Bio-based Economy in the EU-27:

A first quantitative assessment of biomass use in the EU industry

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This paper presents the first ever collection and analysis of data on the bio-economy at an EU-27 level. It gives a rough overview of the quantitative dimensions of Europe's bio-based economy with a focus on industrial material use of biomass. The paper is divided into three parts: The first section explains the methodology and definitions that constitute the basis of the research and a short review of existing literature. This is then followed by a depiction of market data of the bio-based sector. EUROSTAT data was used to calculate the volume of biomass flows that are used industrially as well as the different macro-economic effects generated by several bio-based industries. This part also includes an overview of the current situation on the market of bio-plastics and bio-composites. As a last part, a survey of company communications and news has been conducted in order to assess the number, financial volume and target regions of investments done by European companies in industrial biotechnology.

It must be noted that there is a huge demand for research, seeing as basic data on this sector is mostly not available. This paper is only a first draft and needs to be extensively expanded and elaborated upon. It should be considered as a first step. For this, existing research on certain EU member states has been up-scaled to EU-27 dimensions, experts from associations have given their input and statistical data from official sources have been evaluated. In most cases, the bio-based share of an industrial branch is based on estimations by experts, since official numbers do not exist. The methodologies that were used will be explained further in each respective chapter.

Call for Feedback: Any contributions that can help elaborating on this paper are most welcome. If you or your organisation has access to better and more detailed data on the mentioned sectors, please do not hesitate to contact us and let us know. This is a work in progress and we will be happy to include any new information.

1. Methodology, definitions, review of existing literature

1.1. Definitions

First, we shall define the basic terms that will be essential for our research:

Biomass and biogenic raw materials, renewable resources and biogenic residues

The definition of "biomass" is based on Kaltschmitt et al. 2009:

The term "biomass" describes all substances that are of organic origin and not of fossil origin.

According to this definition, biomass includes:

- Naturally occurring phyto- and zoomass (plants and animals);
- Residues produced by these (e.g. animal excrement);

- Dead, but not yet fossil, phyto- and zoomass (e.g. straw); peat is explicitly excluded from this project;
- More generally, any substances that occur due to technical processing or the production of materials (e.g.
- black liquor, paper, abattoir refuse, organic domestic waste, vegetable oils, alcohol).

Since for our purposes we are only considering biomass that can be used as a raw material, we shall define "renewable raw materials" following Carus et al. 2010:

Renewable raw materials comprise the totality of plant, animal and microbial biomass, including biomass delivered through food chains, whose primary production is based on photosynthesis and which are provided for material and energy uses of all kinds outside food and feed.

… and also the term "industrial material use".

In "material use" the biomass serves as raw material for the (industrial) production of all kinds of goods as well as their direct use in products. This clearly distinguishes it from energy use, in which the biomass serves purely as an energy source."

Cascade utilization

The following definition of cascade utilization reflects its use by Arnold et al. 2009 (Wuppertal Institute):

"Cascade utilization" is the sequential use of biogenic raw materials to produce materials and energy.

According to this definition, "raw material" can describe the original raw material (primary crop, oilseed, etc.) as well as a co- or by-product, as long as it is used sequentially (in a "cascade"). Recycling processes are mainly sequential and can therefore be considered as cascade utilization.

The understanding of the German Federal Enviroment Agency (UBA 2012) expands the definition towards a key area:

"A strategy for using raw materials or the products made from them in chronologically sequential steps as long, often and efficiently as possible for materials and only to recover energy from them at the end of the product life cycle. It is based on the use of so-called 'cascades of use' that flow from higher levels of the value chain down to lower levels, increasing the productivity of the raw material."

Examples of cascade utilizations:

- Cascade utilization of wood: Wood, as a raw material, is used sequentially for materials and then for energy use (e.g. solid wood furniture, chipboard, recycled chipboard, burning);
- Cascade utilization of glycerine: Glycerine, as a raw material and by-product of biodiesel production, is used sequentially for materials and then for energy use (e.g. epichlorohydrin for epoxy resin, burning).

System boundaries

When looking at the economic dimensions of the industrial material use of biomass, we considered the distinct structure of the sector: The analysis of material flows through complex and sometimes interacting supply chains raises questions about the identification of suitable system boundaries and partitioning of resource flows from raw material production, intermediate products, through to consumer products while avoiding double counting. **This paper comprises analyses that consider all flows from renewable raw materials (from domestic cultivation and imports) and the flows arising from semi-finished products imported for further processing in the European industry.**

1.2. Methodology

The following section reviews existing studies on the structure of the biobased economy in Europe and its effects in terms of turnover and employment. In general, the data basis is weak and mostly relies on industry and expert estimations. In order to improve these estimations, I propose a framework which systematically starts with the available biomass, then derives the actually used raw materials from this biomass and finally assesses the distribution of uses of these raw materials between materials, energy and food & feed. The primary data for the available biomass was obtained from official statistics (Eurostat and trade data from DG Trade). However, the data basis for the assessment of uses of the different raw materials still remains weak (often not even the right categories are existing), therefore the results presented below must be understood as a first estimation. A thorough assessment of each raw material would require an extensive amount of time.

In several studies, the nova-Institute has conducted such a thorough assessment for Germany and has produced biomass flowcharts for each raw material. As an example, Annex I shows the flowchart for sugar and starch. Ideally, such flowcharts should also be produced for Europe.

1.3. Overview of existing literature

This section provides an overview of existing published data on the bio-based sector in the EU. There is no claim on completeness of this collection of literature; however, the most prominent and often quoted works are included. The list of references at the end of the document includes also a commentary giving a very brief overview on what each document contains.

Generally it must be said that the existing data on the bio-based economy in the EU-27 is severely limited. Some studies give very detailed insights into the technical or even legal aspects of certain sectors – such as IEA Bioenergy 2012 and Nieuwenhuizen et al. 2009 on bio-chemicals, Star-COLIBRI 2011 on bio-refineries or EuropaBio / Ernst & Young 2012 on the legal frameworks for investments in biotechnology in the EU member states. However, sources that paint the big picture while still giving exact numbers are rare. As a rule, there are no official data on the shares that bio-based products make up of certain industry

branches. Mostly, everyone relies on the estimations of experts when calculating to which extent economic effects are reached by bio-based processes.

