**375**	**891**		
B2	BR	319	1,054	24.0	21.5
	MZ	22	45	26.5	25.3
	Total	**341**	**1,099**		

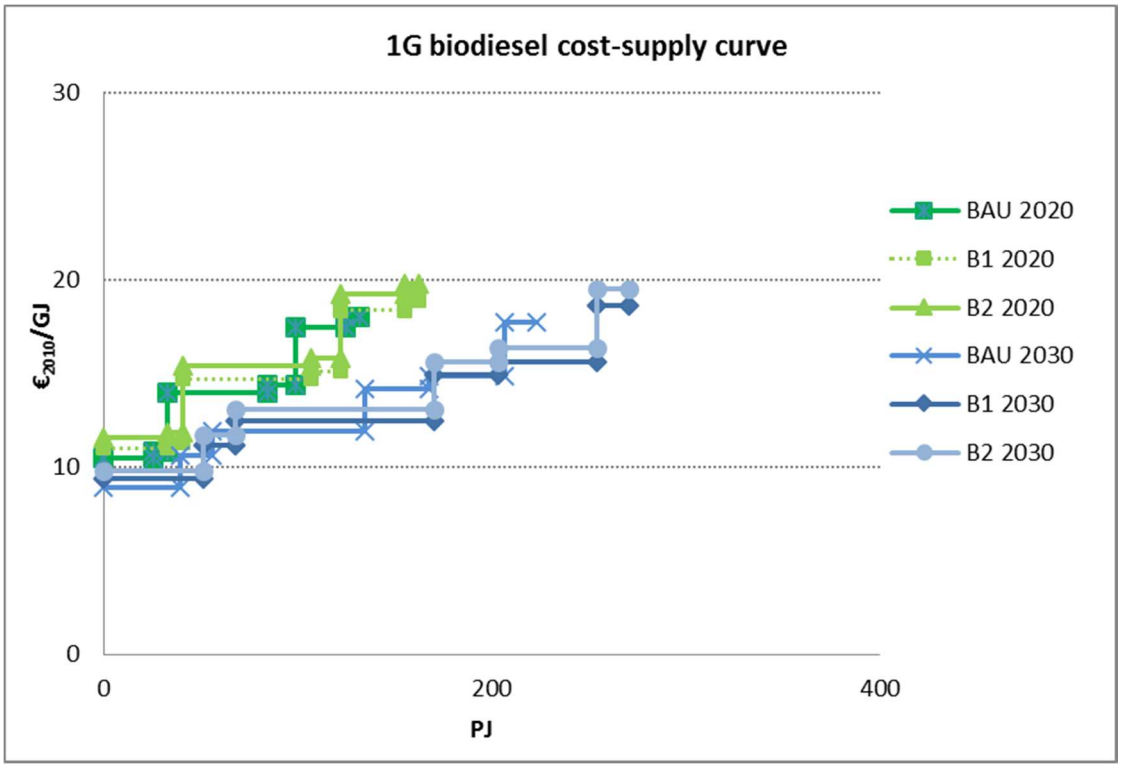
Source: own elaboration. Note: Annex 1 summarizes methodological considerations, Annex 2 provides detailed result

3.1.2 1G Biodiesel

Selected exporting countries for biodiesel are Argentina, based on soybean cultivation and Indonesia, with palm oil as feedstock. Indonesia is a major player in palm oil production and palm oil derived biodiesel. Same is true for the soy based biodiesel produced in Argentina. *Figure 7* depicts the cost-supply curve for 1G biodiesel for 2020 and 2030.

With the aim of meeting EU RED sustainability criteria on GHG emission savings a very restrictive estimate of sustainable potentials have been considered. Indonesian potentials are about three times those observed in Argentina. The results show much smaller export potential than for 1G EtOH but at a lower delivered cost (CIF ARA; in terms of energy) than that of 1G EtOH.

Figure 7 Cost-Supply Curve for 1G biodiesel



Source: own elaboration

Table 9 Cost-Supply Data for 1G Biodiesel

Scenario	Country	Sustainable availability to export to EU (PJ)		Average costs (€$_{2010}$/GJ)	
		2020	2030	2020	2030
BAU	AR	30	66	14.4	14.2
	ID	102	158	14.0	11.9
	Total	**132**	**224**		
B1	AR	30	66	15.1	14.9
	ID	132	205	14.7	12.5
	Total	**162**	**271**		
B2	AR	28	63	15.8	15.6
	ID	160	249	15.4	13.1
	Total	**188**	**312**		

Source: own elaboration. Note: Annex 1 summarizes methodological considerations, Annex 2 provides detailed results

3.1.3 2G EtOH

Despite the fact that the pace of advanced biofuels development is uncertain (IEA 2012) this study assumes a scenario where efforts are made to introduce 2G biofuels in the market in significant amounts.

Ukraine[9] and Brazil are the most promising 2G EtOH exporters to the EU in the medium term. Brazil has already started commercial production of 2G EtOH (see SQ Consult & IINAS 2015) since Ukraine might start developing this sector from 2020 onwards as long as favorable investment climate is created.

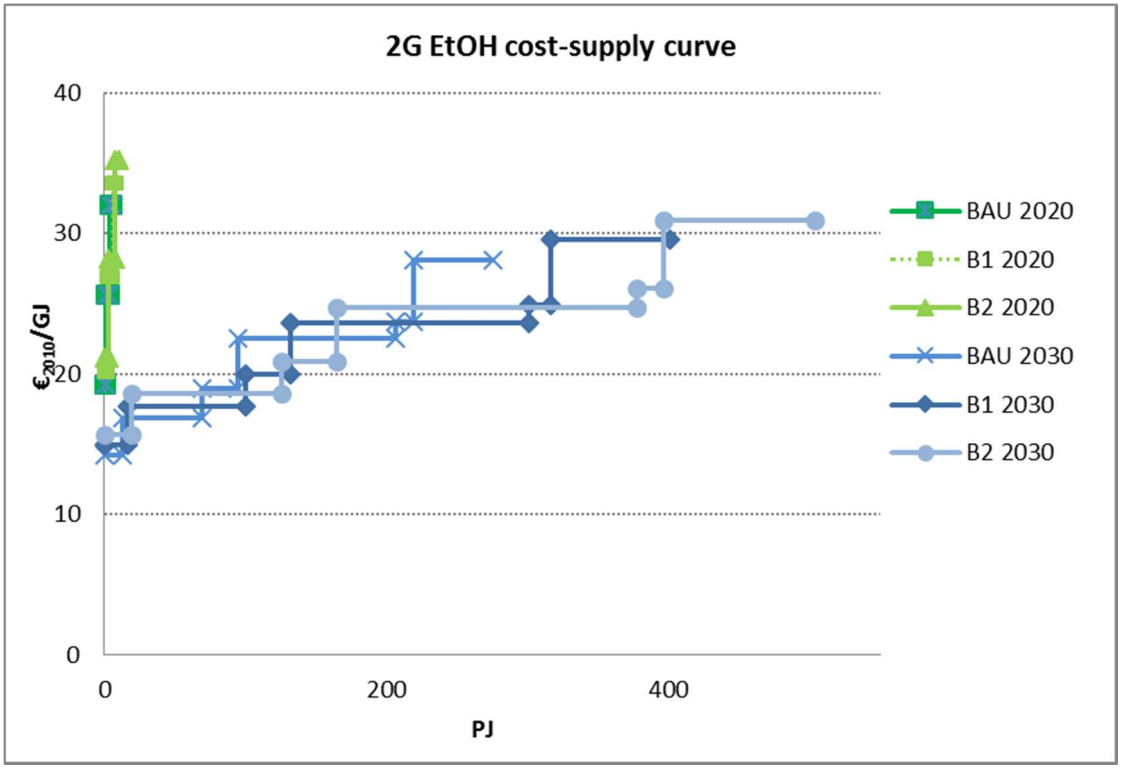
In Brazil, in addition to the additional available land, there is room to optimize the utilization of bagasse (currently used for energy cogeneration in the sugar mills) and the use of straw (de Oliveira 2012).

This results in a significant increase of 2G EtOH available to be exported by 2030 with respect to 2020.

Even if the delivered CIF ARA costs from Brazilian 2G EtOH are expected to be reduced with time, in 2030 they are expected to be a little bit higher (22.5 €$_{2010}$/GJ) than that for 1G EtOH (19.5 €$_{2010}$/GJ). The production costs in Brazil are expected to be lower than in Ukraine.

[9] This study doesn´t consider political contexts that might significantly alter the attractiveness of Ukraine to export.

Figure 8 Cost-Supply Curve for 2G EtOH



Source: own elaboration

The following table shows 2G EtOH cost supply data for Brazil and Ukraine. Please note that costs for Ukraine are delivered costs in Ukraine without including international transport to Europe. Costs given for Brazil refer to delivered costs to ARA and they refer to 1G and 2G integrated production (bagasse obtained from 1G EtOH production is processed onsite to 2G EtOH).

Table 10 Cost-Supply Data for 2G EtOH

Scenario	Country	Sustainable availability to export to EU (PJ)		Average costs (€2010/GJ)	
		2020	2030	2020	2030
BAU	BR	5	224	25.6	22.5
	UA	-	51		(19.0)
	Total	5	276		
B1	BR	8	337	26.9	23.6
	UA	-	63.9		(20.0)
	Total	8	401		
B2	BR	10	426	28.2	24.8
	UA		77		(20.9)
	Total	10	503		

Source: own elaboration. Note: Annex 1 summarizes methodological considerations, Annex 2 provides detailed results

3.2 Wood Pellets and Wood Chips

Wood pellet or chips supply potentials to the EU by 2020 and 2030 are shown in Figure 9 and Figure 10. By 2020, 627 PJ are expected to be available and 1163 PJ by 2030 in the BAU scenario. These amounts refer to total sustainable quantities available for the EU markets either as wood pellets or wood chips. Currently, US is the major player in the international trade of wood pellets to the EU and could continue playing a relevant role by 2020 and 2030, depending on local demand not only for bioenergy but also for biomaterials. East Canada is well positioned to be a major exporter to the EU28 by 2020 and 2030, given the relevant amount of natural resources (Dymond et al. 2010). This is also the case for Northwest Russia, which is endowed with high amounts of forest resources. However, the investment climate might be more risky than in other areas in the world (Rasmussen 2012) hiding the competitive advantage of cheaper fiber.

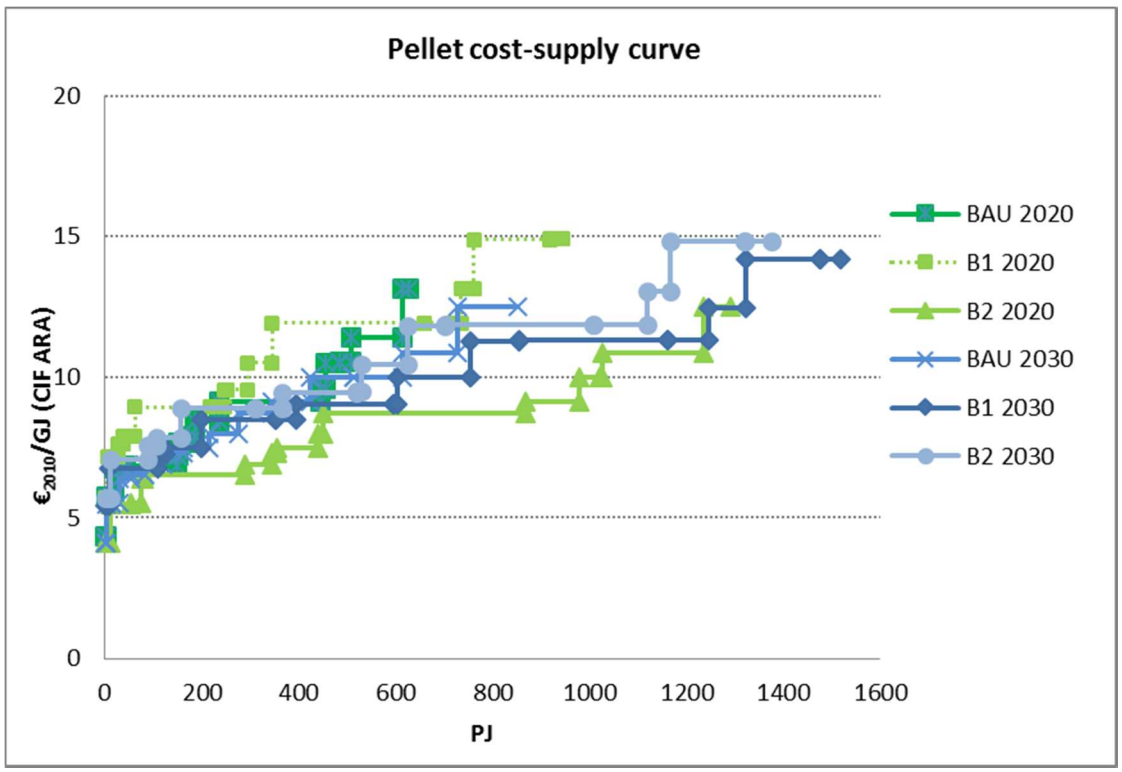
There are several feedstocks that could be subjected to pellet or wood chips production in Brazil such as forestry residues, industry residues and roundwood from dedicated short rotation plantations (or coppices), especially eucalyptus[10]. Fast growing eucalyptus roundwood might be the most promising feedstock (Junginger 2013) given the experience the country has acquired in this respect. Mozambique might also be a relevant player if part of the available land would be used for short rotation plantations.

Given the uncertainty of domestic demand for bioenergy and for wood for products in these countries, biomass available to export will depend on the biomass internally consumed (see section 2.2.1). This is particularly important in countries such as Brazil where the charcoal demand for the steel industry in the medium term is quite uncertain.

The costs for wood pellets are in accordance to those reported in the literature (i.e. Cocchi et *al*. 2012; Peng et *al*. 2010; Johansson 2012) with a range between 7.3 and 11.4 €$_{2010}$/GJ by 2020 and 6.9-10.8 €$_{2010}$/GJ 2030. The delivered CIF ARA costs of wood chips are a little bit lower: 5.8-10.5 €$_{2010}$/GJ by 2020 and 5.5-10 €$_{2010}$/GJ by 2030.

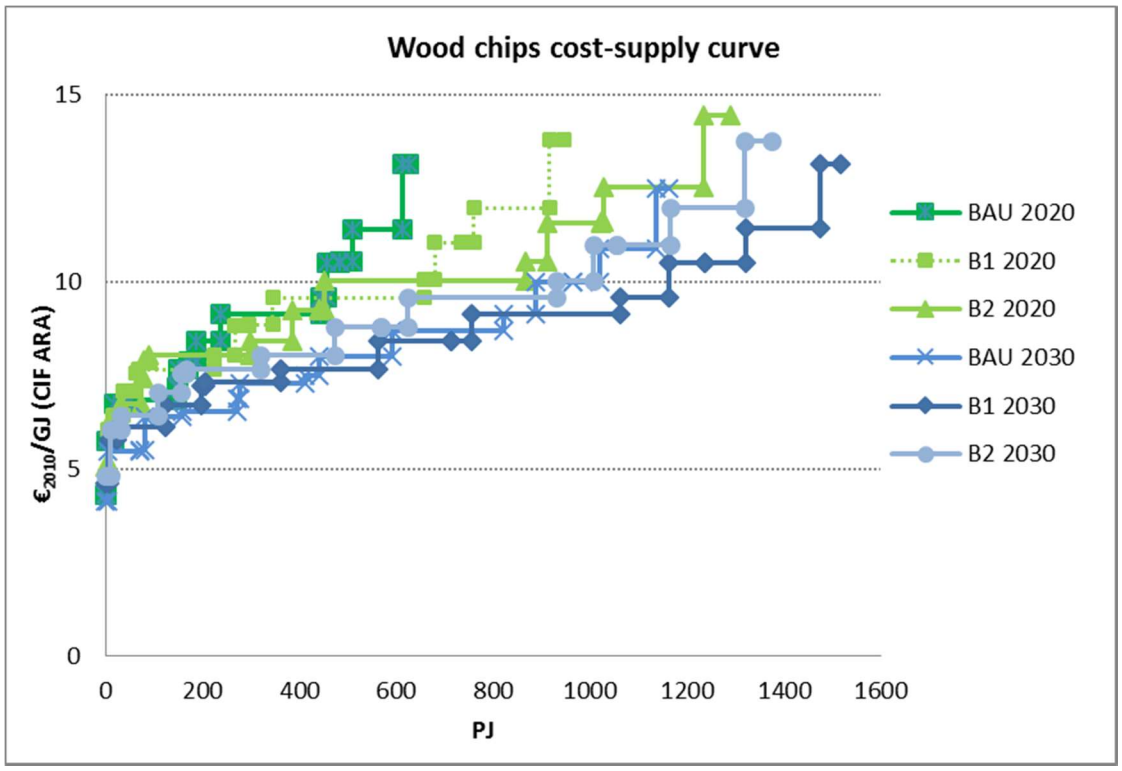
[10] See IINAS & CENBIO (2014) for a comprehensive discussion

Figure 9 Cost-Supply Curve for Wood Pellets



Source: own elaboration

Figure 10 Cost-Supply Curve for Wood Chips



Source: own elaboration

Table 11 Cost-Supply Data for Wood Pellets and Wood Chips

Scenario	Country	Sustainable availability to export to EU (PJ)		Average Costs (€2010/GJ)			
				Wood pellets		Wood chips	
		2020	2030	2020	2030	2020	2030
BAU	US - SE	101	302	10.0	9.5	8.4	8.0
	CA-E	417	461	11.4	10.8	9.1	8.7
	RU- NW	10	21	7.3	6.9	5.8	5.5
	BR	43	268	9.1	8.6	7.7	7.3
	MZ	56	111	11.4	10.8	10.5	10.0
	Total	**627**	**1,163**				
B1	US - SE	101	302	10.5	10.0	8.9	8.4
	CA-E	625	614	11.9	11.3	9.6	9.1
	RU- NW	21	31	7.6	7.2	6.0	5.8
	BR	87	402	9.5	9.0	8.0	7.7
	MZ	111	167	11.9	11.3	11.0	10.5
	Total	**945**	**1,516**				
B2	US - SE	20	191	11.0	10.5	9.3	8.8
	CA-E	833	614	12.5	11.9	10.0	9.6
	RU- NW	41	41	8.0	7.6	6.3	6.1
	BR	173	307	10.0	9.5	8.4	8.0
	MZ	223	223	12.5	11.9	11.6	11.0
	Total	**1,290**	**1,376**				

Source: own elaboration. Note: Annex 1 summarizes methodological considerations, Annex 2 provides detailed results

3.3 Biomethane

Based on the assumptions discussed in Annex 1, Figure 11 and Table 12 give an overview to the estimated biomethane export potentials from UA and (Western) RU. The sustainable availability to export to EU28 by 2020 would be 153 PJ (from Ukraine) and 1,919 PJ by 2030 (from Ukraine and Russia).

Given the political unstable situation in the Ukraine, near-term large-scale investment in biomethane production seems unrealistic.