The KBBE final report (Clever Consult 2010) counters these tendencies to some point. The study comprises a compact table that gives an overview of different economic variables for several bio-based sectors.

Sector	Annual turnover (billion Euro)	Employment (thousand)	Data source
Food	965	4400	CIAA
Agriculture	381	12000	COPA-COGECA Eurostat
Paper/Pulp	375	1800	CEPI
Forestry/Wood ind.	269	3000	CEI-BOIS
Biobased products			
▪ **Chemicals and plastics**	50 (estimation*)	150 (estimation*)	USDA[3] Arthur D Little[4] Festel[5] McKinsey[6] CEFIC
▪ **Enzymes**	0.8 (estimation*)	5 (estimation*)	Amfep Novozymes, Danisco/Genencor, DSM
▪ **Biofuels**	6**	150	EBB eBio
Total	**2046**	**21505**	

* estimation for Europe for 2009
** estimation based on a production of 2.2 million tonnes bioethanol and 7.7 million tonnes biodiesel at average market price in Europe

Table 1: Turnover and employment KBBE sectors in Europe, 2009 (Source: Clever Consult 2010)

These data are often quoted by other studies and in some cases extended (e.g. the sector "fisheries" has been added in EuropaBio / Ernst & Young 2012). It has also been a basis for this report and the following sections aim to further improve these numbers and to assess the structure of the bio-based economy in more detail.

2. Overview of the bio-based sector in the EU-27

The following sections provide my initial results regarding the structure of the biobased economy in the EU-27. Since the material biomass sector is much more diverse and much less well studied than the energy sector, Section 2.1 first highlights the general structure of biomass flows and their uses in material applications in Europe. Since the nova-Institute had already conducted a large study on this topic for Germany while the data basis for Europe is quite weak, this section gives also examples for the material

use in Germany. Section 2.2 then attempts to provide an economic assessment of the bio-based industry in the EU-27, mainly in terms of the industry structure, employment and turnover.

2.1. Biomass flows and their uses in material applications

The bio-based economy is made up of a multitude of different product lines and applications, including several intermediate products and process chains. The following pictures give an impression of the volume of biomass flows in the EU-27 and how they are used, including domestic production and imported biomass. It is an update of the existing work on the German bio-based economy by Raschka et al. 2012 and was up-scaled to EU-27 levels according to expert estimations as well as to data from Mantau et al. 2010 and USDA 2011. It is very interesting to see that the material use of biomass exceeds the energetic use of biomass in volume, since popular opinion expects quite different results in most cases (see the below text for an explanation of the numbers shown in Figure 1).

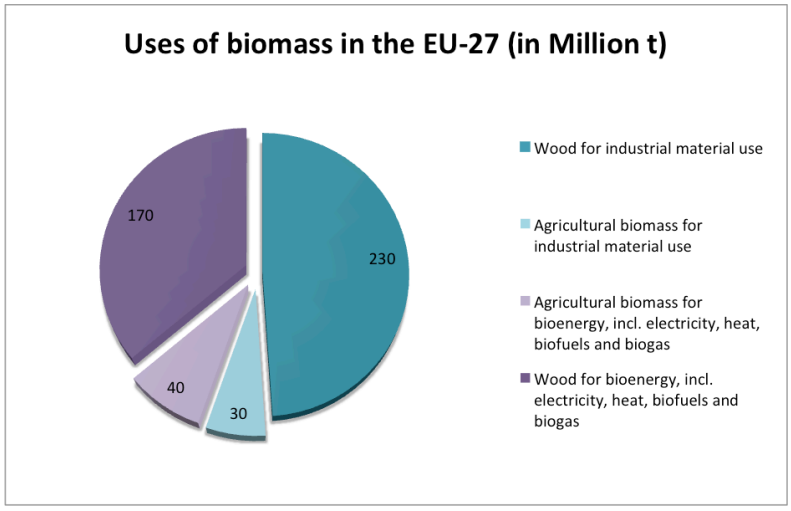
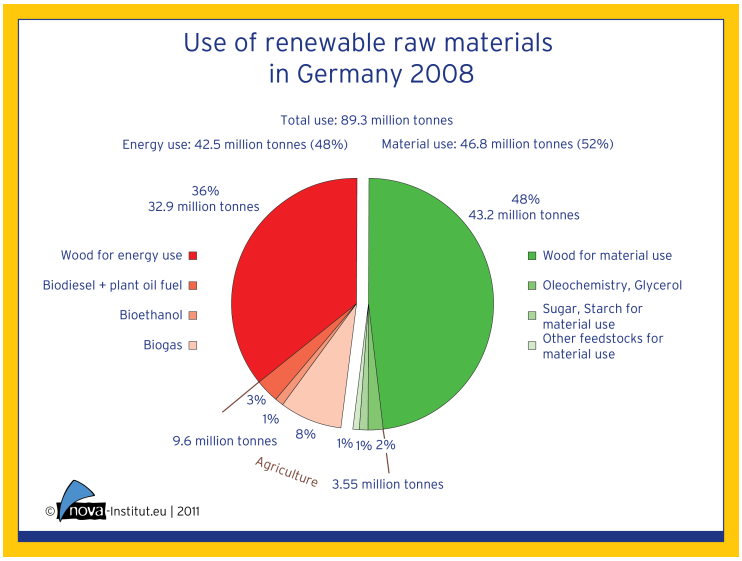


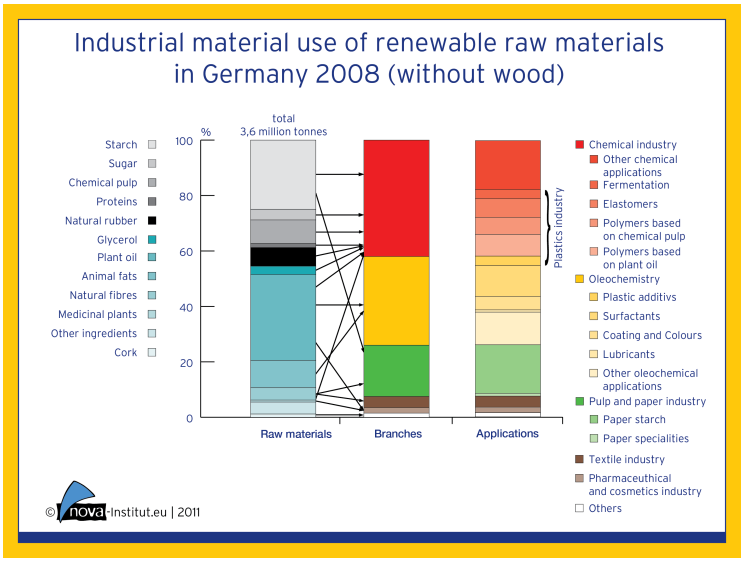
Figure 1: Use of biomass for energy and material use in the EU-27 New data from primary research

Sources:
- Agricultural biomass for industrial material use: estimations by Carus 2012 based on USDA 2011 and data from Germany, adapted to EU-27
- Agricultural biomass for energy: USDA 2011 and estimations by Carus 2012
- Wood: Mantau et al. 2010

These numbers are very rough estimations, seeing as there is no official data available for Europe. One aspect that should be worked on in this respect is the categorisation of industry data in statistical databases, e.g. Eurostat. While there is in principal a lot of data available, the suitable categories for industrial material and energy uses of biomass are lacking.

The work done by Raschka et al. 2012 shows that it is possible to acquire much better data if the appropriate time and work can be invested into the research. For this, a dedicated project would be necessary, including partners from all European member states that could do first-hand research, interviewing experts, companies and associations. The following graphs illustrate the detail and depth such a research could result in, by giving more detailed data on the uses of biomass in Germany (more graphs are included in the annex). Currently, such data is only available for Germany.

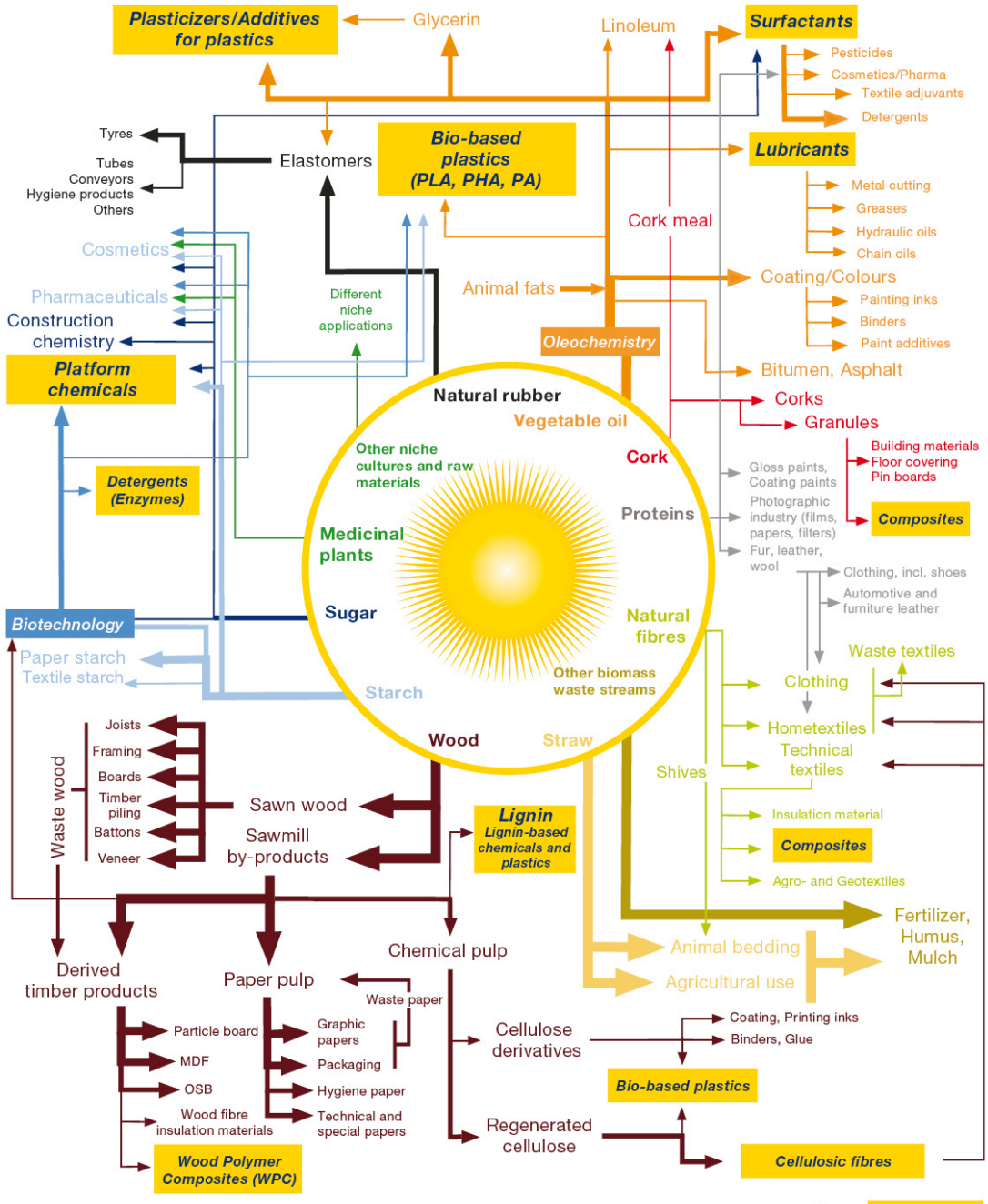




Source: Raschka et al. 2012

The following illustration is also based on the work of Raschka et al. 2012 and has been adapted to EU-27 structure and up-scaled to EU-27 levels. It gives a very impressive overview on the multitude of applications that are comprised in the bio-based economy and has to be covered by a comprehensive market analysis.

Material use of renewable raw materials in the processing industry in the European Union 2012



Use of biomass in the EU-27 2010 (domestic and imported)

	Industrial material use	Bioenergy, incl. electricity, heat, biofuels and biogas
Agricultural biomass	30 Million t*	40 Million t**
Wood	230 Million t***	170 Million t***

* source: estimations by nova-Institute based on USDA 2011 and data from Germany, adopted to EU-27
** source: USDA 2011 and estimations by nova-Institute
*** source: Mantau et al. 2010

In the following text, it is explained further how the numbers shown in Figure 1 have been calculated. The situation for forest biomass and agriculture need to be differentiated as shown below.