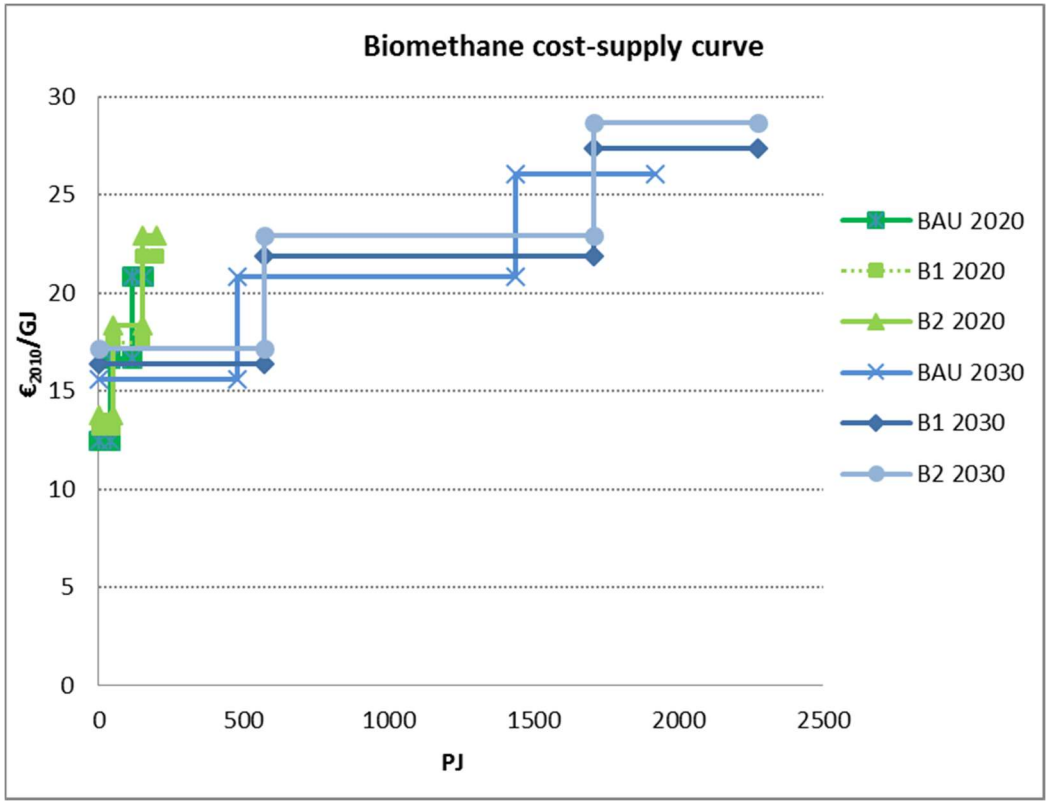
Still, increasing economic cooperation with the EU and security of supply concerns may well spur such investments from 2015 onwards. The domestic industry is getting interested in such developments (UABIO 2013a+b).

As agricultural yields are far below EU levels, and abandoned land exists in the order of be 3.5 Mha, one can expect up to 2 Mha to be suitable for biomass feedstock production (Mizgajski 2014; Geletukha 2014). Compared to the relatively small wood potentials, biogas seems a real option for possible exports.

As costs of biomethane from energy crops in the UA are estimated in the order of 15.6 €cent/kWh for 2010) and 16.7-19.4 €cent/kWh for 2030 (DBFZ 2012b+c; 2014) and natural gas import prices are in the order of 5.6 $€_{cent}$/kWh (in 2013), even drastic price increases of natural gas would make biomethane not competitive on the domestic market. Due to security of supply concerns, the UA might absorb a certain share of its biomethane potential domestically, but the majority would be available for exports to the higher-price markets of the EU28 where e.g. increasing CO_2 certificate costs would allow to pay even for costly biomethane.

There are no detailed studies for (Western) Russia other than Thrän et al. (2007) and DBFZ (2012b+c). The current political situation in Russia makes near-term (2020) foreign investments for exports unrealistic. For 2030, the prospects appear better, and up to 35% of the biogas potential could be exported to the EU, as the biogas cost is much higher than the Russian domestic gas price.

Figure 11 Cost-Supply Curve for Biomethane



Source: own elaboration

Table 12 Cost-Supply Data for Biomethane

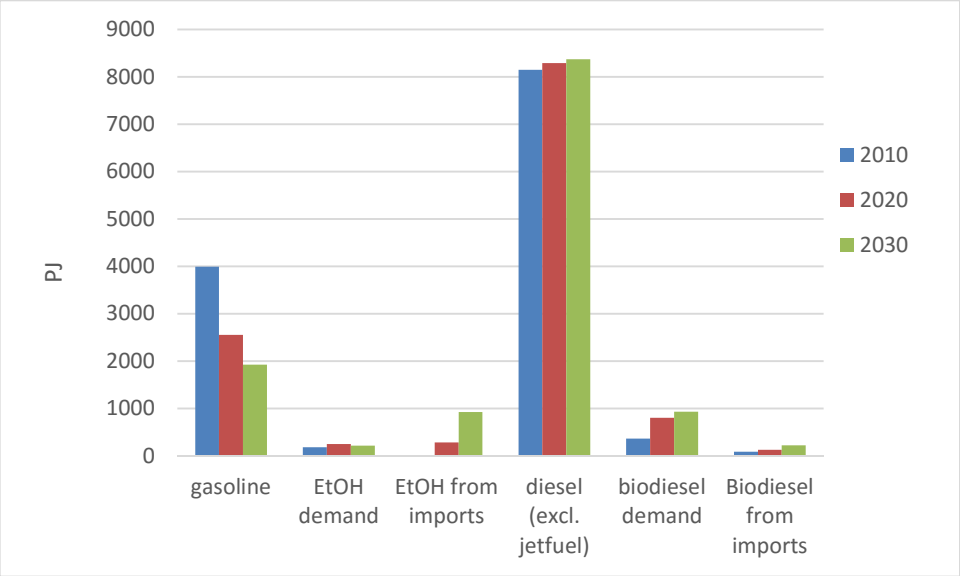
Scenario	Country	Sustainable availability to export to EU (PJ)		Average Costs (€2010/GJ)	
		2020	2030	2020	2030
BAU	RU	0	1,152		20.8
	UA	153	767	16.7	20.8
	Total	**153**	**1,919**		
B1	RU	0	1,279		21.9
	UA	200	998	17.5	21.9
	Total	**200**	**2,277**		
B2	RU	0	1,279		22.9
	UA	200	998	18.3	22.9
	Total	**200**	**2,277**		

Source: own elaboration. Note: Annex 1 summarizes methodological considerations, Annex 2 provides detailed results

3.4 Share of imports in the energy mix

In order to compare the imports resulted in this study with the potential demand expected at the EU level under the REF scenario from EC 2050 Roadmap (EC 2013), Figure 12 and Figure 13 show the results of the analysis for transport fuels and pellets.

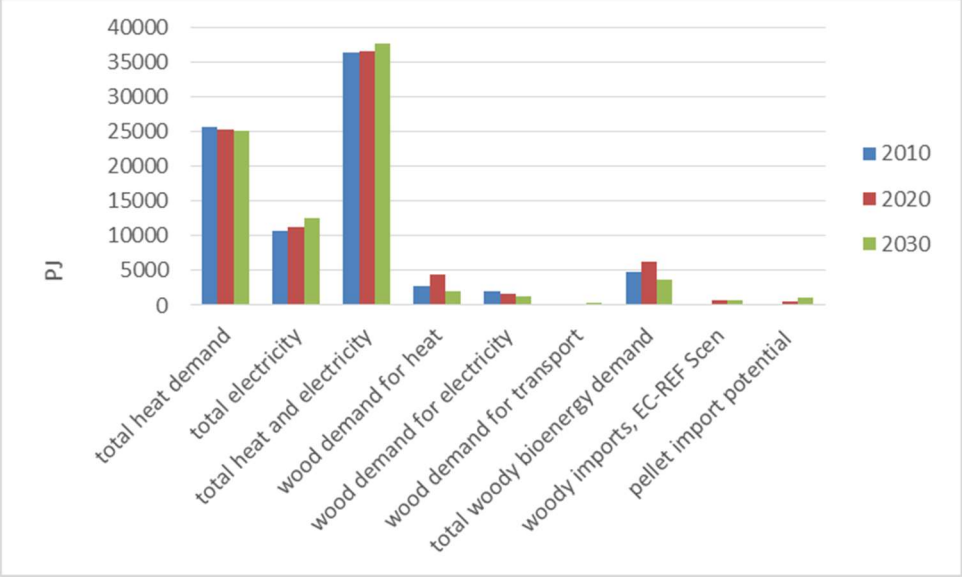
Figure 12 Key data for gasoline, diesel, and biofuel demands and imports in the EU28 by 2020 and 2030



Source: own elaboration (based on EC 2013) and own calculations

According to the results of this report, sustainable imported biofuels to EU could represent 40 % and 100 % of the biofuels demand by 2020 and 2030 respectively. With regard to EtOH (1G and 2G EtOH) imports could represent 115 % and 431 % of the demand of EtOH expected by 2020 and 2030, respectively.
For biodiesel, imports could provide 16 % and 24 % of the demand by 2020 and 2030, respectively.
The share of imported pellets might sum up to 10 % by 2020 and 31 % by 2030 of the wood demand for energy (heat, electricity and transport).
Biomethane from imports could represent 0.4 % of the total heat and electricity demand by 2020 and 5.1 % by 2030, respectively.