Situation for the forestry sector

For the forestry sector, the data basis is quite good, especially owing to the extensive work of Prof. Udo Mantau (University of Hamburg, Germany). The following Table 2 shows the data for the wood resource demand for material and energy use as calculated in Mantau et al. 2010. The estimate of 805 million m^3 of wood demand in the EU-27 in 2010 results in about 400 million tonnes, using the typical conversion rate of 0.5. These are divided between 58% for material use (230 million tonnes) and 42% for energy use (170 million tonnes).

Wood Resource Balance (without solid wood fuels)							
Region	**EU27**			**IPCC Scenario:**			**A1**
potential	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**demand**
		M m³			**M m³**		
forest woody biomass	686	678	680	458	529	620	material uses
other woody biomass	287	327	375	346	573	752	energy uses
total	**973**	**1,005**	**1,056**	**805**	**1,102**	**1,372**	**total**

Table 2: Wood resource balance in the EU-27

Source: Mantau et al. 2010

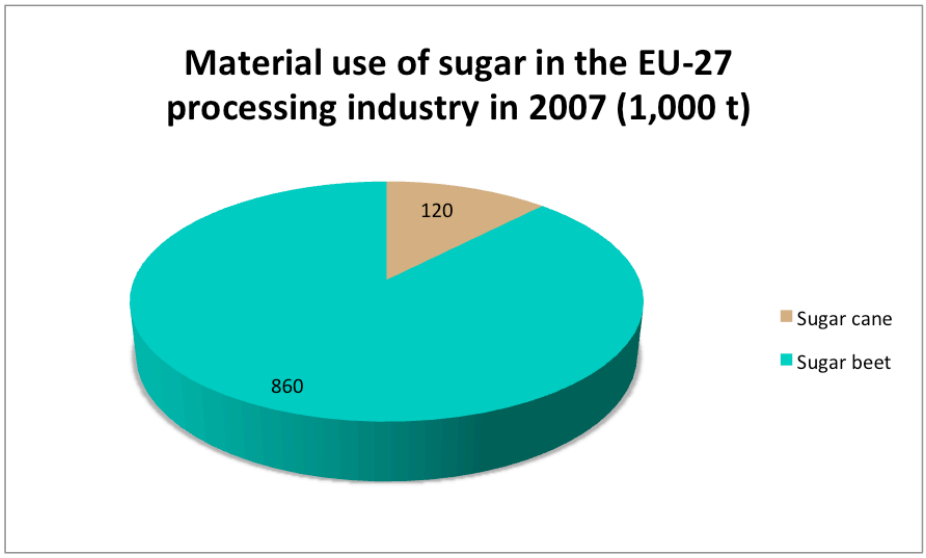
Situation for agricultural biomass

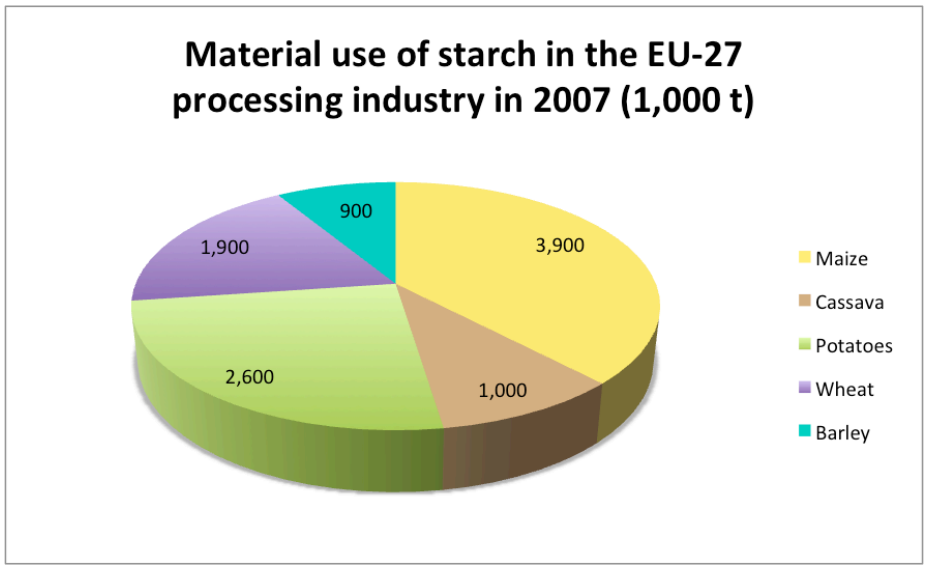
In the case of agriculture, the data basis is much weaker. An estimated 40 million tonnes are used for energy (mainly based on USDA data, see Table 4 to Table 6) and 30 million tonnes for industrial materials, first time estimated for this report.

For the situation of Europe, an attempt has been made to also assess the flows from biomass raw materials to applications for each crop (domestic cultivation and imports). The result is shown in Table 33 below. First, the total production of agricultural crops is assessed, using the Eurostat production data (second column). From these total masses, percentages have been estimated for the main raw material actually used from the biomass (e.g. starch). Then, further estimations have been conducted for the shares of material, energy and food & feed uses for each raw material. Furthermore, imported raw materials have been added. The final three columns then show the estimated actual use of raw materials for industrial materials, energy and food & feed. To give a first idea of the ranges, the estimated use of raw materials for industrial materials amounted to about 16.5 million tonnes and for energy to about 15 million tonnes. Since on average, the main raw material only account for about 40% of the total biomass, these ranges are quite in line with the estimated 30 million tonnes for materials and 40 million tonnes for energy.

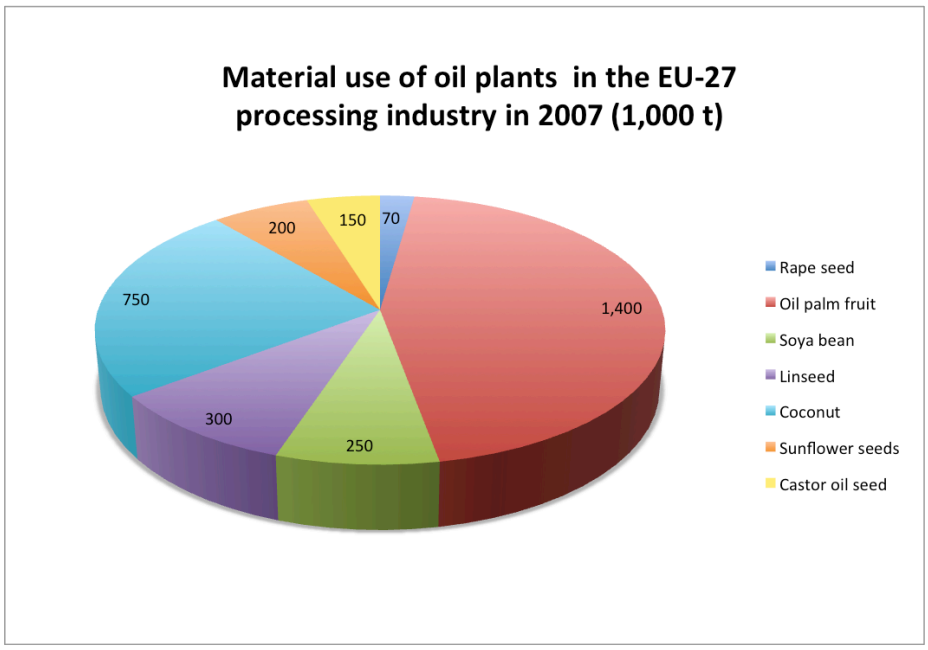
It should be noted at this stage, however, that these results mainly serve to show the methodology of how to systematically assess the material flows from biomass input to applications To get better data extensive research is needed.

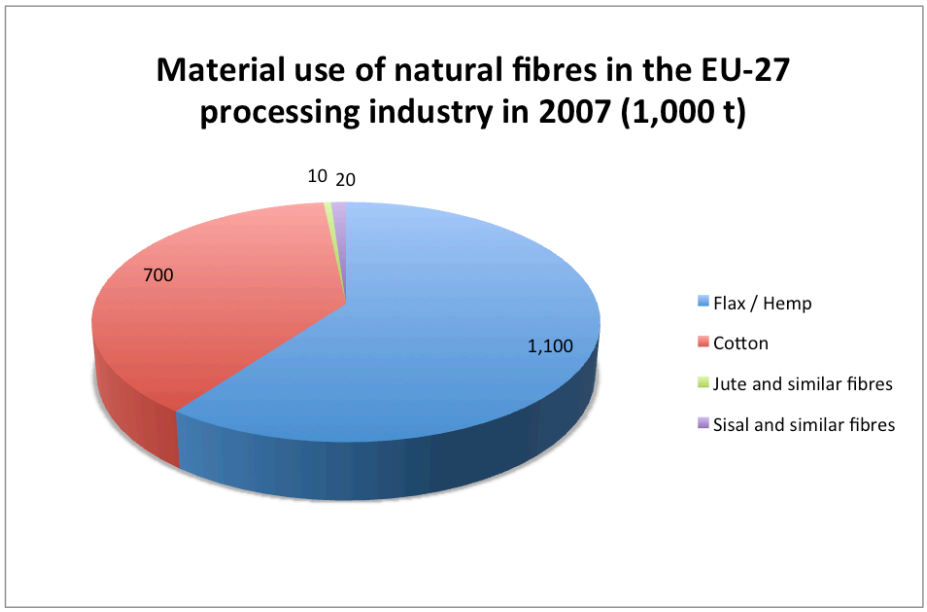
The following figures highlight the main results from this rough assessment:





New data from primary research





New data from primary research

New data from primary research	Production in the EU-27 in 1,000 t	Main raw material in %	Main raw material produced in the EU-27 in 1,000 t	Distribution of use in the EU-27 (%)			Production in the EU-27 in 1,000 t			Imports into the EU-27 in 1,000 t (see extra table for calculation)			Total use in the EU-27 in 1,000 t		
Material				Materials	Food/ Feed	Energy	Materials	Food/ Feed	Energy	Materials	Food/ Feed	Energy	Materials	Food/ Feed	Energy
Bamboo	0	95	0	95	5	0	0	0	0	61	133	0	61	133	0
Cotton (lint)	279	95	265	100	0	0	265	0	0	445	0	0	710	0	0
Cotton (seed)	482	10	48	1	99	0	0	48	0	0	22	0	0	70	0
Cassava	0	77	0	99	1	0	0	0	0	1,015	10	0	1,015	10	0
Flax fibres (straw)	100	100	100	100	0	0	100	0	0	17	0	0	117	0	0
Hemp fibres (straw)	11	100	11	100	0	0	11	0	0	0	0	0	11	0	0
Barley	57,975	50	28,988	3	96	1	870	27,828	290	2	60	1	872	27,888	291
Jute and similar fibres	0	95	0	100	0	0	0	0	0	8	0	0	8	0	0
Potatoes	63,546	82	52,108	5	95	0	2,605	49,502	0	26	499	0	2,631	50,000	0
Coconut	0	20	0	95	5	0	0	0	0	754	68	0	754	68	0
Linseed	100	35	35	99	1	0	35	0	0	246	2	0	281	2	0
Maize	48,563	65	31,566	10	75	15	3,157	23,675	4,735	723	5,544	1,056	3,880	29,219	5,791
Natural rubber	0	95	0	100	0	0	0	0	0	938	0	0	938	0	0
Oil palm fruit	0	22	0	30	50	20	0	0	0	1,392	4,617	928	1,392	4,617	928
Rape seed	18,338.8	35	6,419	1	90	9	64	5,777	578	7	672	61	71	6,449	639
Rice (unhulled)	2,729	70	1,910	0.5	99.5	0	10	1,901	0	5	1,015	0	15	2,916	0
Castor oil seed	0	42	0	100	0	0	0	0	0	145	0	0	145	0	0
Rye	7,655	50	3,827	5	75	20	191	2,870	765	2	35	9	193	2,905	774
Sisal and similar fibres	0	100	0	100	0	0	0	0	0	16	0	0	16	0	0
Soya beans	762	15	114	5	85	10	6	97	11	223	26,470	228	229	26,567	239
Sunflower seeds	4,822	34	1,640	5	92	3	82	1,508	49	128	2,949	9	210	4,457	58
Triticale	9,625	50	4,813	3	95	2	144	4,572	96	0	0	0	144	4,572	96
Wheat	120,075	50	60,037	3	96	1	1,801	57,636	600	65	2,904	256	1,866	60,540	856
Sugar cane	0	10	0	5	75	20	0	0	0	124	2,441	495	124	2,441	495
Sugar beet	114,427	15	17,164	5	65	30	858	11,157	5,149	0	0	0	858	11,157	5,149
Total (excl. wood)							**10,200**	**186,571**	**12,274**	**6,343**	**47,441**	**3,041**	**16,542**	**234,012**	**15,317**
Distr. material/energy use	**449,491**		**209,045**				**45%**		**55%**	**68%**		**32%**	**52%**		**48%**
Distr. Material/food&feed/energy							**5%**	**89%**	**6%**	**11%**	**83%**	**5%**	**6%**	**88%**	**6%**