Figure 13 Key data for electricity, heat and bioenergy demand and pellet imports in the EU28 by 2020 and 2030



Source: own elaboration (based on EC 2013) and own calculations

References

Abt, Karen L.; Abt, Robert C.; Galik, Christopher S.; Skog, Kenneth E. (2014): Effect of policies on pellet production and forests in the U.S. South. Tech. Rep. SRS-GTR-XXX. Asheville, NC: USDA-Forest Service, Southern Research Station http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs202.pdf (Last accessed, March 1, 2016)

Alavalapati, Janaki R. R.; Lal, Pankaj; Susaeta, Andred; Abt, Robert C.; Wear, David N (2013): Chapter 10. Forest Biomass-Based Energy. In: Southern Forest Futures Project. USDA Forest Service Southern Research Station http://www.srs.fs.usda.gov/futures/technical-report/10.html#top (Last accessed, March 1, 2016)

Aranha, Mariá Almeida (2014): Export or local use of biomass, is it a dilemma? The Brazilian Case. Presentation at the International Workshop Towards sustainable international biomass trade strategies. 24 October, Brussels http://www.biotrade2020plus.eu/images/workshop_2014_brussels/9_Aranha.pdf (Last accessed, March 1, 2016)

Batidzirai, Bothwell; Faaij, André P.C.; Smeets, Edward (2006): Biomass and bioenergy supply from Mozambique. Energy for Sustainable Development 10 (1): 54-81

Cartwright, Anton (2007): Biofuels trade and sustainable development: An analysis of South African bioethanol. IIED. London http://pubs.iied.org/pdfs/G02285.pdf (Last accessed, March 1, 2016)

CENBIO (2013): Possibilities of sustainable woody energy trade and impacts on developing countries: Country Case Study Brazil. Sao Paulo http://www.iinas.org/tl_files/iinas/downloads/CENBIO_2013_Brazil-Case-Study_GIZ.pdf (Last accessed, March 1, 2016)

Chum, Helena; Faaij, Andre; Moreira José (Coordinating Lead Authors) (2011): Bioenergy. In: Edenhofer O et al. (eds.): IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Cambridge http://www.ipcc.ch/pdf/special-reports/srren/Chapter%202%20Bioenergy.pdf (Last accessed, March 1, 2016)

Cocchi, Maurizio (Coordinating author) (2011): Global Wood Pellet Industry Market and Trade Study. IEA Bioenergy Task 40: Sustainable International Bioenergy Trade. Florence etc. http://www.bioenergytrade.org/downloads/t40-global-wood-pellet-market-study_final.pdf (Last accessed, March 1, 2016)

DBFZ (2012a): Focus on Biomethane - Biomass for Energy. Leipzig http://www.energetische-biomassenutzung.de/fileadmin/user_upload/Downloads/Ver%C3%B6ffentlichungen/fh_biomethane_engl_2.pdf (Last accessed, March 1, 2016)

DBFZ (2012b): Nachhaltige Europäische Biomethanstrategie. Angelova, E u.a. in Kooperation mit Wuppertal Institut, IAMO, TU Dresden. Endbericht_03KB024A-D gefördert vom BMUB. Leipzig etc. https://www.energetische-biomassenutzung.de/fileadmin/user_upload/Steckbriefe/dokumente/Endbericht_03KB024A-D.pdf (Last accessed, March 1, 2016)

DBFZ (2012c): Brückenschlag nach Osteuropa - Biomassepotenziale und -nutzungsoptionen in Russland, Weißrussland und der Ukraine. Thrän, Daniela & Pfeiffer, Diana (Hrsg.). Schriftenreihe BMU-Förderprogramm „Energetische Biomassenutzung“. Leipzig https://www.energetische-biomassenutzung.de/fileadmin/user_upload/Downloads/Ver%C3%B6ffentlichungen/06_Osteuropa_1-70_web.pdf (Last accessed, March 1, 2016)

DBFZ (2014): Biomethane production as a development option for the Ukraine. Angelova, E & Stinner, W. Presentation at the BioGasWorld 2014, April 1-3, 2014 in Berlin https://www.dbfz.de/web/fileadmin/user_upload/Vortraege/BiogasWorld2014/09_Angelova.pdf (Last accessed, March 1, 2016)

Dymond, Caren C; Titus, Brian D; Stinson, Graham; Kurz, Werner A (2010): Future quantities and spatial distribution of harvesting residue and dead wood from natural disturbances in Canada. Forest Ecology and Management 260: 181–192

de Oliveira, Celso M (2012): The Future for Bioenergy and Biomass in Brazil; Brazilian association industry biomass and renewable energy. Brazil biomass and renewable energy http://es.slideshare.net/cmoconsultoria/the-future-biomass-and-bioenergy-brazil (Last accessed, March 1, 2016)

EC (2013): EU Energy, transport and GHG emissions trends to 2050 - Reference Scenario 2013. Capros, P; De Vita, A.; Tasios, N.; Papadopoulos, D.; Siskos, P.; Apostolaki, E.; Zampara, M. ; Paroussos, L.; Fragiadakis, K.; Kouvaritakis, N.; Höglund-Isaksson, L.; Winiwarter, W.; Purohit, P.; Böttcher, H.; Frank, S.; Havlík, P.; Gusti M.; Witzke H. P. Brussels http://ec.europa.eu/transport/media/publications/doc/trends-to-2050-update-2013.pdf (Last accessed, March 1, 2016)

EIA (undated): International Energy Statistics. US Energy Information Administration http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=5&aid=2 (Last accessed, March 1, 2016)

Elbersen, Berien; Staritsky, Igor; Hengeveld, Geerten; Jeurissen, Leonne; Lesschen; Jan-Peter (2015): Outlook of spatial biomass value chains in EU28. Deliverable 2.3 of the Biomass Policies project. Wageningen http://www.biomasspolicies.eu/?page_id=414 (Last accessed, March 1, 2016)

EMBRAPA (2009): Sugarcane Agroecological Zoning for Ethanol and Sugar production in Brazil https://www.google.es/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjg56quwJ_LAhWBPBQKHV6XBUgQFggeMAA&url=http%3A%2F%2Funica.com.br%2Fdownload.php%3FidSecao%3D17%26id%3D2553476&usg=AFQjCNG2aPGIIHX0BynAY_qbylhHxWpqIw&sig2=qSFTVXumVrXl9g9Jw2z5aA&bvm=bv.115339255,d.d24 (Last accessed, March 1, 2016)

Emerson, Kloss (2013): Bioenergy in Brazil. PANGEA-GBEP. Access to Sustainable Bioenergy Globally. Presentation at the European Parliament, 24 June, Brussels http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/2013_events/GBEP-PANGEA_event_Brussels_24_June_2013/6_-_EMERSON.pdf (Last accessed, March 1, 2016)

Eurostat (2013): European Demography; 173/2013 - 20 November http://ec.europa.eu/eurostat/documents/2995521/5167222/3-20112013-AP-EN.PDF/73c338ef-13c4-42d2-99a5-179eabff244c (Last accessed, March 1, 2016)

EurObserv'ER (2012): Solid Biomass Barometer. Brussels http://www.eurobserv-er.org/pdf/baro212biomass.pdf (Last accessed, March 1, 2016)

EurObserv'ER (2013): Biofuels Barometer. Brussels http://www.eurobserv-er.org/biofuels-barometer-2013/ (Last accessed, March 1, 2016)

EU (2009): Directive 2009/28/EC of the European Parliament and of the Council of 23 April 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. Official Journal of the EU, June 5, 2009 L 140: 16–62 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN (Last accessed, March 1, 2016)

FAO (2009): Global agriculture towards 2050. Rome www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf (Last accessed, March 1, 2016)

FAO (2010): Forest Resource Assessment. Canada. Rome http://www.fao.org/docrep/013/al472E/al472E.pdf (Last accessed, March 1, 2016)

Faostat (2014): Forestry Database http://faostat3.fao.org/home/E (Last accessed, March 1, 2016)

Festel, Gunter; Würmseher, Martin; Rammer, Christian; Boles, Eckhard; Bellof, Martin (2014): Modelling production cost scenarios for biofuels and fossil fuels in Europe. Journal of Cleaner Production 66: 242-253

FNR (2014): Leitfaden – Biogasaufbereitung und –einspeisung. Gülzow http://mediathek.fnr.de/media/downloadable/files/samples/l/e/leitfaden_biogaseinspeisung-druck-web.pdf (Last accessed, March 1, 2016)

Franke, Bernd; Fehrenbach, Horst; Reinhardt, Guido; Köppen, Susanne; Mueller- Lindenlauf, Maria; Rettenmaier, Nils; Gärtner, Sven; Münch, Julia; Malavelle, Jérôme; Otto, Martina; Leagnav, Punjanit; Faaij, André; van Eijck, Janske; Batidzirai, Bothwell; van der Hilst, Floor; Fritsche, Uwe R.; Hünecke, Katja; Hennenberg, Klaus (2013): Global Assessment Guidelines for Sustainable Liquid Biofuels Production in Developing Countries. GEF Targeted Research Project executed by UNEP, FAO, UNIDO. Heidelberg, Utrecht, Darmstadt http://www.unep.org/bioenergy/Portals/48107/publications/Global%20Assessment%20and%20Guidelines%20for%20Biofuels.pdf (Last accessed, March 1, 2016)

Geletukha, Georgiy (2014): Bioenergy in Ukraine: state of the art, prospects, barriers. Presentation at the EC-JRC/UABIO Workshop: Use of agricultural residues for bioenergy, 25 September, Kiev http://iet.jrc.ec.europa.eu/remea/sites/remea/files/files/documents/events/1._georgii_geletukha_ukraine.pdf (Last accessed, March 1, 2016)

Goh, Chun Sheng; Junginger, Martin H (Editors) (2013): Low Cost, Long Distance Biomass Supply Chains. IEA Bioenergy Task 40. Utrecht etc.

http://www.bioenergytrade.org/downloads/t40-low-cost-long-distance-biomass-supply-chains.pdf (Last accessed, March 1, 2016)

GRFA (2014): Interactive Global Biofuel Map http://globalrfa.org/biofuels-map/ (Last accessed, March 1, 2016)