Table 3: Use of biomass in the EU-27 in 2007 (Source: Eurostat, DG Trade 2012, nova 2012)

In spite of the weak data, Table 3 confirms several aspects regarding the uses of agricultural biomass. According to Star-COLIBRI 2011, **starch** is in the European Union mainly produced from maize, wheat and potatoes. More than 21 million tonnes of agricultural raw materials, primarily from European producers, are processed every year (Star-COLIBRI 2011, p. 20). According to the European Starch Industry Association (AAF), **38%** of starch are used for non-food or feed uses (28% for corrugating & paper making, 6% for pharmaceuticals & chemicals and 4% for other non-food uses), **61%** were used for food (32% for confectionary & drinks and 29% for processed food) and **1%** for feed. Given the total of 21 million tonnes of raw materials, the use for non-food or feed uses therefore amounts to about **8 million tonnes**. This is in line with the results of Table 3 according to which a total of about 8.4 million tonnes of raw materials from potatoes (2.6 million tonnes), maize (3.9 million tonnes) and wheat (1.9 million tonnes) were used for materials, of which starch is the most important use.

Also according to Star-COLIBRI 2011, about 19-20 million tonnes of **sugar** are annually produced in the EU (estimated at about 17 million tonnes in Table 3 using a typical sugar yield from sugar beets of 15%).

Biofuels

Liquid biofuel production in the EU amounted to 12 Mtoe (million tonnes oil equivalent) in 2009, dominated by **biodiesel** (**9.6 Mtoe**), mainly produced from rapeseed. **Ethanol** is mainly produced from wheat and to a lesser extent sugar beet, with a total output of around **2.3 Mtoe** in 2009 (Star-COLIBRI 2011, p. 23).

The study by USDA 2011 provides extensive data on the use of different biomass feedstocks in the EU for the production of biofuels (Table 4 to Table 6). Among other sources, these figures are for Table 5 below.

Feedstock Used for Fuel Ethanol Production (1,000 MT)							
Calendar Year	**2006[r]**	**2007[r]**	**2008[r]**	**2009[r]**	**2010[e]**	**2011[f]**	**2012[f]**
Wheat	1,360	1,390	1,650	2,540	3,870	4,930	6,650
Corn	400	560	1,230	2,350	2,640	2,700	2,780
Rye	1,040	680	720	960	1,110	1,450	1,680
Barley	1,230	1,030	540	780	730	790	1,180
Sugar beet	3,170	5,480	8,480	12,740	9,190	9,930	10,090

r = revised / e = estimate / f = forecast EU FAS Posts. Note: Official data for feedstock use is scarcely available. The figures above represent estimates by EU FAS posts based on known feedstock / ethanol conversion rates.

Table 4: Feedstock used for fuel ethanol production in the EU

Source: USDA 2011, p. 17

Biogas for Heat and Electricity in the EU (Ktoe)							
Calendar Year	**2006**	**2007**	**2008**	**2009**	**2010[f]**	**2011[f]**	**2012[f]**
Field Crops/Manure/ municipal waste	1,331	3,504	4,155	4,341	4,700	5,000	5,500
Landfill	2,007	2,795	2,891	3,002	3,050	3,100	3,150
Sewage Sludge	868	925	953	1,004	1,050	1,100	1,150
Total	4,899	7,224	7,999	8,346	8,800	9,200	9,800

f = Forecast EU FAS Posts Source: Eurobserv'ER, Barometer 2008, 2009, and 2010
http://www.eurobserv-er.org/pdf/baro200b.pdf

Table 5: Feedstock used for heat and electricity in the EU

Feedstock Used for Biodiesel Production (1,000 MT)							
Calendar Year	**2006[r]**	**2007[r]**	**2008[r]**	**2009[r]**	**2010[e]**	**2011[f]**	**2012[f]**
Rapeseed oil	3,900	4,250	5,360	5,900	6,300	6,700	6,720
Soybean oil	380	680	960	800	1,000	1,080	1,140
Palm oil	120	240	590	650	850	910	960
Sunflower oil	10	70	110	100	110	120	120
Other veg. oils	230	300	290	380	430	490	490
Recycled veg. oils	70	200	330	310	420	550	560
Animal fats	50	140	360	340	390	460	470
Other	-	-	-	-	10	50	160
Total	**4,760**	**5,880**	**8,000**	**8,480**	**9,510**	**10,350**	**10,550**

Note: Data for feedstock use is not available. The figures above represent estimates by EU FAS posts.

Source: USDA 2011, p. 32

Table 6: Feedstock used for biodiesel production in the EU

Source: USDA 2011, p. 32

2.2. Economic assessment of the bio-based industry

This section sketches the economic aspects of the industry sectors involved in the bio-based economy in the EU-27. It is primarily based on an analysis of the Eurostat database.

The results of this analysis are shown in Table 7 below. According to the Eurostat classification, the sectors that are mainly relevant for the bio-based economy are:

- Manufacture of starch & starch products (mainly bio-based)
- Manufacture of sugar (mainly bio-based)
- Manufacture of vegetable and animal oils and fats (mainly bio-based)
- Manufacture of wood and wood products (mainly bio-based)
- Manufacture of pulp, paper and paper products (mainly bio-based)
- Manufacture of chemicals, chemical products and man-made fibres (ca. 10% bio-based)
- Manufacture of textiles (up to 50% bio-based)

Additionally, agriculture and forestry can be counted as belonging to the bio-based economy. However, in a stricter sense, only the industries processing the agricultural and forest biomasses further will be counted as belonging to the bio-based economy in the following analysis.