Heinimö, Jussi; Junginger, Martin H (2009): Production and trading of biomass for energy – An overview of the global status. Biomass and Bioenergy 33: 1310-1320

Hetemäki, Lauri (2013): Can European Union forests supply the woody biomass needed to meet the renewable energy action plans of EU member states? Presentation at the ThinkForest–seminar, European Parliament, April 11,2013 in Brussels http://www.efi.int/files/attachments/events/2013/hetemaki_thinkforest_11_april.pdf (Last accessed, March 1, 2016)

ECF, Södra, Sveaskog, Vattenfall (2010): Biomass for heat and power. Hogan, Michael; Otterstedt, Jens; Morin, Roine; Wilde, Jonas. The Hague etc. http://www.europeanclimate.org/documents/Biomass_report_-_Final.pdf (Last accessed, March 1, 2016)

IC et al. (2012): Biomass Futures - Analysing Europe's Future Bioenergy Needs. Panoutsou, Calliope (project coordinator), Imperial College et al. London etc. http://www.biomassfutures.eu/ (Last accessed, March 1, 2016)

IEA (2008): From 1st- to 2nd-generation Biofuel Technologies: An Overview of Current Industry and RD&D Activities. Paris http://www.iea.org/publications/freepublications/publication/2nd_Biofuel_Gen.pdf (Last accessed, March 1, 2016)

IEA (2011): Biofuels for Transport: IEA Technology Roadmap. Paris www.iea.org/roadmaps (Last accessed, March 1, 2016)

IEA (2012): Technology Roadmap Bioenergy for Heat and Power. Paris http://www.globalbioenergy.org/uploads/media/1205_IEA_-_Technology_Roadmap_Bioenergy_for_Heat_and_Power_.pdf (Last accessed, March 1, 2016)

IEA (2014): IEA Energy Technology Perspectives 2014. Paris

IEA-ETSAP & IRENA (2013a): Production of Liquid Biofuels. Technology Brief P10 http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20P10%20Production_of_Liquid%20Biofuels.pdf (Last accessed, March 1, 2016)

IEA-ETSAP & IRENA (2013b): Biomass Co-firing. Technology Brief E21 http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20E21%20Biomass%20Co-firing.pdf (Last accessed, March 1, 2016)

IINAS & CENBIO (2014): Possibilities of sustainable woody energy trade and impacts on developing countries. Study commissioned by GIZ. Darmstadt, Madrid, Sao Paulo http://www.iinas.org/tl_files/iinas/downloads/IINAS_CENBIO_2014_Sust_Woody_Bioenergy_GIZ_full.pdf (Last accessed, March 1, 2016)

IINAS & IFEU (2012): Biofuels – what role in the future energy mix? Facts, trends and perspectives. Study commissioned by Shell Deutschland Oil. Fritsche, Uwe R; Fehrenbach, Horst; Köppen, Susanne; Adolf, Jörg; Liebig Dorothea. Darmstadt, Heidelberg, Hamburg http://www.iinas.org/tl_files/iinas/downloads/bio/IINAS_IFEU_2012_Shell_Biofuels_en.pdf (Last accessed, March 1, 2016)

IPCC (2012): Renewable Energy Sources and Climate Change Mitigation. Special Report of the Intergovernmental Panel on Climate Change. Edenhofer, Ottmar; Pichs-Madruga, Ramón; Sokona, Youba (Editors). New York https://www.ipcc.ch/pdf/special-reports/srren/SRREN_FD_SPM_final.pdf (Last accessed, March 1, 2016)

Johansson, Anders (2012): Export of wood pellets from British Columbia – a study about the production environment and international competitiveness of wood pellets from British Columbia. Master Thesis, Department of Forest Products, Faculty of Forest Sciences. Swedish University of Agricultural Sciences. Uppsala http://stud.epsilon.slu.se/4807/1/Johansson_A_120914.pdf (Last accessed, March 1, 2016)

Junginger, Martin H (2013): Forest carbon accounting on co-firing woody biomass – a matter of perspectives? Presentation at the Joint Workshop on Developing a Binding Sustainability Scheme for Solid Biomass for Electricity & Heat under the RED; 1-2 July 2013; Arona, Italy http://iet.jrc.ec.europa.eu/bf-ca/sites/bf-ca/files/files/documents/events/presentatie_junginger_redex_workshop_1-2_july_ispra.pdf (Last accessed, March 1, 2016)

Lamers, Patrick; Hamelinck, Carlo; Junginger, Martin; Faaij, André (2011): International bioenergy trade – A review of past developments in the liquid biofuels market. Renewable and Sustainable Energy Reviews 15 (6): 2655–2676

Mai-Moulin, Thuy; Junginger, Martin (2014): Sustainable Lignocellulosic Biomass Potentials in Mozambique and Kenya – preliminary results. Presentation at the International Workshop Towards sustainable international biomass trade strategies; 24 October, Brussels http://www.biotrade2020plus.eu/images/workshop_2014_brussels/6_Mai-Moulin.pdf (Last accessed, March 1, 2016)

Mizgajski, Jan T (2014): Possible solutions for worldwide land use change. Presentation at the IEA Bioenergy ExCo 74 Workshop: Land use and Mitigating iLUC; Brussels, October 23, 2014 http://www.ieabioenergy.com/wp-content/uploads/2014/10/P04-Possible-solutions-for-worldwide-land-use-change-Mizgajski.pdf (Last accessed, March 1, 2016)

MME (2013): Balanço Energético Nacional - Resultados Preliminares 2012. Ministério de Minas e Energia - Brazil. Rio de Janeiro https://ben.epe.gov.br/downloads/Resultados_Pre_BEN_2012.pdf (Last accessed, March 1, 2016)

NRC (2014): The State of Canada´s Forests. Annual Report 2013. Ottawa http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/35191.pdf (Last accessed, March 1, 2016)

Panichelli, Luis (2006): Anáisis de Ciclo de Vida (ACV) de la producción de biodiesel (B100) en Argentina. Trabajo Final. Universidad de Buenos Aires. Buenos Aires http://www.biodiesel.com.ar/download/ACV_Biodiesel_L_Panichelli_Tesis_UBA_FINAL.pdf (Last accessed, March 1, 2016)

PIC (2013): The Transatlantic Trade In Wood For Energy: A Dialogue on Sustainability Standards and Greenhouse Gas Emissions. Savannah (GA) 23-24 October 2014. Pinchot Institute for Conservation). Washington DC http://www.Pinchot.org/pellets (Last accessed, March 1, 2016)

Pöyry (2011): Biomass imports to Europe and global availability. Freising http://www.eurelectric.org/download/download.aspx?DocumentFileID=71444 (Last accessed, March 1, 2016)

Pöyry (2012): Biomass Pellet Prices – Drivers and Outlook. What is the worst that can happen? O´Carroll, C. Presentation at the European Biomass Power Generation; 1st-2nd October 2012. London

Pöyry (2013): Biomass Sourcing Strategies. Non-Technical Challenges of a Company Intending to Build a Demonstration/Flagship plant. Lechner, H. Presentation at the European Biofuels Technology Platform 5th Stakeholder Plenary Meeting; 6th-7th February 2013, Brussels

Pöyry (2014): The Global Pellet Market Growth prospects and market dynamics. Lechner, H. Presentation the Working Group on Dutch Sustainability Criteria for Solid Biomass 10th March 2014, Utrecht

Qian, Yifei; McDow, Will (2013): The Wood Pellet Value Chain An economic analysis of the wood pellet supply chain from the Southeast United States to European Consumers. US Endowment for Forestry and Communities http://www.usendowment.org/images/The_Wood_Pellet_Value_Chain_Revised_Final.pdf (Last accessed, March 1, 2016)

Rebiere, Michele (2013): Canadian Biomass Pellet Export Situation. Presentation at the Ag Biomass Canada Conference 22-23 August 2013, Ottawa http://www.pellet.org/images/2013-09-22_Michele_Rebiere-3.pdf (Last accessed, March 1, 2016)

Rasmussen, Eric (2012): Summary of the European Bank for Reconstruction and Development´s New Russian Forest Policy Dialogue Study. Presentation at the Northern Dimension Business Council 23 March 2012, Saint Petersburg

Rauch, Anna; Thöne, Michael (2012): Biofuels – At What Cost? Mandating ethanol and biodiesel consumption in Germany. FiFo Institute. Geneva https://www.iisd.org/gsi/sites/default/files/bf_awc_germany.pdf (Last accessed, March 1, 2016)

REN21 (2013): Renewables 2013. Global Status Report. Paris www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf (Last accessed, March 1, 2016)

Republic of Mozambique (2009): Boletim da República. Conselho de Ministros Resolução nº 22/2009 de 21 de Maio. Política e Estratégia de Biocombustíveis

Schut, Marc; Slingerland, Maja; Locke, Anna (2010): Biofuel developments in Mozambique. Update and analysis of policy, potential and reality. Energy Policy 38 (9): 5151–5165

Serates database: http://www.searates.com/reference/portdistance/ (Last accessed, March 1, 2016)

Sikkema, Richard; Steiner, Monika; Junginger, Martin; Hiegl, Wolfgang; Hansen, Morten Tony; Faaij, Andre (2011): The European wood pellet markets: current status and prospects for 2020. Biofuels, Bioproducts, and Biorefining 5: 250-278

Sikkema, Richard; Junginger, Martin; van Dam, Jinke; Stegeman, Gerben; Durrant, David; Faaij, Andre (2014): Legal & sustainable wood sourcing for bioenergy and cross compliance with certification frameworks for Sustainable Forest Management. Forests 5: 2163-2211

Smeets, Edward; Faaij, Andre (2010): The impacts of sustainability criteria on the costs and potentials of bioenergy production – Applied for case studies in Brazil and Ukraine. Biomass and Bioenergy 34: 319-333

SQ Consult & IINAS (2015): RES-T-BIOPLANT: Options for Integrating Conventional and Advanced Biofuel Production Sites. Ugarte, Sergio; Fritsche, Uwe; Iriarte, Leire. Study for IEA RETD. Barcelona, Darmstadt, Madrid http://iea-retd.org/wp-content/uploads/2016/02/20160202-IEA-RETD-RES-T-BIOPLANT.pdf (Last accessed, March 1, 2016)

Stecher, Kitty; Brosowski, André; Thrän, Daniela (2013): Biomass potential in Africa. Report for IRENA. Abu Dhabi, Leipzig https://www.irena.org/DocumentDownloads/Publications/IRENA-DBFZ_Biomass%20Potential%20in%20Africa.pdf (Last accessed, March 1, 2016)

Thiffault, Evelyne; Lorente, Miren; Murray Jessica; Fritsche, Uwe; Iriarte, Leire; Endres, Jody Michelle; McCubbins James S.N. (2014): Ecological sustainability of wood bioenergy feedstock supply chains: Local, national and international policy perspectives. Report for IEA Bioenergy Task 40 http://www.bioenergytrade.org/downloads/t40-sustainable-wood-energy-2014.pdf (Last accessed, March 1, 2016)

Thrän, Daniela; Billig, Eric; Persson, Tobias; Svensson, Mattias; Daniel-Gromke, Jaqueline; Ponitka, Jens; Seiffert, Michael; Baldwin, John; Kranzl, Lukas; Schipfer, Fabian; Matzenberger, Julian; Devriendt, Nathalie; Dumont, Mathieu; Dahl, Jonas Bochmann, Günther (2014): Biomethane: Status and Factors Affecting Market Development and Trade. A Joint Study by IEA Bioenergy Task 40 and Task 37 http://www.bioenergytrade.org/downloads/t40-t37-biomethane-2014.pdf (Last accessed, March 1, 2016)

UABIO (2013a): The Prospects of Biogas Production and Use in Ukraine, Geletukha, G; Kucheruk, P & Matveev, Y. UABIO's Position Paper N4. Kiev http://www.uabio.org/img/files/docs/position-paper-uabio-4-en.pdf (Last accessed, March 1, 2016)

UABIO (2013b): Development of Biogas Technologies in Ukraine and Germany: Regulatory and Legal Framework, Status and Prospects. Geletukha, G. Kiev, Gülzow http://www.uabio.org/img/files/news/pdf/development-of-biogas.pdf (Last accessed, March 1, 2016)

UNCTAD (2014): The State of the Biofuels Market: Regulatory, Trade and Development Perspectives. Geneva http://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=1059 (Last accessed, March 1, 2016)

UN-STATS (2014): Population and Vital Statistics Report Population, latest available census and estimates (2011 - 2012) http://unstats.un.org/unsd/demographic/products/vitstats/serATab2.pdf (Last accessed, March 1, 2016)

USDA FAS (2013): Country reports 2013 – Biofuels annual. Washington DC http://gain.fas.usda.gov/Lists/Advanced%20Search/AllItems.aspx (Last accessed, March 1, 2016)

USDA FAS (2015): EU28 Biofuels Annual 2015. Washington DC http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-28_7-15-2015.pdf (Last accessed, March 1, 2016)

van Der Hilst, Floor; Verstegen, Judith A; Karssenberg, Derek; Faaij, Andre P C (2012): Spatiotemporal land use modelling to assess land availability for energy crops – illustrated for Mozambique. GCB Bioenergy 4 (6): 859–874

van Dam, Jinke (2009): Sustainability of bioenergy chains: the result is in the details. Dissertation. Utrecht University http://igitur-archive.library.uu.nl/dissertations/2009-0504-200337/dam.pdf (Last accessed, March 1, 2016)

van den Wall Bake, J.D.; Junginger, Martin; Faaij, Andre; Poot T; Walter, Arnaldo (2009): Explaining the experience curve: Cost reductions of Brazilian ethanol from sugarcane. Biomass and Bioenergy 33: 644-658

van Eijck, Janske; Batidzirai, Bothwell; Faaij, Andre (2014): Current and future economic performance of first and second generation biofuels in developing countries. Applied Energy 135: 115-141

Walter, Arnaldo; Rosillo-Calle, Frank; Dolzan, Paulo; Piacente, Erik; Borges da Cunha, Kamlyla (2008): Perspectives on fuel ethanol consumption and trade. Biomass and Bioenergy 32: 730– 748

Wear, David N.; Prestemon, Jeffrey ; Huggett, Robert; Carter, Douglas (2013): Chapter 9. Markets. In: Southern Forest Futures Project. USDA Forest Service Southern Research Station http://www.srs.fs.fed.us/pubs/gtr/gtr_srs178.pdf? (Last accessed, March 1, 2016)

Winrock International (2009): Implications of Biofuel Sustainability Standards for Indonesia. White Paper 4. Arlington http://www.globalbioenergy.org/uploads/media/0912_Winrock_Int_-_Implications_of_biofuel_sustainability_standards_for_Indonesia.pdf (Last accessed, March 1, 2016)

Annex 1. Methodological considerations

Table 13 Main methodological considerations for 1G biofuels (1G EtOH, biodiesel and 2G EtOH) by 2020 and 2030

	1G EtOH		Biodiesel		2G EtOH	
	BR	MZ	AR	ID	BR	UA
Technical potential	25 Mha available for crops for energy purposes (sugar cane, oil palm, elephant grass, etc.) by 2030 (CENBIO 2013). This might equal to about 107,000 to 250,000 Ml of EtOH. Average estimate has been chosen, of which 40 % might be available by 2020. Ethanol production in 2012 – 23,500 Ml (MME 2013)	Land available for bioethanol production 1.87 Mha by 2030, based on Schut, Slingerland & Locke (2010). Yield increase between 2012-2030 assumed as 50 % of that in Brazil (312.5 l/ha/yr) so 156.25 l/ha/yr. Productivity 1906 l ethanol/ha/yr (own calculations based on Batidzirai, Faaij, Smeets 2006)	Averaged potential of that calculated by van Dam 2009 (7.1-13.8 Mt of crude soybean oil by 2030) with a density of 0.876 kg/l and transesterfication yield of 0.973(Panichelli 2006). In 2020, 60 % of the potential estimated for 2030	53,000 Ml (Total potential production considering high level sustainability criteria, Winrock 2009). That might increase up to 101,230 Ml if productivity increase by 91 % (by 2030) (Winrock 2009)	Depending on the 1G EtOH production	1 Mha by 2020 and 2030, based on Geletukha (2014): half of the land available for energy crops (2 Mha), equivalent to 3.14 Mtce. LHV: 21.1 MJ/l
Sustainable potential	Assumed that 80 % of the technical potential meets RED sustainability requirements	Assumed that 50 % of the technical potential meets EU RED sustainability requirements	According to van Dam (2009), most bioenergy production is from a combination of suitable and moderately suitable surplus land.	Assumed that 50 % of the figures provided by Winrock (2009) meet RED sustainability criteria.	Same as for 1G EtOH	

	1G EtOH		Biodiesel		2G EtOH	
	BR	MZ	AR	ID	BR	UA
			Assumed that 50 % is sustainable			
Production capacity	Assumed that production potential might grow by 50 % over the estimations by Walter et al. (2008)	Assumed that an annual sustainable production development could be 10 % and considering an installed capacity of 610 Ml in 2010 (Schut, Slingerland & Locke 2010)	Potential production capacity considering 2006-2014 production capacity of USDA-FAS (2013)	Potential production capacity considering 2006-2014 production capacity of USDA-FAS (2013)	Installed capacity of 2G EtOH in 2021 equals to 100 Ml and it is doubled every 2 years	Installed capacity doubled every two years, starting with 100 Ml in 2021
Sustainable potential available	Based on the potential installed capacity	Based on the potential installed capacity	Based on the sustainable potential	Based on the potential installed capacity	Based on the installed capacity basis	Based on the installed capacity basis
Potential demand for other uses than fuel (i.e. industrial)	1,100 Ml in 2011 and 3,500 Ml by 2020 (Emerson 2013). Data for 2030 calculated from the regression from 2011 to 2020	Not considered since bioeconomy is not expected to be relevant by 2030	Not considered since bioeconomy is not expected to be relevant by 2030	Not considered since bioeconomy is not expected to be relevant by 2030	No	No

	1G EtOH		Biodiesel		2G EtOH	
	BR	MZ	AR	ID	BR	UA
Domestic biofuel demand	Own calculations based on the IEA demand for the average 2° Scenario (2DS) and 6DS (962 MJ and 1233 PJ for transport will be needed by 2020 and 2030 respectively). Energy content: 21.3 MJ/l (GEMIS); Assumed that 83.33 % of the energy demand for transport would be of ethanol (E25 vs B5). Assumed that half of the 2G EtOH production is consumed domestically.	E20 by 2020 and E30 by 2030 is assumed. Gasoline consumption in 2010: 114.5 Ml (IEA database). Annual increase of 12.77 % is assumed based on the annual petroleum consumption increase between 2009 and 2013 (EIA 2014)	Own calculation based on the diesel on-road use for 2010 (USDA-FAS 2013) (893 Mt) and B10 by 2020 and 2030. 20.7 % of diesel consumption equivalent increase by 2020 (over 2010 levels) and 25.5 % by 2030 (over 2010 levels)	A constant growth to meet the national target by 2025 (10.2% share in primary energy; REN21 (2013) means that in 2020 the blending share would be 7.78 and it is assumed that the biodiesel share is 13.1 by 2030	50 % of the 2G production is consumed domestically	No, all investments are EU export oriented
Net sustainable potential for export to EU28	Calculated on a per capita basis (47.5 % of the production to the EU)	Calculated on a per capita basis (47.5 % of the production potentially available for export to the EU)	Calculated on a per capita basis (47.5 % of the production potentially available for export to the EU)	Calculated on a per capita basis (47.5 % of the production potentially available for export to the EU)	Calculated on a per capita basis for 2G EtOH (49 % of the production potentially available for export to the EU)	Calculated on a per capita basis for 2G EtOH (100 % of the production potentially available for export to the EU)

Source: own elaboration

The scenarios B1 and B2 were modifications of the BAU scenario.