For the industries mentioned above, Eurostat provides data on the number of enterprises, turnover, production value, value added at factor cost and number of persons employed. These terms are defined in Eurostat as follows (Eurostat 2012):

Number of enterprises: A count of the number of enterprises active during at least a part of the reference period

Turnover: Comprises the totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods or services supplied to third parties; it includes all duties and taxes on the goods or services invoiced by the unit with the exception of the VAT invoiced by the unit to its customer and other similar deductible taxes directly linked to turnover; it also includes all other charges (transport, packaging, etc.) passed on to the customer. Price reductions, rebates and discounts as well as the value of returned packing must be deducted.

Production value: Measures the amount actually produced by the unit, based on sales, including changes in stocks and the resale of goods and services. The production value is defined as turnover, plus or minus the changes in stocks of finished products, work in progress and goods and services purchased for resale, minus the purchases of goods and services for resale, plus capitalised production, plus other operating income (excluding subsidies). Income and expenditure classified as financial or extra-ordinary in company accounts is excluded from production value.

Value added at factor cost: The gross income from operating activities after adjusting for operating subsidies and indirect taxes. Value adjustments (such as depreciation) are not subtracted.

Number of persons employed: Defined as the total number of persons who work in the observation unit (inclusive of working proprietors, partners working regularly in the unit and unpaid family workers), as well as persons who work outside the unit who belong to it and are paid by it (e.g. sales representatives, delivery personnel, repair and maintenance teams). It excludes manpower supplied to the unit by other enterprises, persons carrying out repair and maintenance work in the enquiry unit on behalf of other enterprises, as well as those on compulsory military service.

These data are shown in Table 7 for each industry for the year 2007. The most recent year available from Eurostat is 2009, but due to the economic crisis, this year is not representative. Furthermore, other data that were used for this study were mostly available for 2007.

The **forest-based sector** is estimated in Star-COLIBRI 2011 (p. 22) to account for a production value of some 550-600 billion € in the EU-25, while the study included in this sector, apart from the actual forests, services and non-wood products from forests the wood products chain (including furniture and recycling of wood, the paper chain (including pulp making and paper recycling, the bioenergy chain and the wood-based chemicals chain. The woodworking and pulp & paper industry combined clearly account for the largest share of about 430 billion €.

Since the **woodworking industry** and the manufacture of **pulp, paper and paper products** (excl. publishing and printing) are mainly bio-based, the data contained in Eurostat were taken as 100% attributable to the bio-based sector.

In the case of the **chemical industry**, experts maintain that the share of bio-based activities currently lies at around 10%. The German Association of the Chemical Industry (VCI) estimates that the share of renewable raw materials lies at 13% (the other raw materials being 72% naphtha and crude oil derivatives, 14% natural gas and 1% coal). For the EU-27 the share can be regarded to be slightly lower. Therefore, 10% appears to be a realistic figure (confirmed by different experts) and consequently, 10% of the Eurostat figures for the whole chemical industry are shown in Table 5.

The same range is given in Star-COLIBRI 2011 (p. 33) for the bio-based share in the global chemical industry. According to this study, the bio-based share over all chemicals lies at 9-13% (1-2% for commodity chemicals, 20-25% for specialty, 20-26% for fine chemicals and 5-10% for polymers).

Finally, the share of bio-based activities in the **textile sector** (based on natural fibres) is estimated to be around 50% and therefore 50% of the Eurostat figures for the whole textile sector are shown in Table 7.

Apart from apparel textiles, this sector also includes technical textiles and fibre material for composites:

"In 2005 (the latest year for which figures are available) 40,000 – 50,000 tonnes of bio-based composites (not including wood) and 30,000 tonnes of natural fibres were used in the European automotive industry. Raw materials were about 65% flax and 10% hemp from Europe, with imports accounting for the remaining 25%. Compression moulding using a 95:5 ratio of fibre to resin is the dominant processing technology, used to produce a range of lightweight, high-quality components. A second category of successful products is hemp-based insulation materials. In the European Union, 3,000 to 4,000 tonnes are produced and used annually, mainly in Germany, France and the UK." (Star-COLIBRI 2011, p. 39).

As a result, the bio-based sector in the EU-27 appears to comprise close to 480,000 enterprises, a turnover and production value per enterprise of about 1.2 million € and a value added at factor cost per enterprise of about 521,000 €.

Industry	Estimated bio-based share [%]	Number of enterprises	Number of persons employed [1,000]	Turnover [billion €]	Production value [billion €]	Value added at factor cost [billion €]
Agriculture (only material use – ca. 6%)		***822,000***	***1,602***	***n.a.***	***21***	***n.a.***
Forestry (only material use – ca. 58%)		***n.a.***	***235***	***334***	***n.a.***	***n.a.***
Manufacture of sugar	***100***	***283***	***41***	***15***	***14***	***3***
Manufacture of starch & starch products	***100***	***216***	***18***	***10***	***9***	***2***
Manufacture of vegetable and animal oils and fats	***100***	***9,000***	***66***	***42***	***36***	***4***
Woodworking industry	***100***	***346,558***	***2,772***	***283***	***266***	***82***
Saw-milling and planing	100	34,500	311	42	40	10
Wood-based panels	100	2,600	122	27	26	7
Construction elements	100	112,354	562	53	46	17
Packaging	100	10,211	102	12	12	3
Other	100	35,000	175	13	12	4
Furniture	100	151,893	1,367	136	131	41
Pulp, paper and paper products	***100***	***19,161***	***690***	***170***	***166***	***42***
Pulp, paper and paperboard	100	2,078	214	82	80	18
Articles of paper and paperboard*	***100***	16,784	487	90	90	24
Chemicals, chemical products and man-made fibres*	***10***	***3,357***	***185***	***75***	***68***	***19***
Manufacture of textiles and textile products**	***50***	***108,958***	***1,199***	***97***	***90***	***27***
TOTAL (without agric. & forestry)		***484,176***	***4,786***	***617***	***581***	***160***

Table 7: Structure of the bio-based industry for industrial material uses in the EU-27

Source: Eurostat New data from primary research

* incl.: corrugated paper, containers of paper, household and sanitary goods, stationary, wallpaper, other articles of paper & paperboard
** The numbers are an estimated 10% of the total chemical industry
*** The numbers given are 50% of the total figures for the manufacture of textiles and textile products, given the estimated share of natural fibres.