For the B1 scenario all parameters and calculations were maintained, with the exception of the sustainable potential assumed. In this case, the authors assumed that the production capacity could by increased by + 25 % with respect to the BAU scenario. If this result was higher than the sustainable potential, then, the sustainable potential was taken as the amount of biofuels available. The logic and assumptions of further steps

such as the domestic demand for biofuels and other products as well as the amount of biofuels available to be exported to the EU followed the same logic and assumptions.

In the B2 scenario the production capacity was assumed to increase by + 50 % with respect to the BAU scenario. If this result was higher than the sustainable potential, then, the sustainable potential was taken as the amount of biofuels available. In this scenario, the domestic demand for biofuels was increased by 10 % in comparison to the BAU scenario. The logic and assumptions of further steps such as the demand for other products and the amount of biofuels available to be exported to the EU followed the same logic and assumptions.

Table 14 Main methodological considerations for wood pellets and wood chips by 2020 and 2030

	Countries				
	US	**East CA**	**NW RU**	**BR**	**MZ**
Methodology overview	All resources and respective demands considered. Full woody potentials (industrial roundwood, residues, etc.) and demands (energy, products) considered.	Only potentials and demands for bioenergy (and bioeconomy).	Only potentials and demands for bioenergy (and bioeconomy) without considering domestic demands which are assumed to be covered with other resources than those considered for bioenergy. Only Northwest region considered (see Thiffault et al. 2014)	All resources and respective demands considered. Full woody potentials (industrial roundwood, residues, etc.) and demands (energy, products) considered.	Only potentials and demands for bioenergy (and bioeconomy) without considering domestic demands which are assumed to be covered with other resources than those considered for bioenergy

	Countries				
	US	**East CA**	**NW RU**	**BR**	**MZ**
Technical potential	Based on Pöyry (2014) (current resources and wood flows), Wear et al. (2013) (expected increase in forest resources) and Alavalapati et al. (2013) for urban wood waste. Averaged values have been chosen.	Only potentials from forest harvesting residues and natural disturbances in the East Provinces have been considered based on Dymond et al. (2010) assuming that roundwood will be used for wood products . Total national forest biomass availability: 248 Mt of harvesting residues plus biomass from natural disturbances (Dymond et al. 2010). Population in the East provinces (from Ontario to the East, 69 % of the total population in the country in 2013) (Wikipedia 2014). Harvest levels for products in 2004-2005 about 200 Mm^3 (138 Mt) (NRC 2013).	Not relevant since forest resources in the Northwest region are huge so they are not a limiting factor (see Thiffault et al. 2014)	Roundwood from plantations and natural forests considered. Similar harvesting levels in natural forests and current plantations for 2020 and 2030 plus the entrance of 1 Mha of forest plantations into production by 2020 and 5 M ha of forest plantations by 2030.	Based on Batidzirai, Faaij & Smeets (2006) and Mai-Moulin & Junginger (2014). Only surplus land available to cultivate energy crops considered
Sustainable potential	95 % of the technical potential is considered sustainable potential by 2020 and 2030	Same as technical potential since Dymond considering a factor discount of 50 %	Based on Thiffault et al. (2014) and Sikkema et al. (2014). Ambitious sustainability requirement estimations from Sikkema et al. (2014) considered	90 % of the technical potential by 2020 and 2030.	Assumed that 4.5 % of the total potential might be used for wood pellet production

	Countries				
	US	**East CA**	**NW RU**	**BR**	**MZ**
Production capacity	Extrapolated from the imports to EU in the period 2009-2013 as reported by USDA-FAS (2013) and increased by 25 % since this rate is considered as sustainable	Total production capacity based on the imports in the period 2009-2012 as reported by USDA-FAS (2013) and increased by 25 % since this rate is considered as sustainable. 50 % of the total installed capacity in the country is assumed to be in the East Coast.	Extrapolated from the imports in the period 2009-2012 as reported by USDA-FAS (2013) and increased by 25 % since this rate is considered as sustainable	Based on projections from Junginger (2013) up to 2020 and own extrapolation to 2030.	Based on the imports from third countries in the period 2009-2012 as reported by USDA-FAS (2013) and increased by 25 % since this rate is considered as sustainable
Domestic demand for bioenergy	Averaged data (6DS and 2DS) based on IEA (2014) and assuming that the share of woody biomass in electricity is 85 %; in residential heat, industry and biorefineries is 100 % (no woody biomass) consumed in transport. Domestic demand calculated on a per capita basis, assuming that population in the US SE is 35.45 % of the total US population for all sectors. For residential heat only 10% of the national domestic demand is allocated in the US SE.	Averaged data (6DS and 2DS) based on IEA (2014) and assuming that the share of woody biomass in electricity is 85 %; in residential heat, industry and biorefineries is 100 % (no woody biomass) consumed in transport	Not relevant	Averaged data (6DS and 2DS) based on IEA (2014) and assuming that the share of woody biomass in electricity is 85 %; in residential heat, industry and biorefineries is 100 % (no woody biomass) consumed in transport	Not relevant

	Countries				
	US	**East CA**	**NW RU**	**BR**	**MZ**
Domestic demand for materials	Estimated constant demand for products at the 2007 level (Abt et al. 2014)	Estimated constant at 2004-2005 levels, i.e. 200 Mm^3 (NRC 2013)	Not relevant	Based on own projections of industrial roundwood demand from historical data (1995-2013) (Faostat 2014)	Not relevant
Available biomass that could be exported	100 % of the sustainable potential available by 2020 and 2030	50 % of the sustainable potential available by 2020 and 75 % by 2030	25 % of the sustainable potential available by 2020 and 50 % by 2030	25 % of the sustainable potential available by 2020 and 50 % by 2030	25 % of the sustainable potential available by 2020 and 50 % by 2030
Net sustainable potential for export to EU28	Calculated on a per capita basis (74 % of the production potentially available for export to the EU)	Calculated on a per capita basis (74 % of the production potentially available for export to the EU)	Calculated on a per capita basis (74 % of the production potentially available for export to the EU)	Calculated on a per capita basis (74 % of the production potentially available for export to the EU)	Calculated on a per capita basis (74 % of the production potentially available for export to the EU)

Source: own elaboration

As for biofuels, the scenarios B1 and B2 were modifications of the BAU scenario.

The main modification in the B1 scenario with respect to the BAU scenario was the available biomass to be exported. In this case, the production capacity was increased by 25 % with respect to the BAU scenario. This means that in East Canada, the available biomass to be exported would be 75 % and 100 % by 2020 and 2030 respectively and for North West Russia, Brazil and Mozambique 50 % and 75 % by 2020 and 2030. The logic and respective assumptions for the rest of the parameters were maintained constant. In the B2 scenario the production capacity was assumed to increase until 100 % in all countries selected and time horizons.

Table 15 Main methodological considerations for biomethane by 2030

	Biomethane	
	RU (NW)	UA
Sustainable Potential	Based on Thrän et al. (2007); DBFZ (2012b+c; 2014). Assumed that fallow land to be used for energy crops is 5 Mha by 2030; 50 % of potential would be available for biomethane from maize and 25 % of the biomethane from SNG (wood)	Based on Thrän et al. (2007); DBFZ (2012b+c; 2014). Assumed that fallow land to be used for energy crops is 1 Mha by 2020 and 3 Mha by 2030 with a mix of grass and maize
Potential demand for other uses than fuel (i.e. industrial)	Only land not in competition, and small share of residues used	Only land not in competition, and small share of residues used
Net sustainable potential for export to EU28	All exports potentially available for export to EU28	All exports potentially available for export to EU28

Source: own elaboration

For both B1 and B2 scenarios, in Russia the sustainable potential reaches the maximum availability in the BAU. In Ukraine the sustainable potential increases by 30 % with respect to BAU in the B1 and B2 scenarios.

Table 16 Costs assumptions for biofuels (1G ethanol, 1G biodiesel and 2G ethanol) in the BAU scenario

Type of costs	Assumptions
Production and processing costs	Own calculations based on van Eijck, Batidzirai & Faaij (2014)
Transport costs to the harbor	5% of the production costs
Load costs and shipment to CIF ARA	Load costs assumed constant @ 40 % of the transport costs. Transport costs calculated based on the distance from major shipping ports to ARA (Serates 2014) and assuming proportional costs as those reported by Goh & Junginger (2013) for palm oil shipping from Malaysia.
Certifiaction costs	Average certification cost (strict criteria) for SRC production in UA and BR: 2.2 €/GJ (Smeets & Faaij 2010); Rauch & Thöne (2012) report various values. A 4 % increase in total cost is assumed due to certification for all countries and biofuel carriers.

Source: own elaboration

Table 17 Costs assumptions for wood pellets and chips in the BAU scenario

Costs categories	Assumptions
Delivery costs	Based on Pöyry (2011). Reduction in costs from 2010 to 2020 for pellets 5 % and for wood chips 20 %. Reduction of 5% in costs from 2020 to 2030 for both wood pellets and wood chips.
Certification costs	Assumed 4 % of the delivered cost

Source: own elaboration

Table 18 Biomethane assumptions about costs

Costs categories	Assumptions
Delivery costs	Own assumptions based on DBZF (2014)

Source: own elaboration

To take into account the variability of costs of ll bioenergy carriers, once the average total cost was calculated considering the assumptions above, the following assumptions were taken into account:

- 25 percent of the feedstock for each country and time frame could be supplied at a 75 percent of the average cost.
- 50 percent of the feedstock for each country and time frame could be supplied at the average cost.
- 25 percent of the feedstock for each country and time frame could be supplied at a 125 percent of the average cost.

In the B1 and B2 scenarios, costs increase by 5 percent and 10 percent in relation to BAU respectively. The distribution in costs for each scenario was assumed as in the BAU scenario.

Annex 2. Detailed results

Table 19 Total EU28 demand for biofuels and bioliquids, in PJ (from EC 2050 Roadmap, REF scenario) and related demand

Demand in (PJ)	2010	2020	2030
All transport fuels	**15,374**	**15,031**	**14,818**
gasoline	**3997**	**2555**	**1926**
EtOH demand	180	248	215
EtOH from impots	10	286	926
diesel	**8148**	**8290**	**8372**
biodiesel demand	368	804	934
Biodiesel from imports	90	132	224
total biofuel	**548**	**1052**	**1148**
Potential import shares for BAU:			
EtOH demand		115%	431%
Biodiesel demand		16%	24%
Total biofuels		40%	100%

Source: own elaboration (based on EC 2013) and own calculations

Table 20 Total EU28 demand for heat and electricity, in PJ (from EC 2050 Roadmap, REF scenario) and related demand

data for REF (BAU) Scenario	2010	2020	2030
Total heat demand	25,690	25,265	25,055
Total electricity	10,723	11,282	12,620
Total heat and electricity	**36,413**	**36,547**	**37,675**
Wood demand for heat	2,765	4,484	2,030
Wood demand for electricity	1,946	1,727	1,249
Wood demand for transport	0	41	438
Total woody bioenergy demand	**4,711**	**6,253**	**3,718**
Woody imports, EC-REF Scen	108	647	734
Pellet import potential		**627**	**1,163**
Potential pellet import share		10 %	31 %
Biomethane		153	1,919
Biomethane import potential share over total heat and electricity)		0.42	5.09

Source: own elaboration (based on EC 2013) and own calculations

Table 21 Cost-supply data for 1G EtOH (for the BAU scenario)

Country	Availability 2020 (PJ)	Availability 2030 (PJ)	Costs 2020 (€2010/GJ)	Costs 2030 (€2010/GJ)
BR (total)	**267**	**611**		
	67	153	16.35	14.63
	134	305	21.80	19.50
	67	153	27.25	24.38
MZ (total)	**14**	**39**		
	4	10	18.08	17.25
	7	20	24.10	23.00
	4	10	30.13	28.75

Source: own elaboration

Table 22 Cost-supply data for biodiesel (for the BAU scenario)

Country	Availability 2020 (PJ)	Availability 2030 (PJ)	Costs 2020 (€2010/GJ)	Costs 2030 (€2010/GJ)
AR (total)	**30**	**66**		
	8	16	10.80	10.65
	15	33	14.40	14.20
	8	16	18.00	17.75
ID (total)	**102**	**158**		
	25	39	10.50	8.93
	51	79	14.00	11.90
	25	39	17.50	14.88

Source: own elaboration

Table 23 Cost-supply data for 2G EtOH (for the BAU scenario)

Country	Availability 2020 (PJ)	Availability 2030 (PJ)	Costs 2020 (€2010/GJ)	Costs 2030 (€2010/GJ)
BR (total)	**5**	**224**		
	1	56	19.20	16.88
	3	112	25.60	22.50
	1	56	32.00	28.13
UA (total)	**0**	**51**		
	0	13		14.25
	0	26		19.00
	0	13		23.75

Source: own elaboration

Table 24 Detailed results for 1G Biofuels (PJ)

Scenario	Parameters	1G EtOH				Biodiesel				2G EtOH			
		BR		MZ		AR		ID		BR		UA	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
BAU	Technical potential	2021	4302	138	201	229	382	1049	1749	0	0	92	92
	Sustainable potential	1617	3442	69	100	115	191	525	875	0	0	0	0
	Market Potential	1428	1981	34	87	306	519	254	401	21	916	0	51
	Sustainable potential available	1428	1981	34	87	115	191	254	401	21	916	0	51
	Potential demand for other uses than fuel (i.e. industrial)	75	126	0	0	0	0	0	0	0	0	0	0
	Domestic biofuel demand	791	569	3	5	51	53	40	69	11	458	0	0
	Net sustainable potential that could be exported	563	1286	30	83	64	138	215	332	11	458	0	51
	Net sustainable potential for export to EU28	267	611	14	39	30	66	102	158	5	224	0	51
B1	Net sustainable potential that could be exported	1617	2476	42	100	115	191	318	501	27	1145	0	64

Scenario	Parameters	1G EtOH				Biodiesel				2G EtOH			
		BR		MZ		AR		ID		BR		UA	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
	Net sustainable potential for export to EU28	357	846	18	45	30	66	132	205	8	337	0	64
B2	Domestic demand for biofuels	870	626	4	5	56	58	43	76	12	504	0	0
	Net sustainable potential that could be exported	1617	2971	51	100	115	191	381	601	32	1374	0	77
	Net sustainable potential for export to EU28	319	1054	22	45	28	63	160	249	10	426	0	77

Source: own elaboration

Table 25 Cost-supply data for wood pellets and wood chips

	Wood pellets and wood chips availability		Wood pellets		Wood chips	
Country	**Availability 2020 (PJ)**	**Availability 2030 (PJ)**	**Costs 2020 (€2010/GJ)**	**Costs 2030 (€2010/GJ)**	**Costs 2020 (€2010/GJ)**	**Costs 2030 (€2010/GJ)**
US SE (total)	**101**	**302**	**10.0**	**9.5**	**8.4**	**8.0**
	25	76	7.5	7.1	6.7	6.4
	51	151	10.0	9.5	8.4	8.0
	25	76	12.5	11.9	10.5	10.0
CA (total)	**417**	**461**	**11.4**	**10.8**	**9.1**	**8.7**
	104	115	8.5	8.1	6.8	6.5
	208	230	11.4	10.8	9.1	8.7
	104	115	14.2	13.5	11.4	10.9
RU (total)	**10**	**21**	**7.3**	**6.9**	**5.8**	**5.5**
	3	5	5.4	5.2	4.3	4.1
	5	10	7.3	6.9	5.8	5.5
	3	5	9.1	8.6	7.2	6.9
BR (total)	**43**	**268**	**9.1**	**8.6**	**7.7**	**7.3**
	11	67	6.8	6.5	5.7	5.5
	22	134	9.1	8.6	7.7	7.3
	11	67	11.4	10.8	9.6	9.1
MZ (total)	**56**	**111**	**11.4**	**10.8**	**10.5**	**10.0**
	14	28	8.5	8.1	7.9	7.5
	28	56	11.4	10.8	10.5	10.0
	14	28	14.2	13.5	13.1	12.5

Source: own elaboration

Table 26 Detailed results for wood pellets and wood chips (PJ)

Scenario	Parameters	US		CA East		NW RU		BR		MZ	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
BAU	Technical potential	3,457	4,173	1,538	1,538			4,363	5,954	6,670	
	Sustainable potential	3,284	3,965	1,538	1,538	56	56	3,927	5,359	301	301
	Domestic wood demand for bioenergy (including biorefineries)	1,094	1,503	411	708			2,417	3,110		
	Domestic wood demand for materials	2,054	2,054					1,275	1,523		
	Sustainable potential to be exported	137	408	1,127	830	56	56	234	725	301	301
	Market potential (as percentage of the sustainable potential)	100%	100%	50%	75%	25%	50%	25%	50%	25%	50%
	Net sustainable potential for export to EU28	101	302	417	461	10	21	43	268	56	111
B1	Sustainable potential to be exported	137	408	1,127	830	56	56	234	725	301	301

Scenario	Parameters	US		CA East		NW RU		BR		MZ	
		2020	2030	2020	2030	2020	2030	2020	2030	2020	2030
	Market potential (as percentage of the sustainable potential)	100%	100%	75%	100%	50%	75%	50%	75%	50%	75%
	Net sustainable potential for export to EU28	101	302	625	614	21	31	87	402	111	167
B2	Domestic demand for bioenergy and biorefineries	1,203	1,653	452	779	0	0	2,659	3,421	0	0
	Sustainable potential that could be exported	27	258	1,127	830	56	56	234	414	301	301
	Net sustainable potential for export to EU28	20	191	833	614	41	41	173	307	223	223

Source: own elaboration

Table 27 Cost-supply data for biomethane

Country	Availability 2020 (PJ)	Availability 2030 (PJ)	Costs 2020 (€cent$_{2010}$/kWh)	Costs 2030 (€cent$_{2010}$/kWh)
RU (total)	**0**	**1,152**		
	0	288		5.6
	0	576		7.5
	0	288		9.4
UA (total)	**153**	**767**		
	38	192	4.5	5.6
	77	384	6.0	7.5
	38	192	7.5	9.4

Source: own elaboration

Table 28 Detailed results for biomethane (PJ)

Scenario	Parameters	RU		UA	
		2020	2030	2020	2030
BAU	Sustainable Potential	0	1,152	153	767
	Potential demand for other uses than fuel (i.e. industrial)	0	0	0	0
	Net sustainable potential for export to EU28	0	1,152	153	767
B1	Available biomethane to be exported	0	1,279	200	998
	Net sustainable potential for be export to EU28	0	1,279	200	998
B2	Available biomethane to be exported	0	1,279	200	998
	Net sustainable potential for export to EU28	0	1,279	200	998

Source: own elaboration