2.3. Market data on Bio-based Plastics and Composites, Bio-lubricants, Bio-solvents and Bio-surfactants

Adding to the general overview of the bio-based sectors in the EU-27, this section gives a more detailed account of the structure of the market for bio-based plastics and composites, bio-lubricants, bio-solvents and bio-surfactants.

Bio-based Plastics

There is a wide agreement regarding the lack of a solid, worldwide and also European market study on the bio-based plastics industry (production, supply, demand, applications, turnover etc.). Until today, no coherent and fundamental inquiry into the worldwide bio-based plastic industry has been made. As long as there exists a lack of basic data, growth of the global bio-based plastic market will be impeded due to insecurity and confusion.

So far, the best market study has been done by Prof. Endres and his team from FH Hannover (Germany), but with only a few specific data on Europe. Recently Prof. Endres is updating his study, the final results will be published in November 2012. Nevertheless, first results could already presented here (see table below). Another extensive and worldwide study is conducted by nova-Institute (Hürth, Germany) and the results will be published as a report and bioplastics producer database in January 2013. The table below also shows first intermediate results from this study. The data on market volumes are based on estimations from ERRMA 2012.

	Production Capacity 2011 (Endres 2012)**	Production Capacity 2011 (nova 2012)**	Market Volume 2008 (ERRMA 2012)
Biodegradable and bio-based plastics (starch polymers, PLA, PHAs, Cellulosics etc.)*	151,000 t	270,000 t	110,000 t (for example: waste & shopping bags 30,000 t, tableware 3,000 t, bio mulch for agricultural 2,000 t)
Durable and bio-based plastics (PA, TPEs, PUR etc.)*	34,000 t	30,000 t	150,000 t
All bio-based plastics	**185,000 t**	**300,000 t*** **	**260,000 t**

Table 8: European Production Capacity and Market Volume for Bio-based Plastics

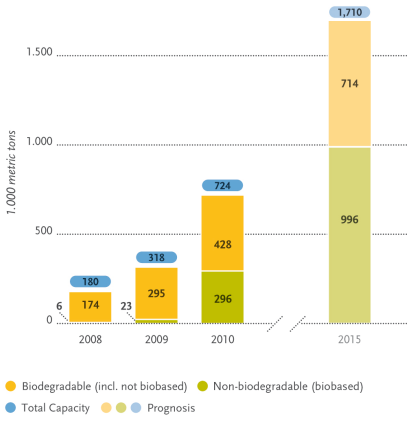
*: The studies have slightly different categories, so the data cannot be easily compared directly.
**: Preliminary data, publication in November 2012 / January 2013
***: Due to rough estimations by nova, production is about 50% of the capacity only (in 2011)

Although the data are not very solid or only preliminary, it can be derived that Europe probably consumes more bio-based plastics than it produces. That is not surprising, because Europe has no or only a very small production capacity for PLA, PHA and also Bio-PE/PP. Only for starch polymers, Europe possesses a truly relevant production capacity.

The running study of nova-Institute also shows that the investments in additional capacities until 2020 will take place in Asia and North and South America mainly, but only marginally in Europe – although the customers in Europe are open minded for bio-based plastics.

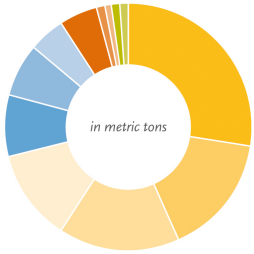
The following figures are taken from the last year's study by Prof. Endres (Endres 2011).

Global production capacity of bioplastics



Source: European Bioplastics | University of Applied Sciences and Arts Hanover (Status May 2011)

Biopolymers production capacity 2010 by type

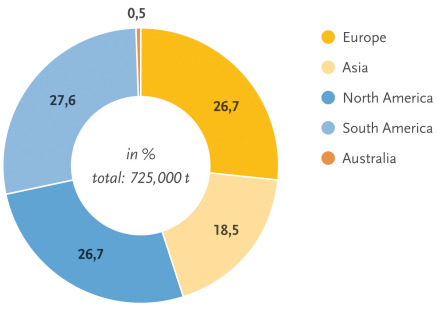


Bio-PE	200.000	28 %
Biodegradable Starch Blends	117.800	16 %
PLA	112.500	15 %
PHA	88.100	12 %
Biodegradable Polyesters	56.500	8 %
Bio-PET	50.000	7 %
Regenerated Cellulose²	36.000	5 %
Bio-PA	35.000	5 %
Cellulose Derivatives¹	8.000	1 %
PLA-Blends	8.000	1 %
Durable Starch-Blends	5.100	1 %
Others	7.500	1 %
Total	**724.500**	100 %

¹ only cellulose ester | ² only hydrated cellulose foils

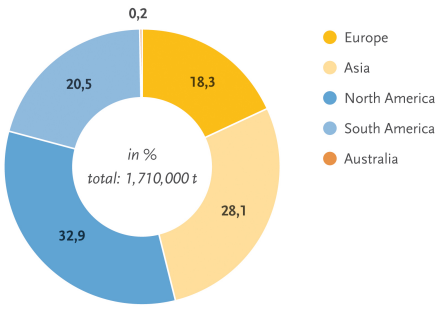
Source: European Bioplastics | University of Applied Sciences and Arts Hanover

Production capacity of biopolymers in 2010 (by region)



Source: European Bioplastics | University of Applied Sciences and Arts Hanover

Production capacity of biopolymers in 2015 (by region)



Source: European Bioplastics | University of Applied Sciences and Arts Hanover

Also, these figures show that the share of Europe in production capacity will decrease until the year 2020 – from 26.7% (193,000 t) in 2010 to 18.3% in 2015 (313,000 t).

Bio-Composites

Bio-composites are composites reinforced by wood or natural fibres instead of glass or carbon fibres. Fully bio-based composites have in addition also a bio-based plastics matrix. The table below shows that bio-composites are the biggest biomaterial group in Europe. The application sectors are mainly automotive and construction.

The share of 14% bio-composites of all composites is remarkably high compared to other biomaterial sectors (bio-based plastics are less than 1% of the total plastic market). And also the increase is impressing: EU 25 plus Norway and Switzerland together have experienced a growth of +35% / year between 2005 and 2010 and a growth of +9% / year between 2010 and 2013 (expected).

One reason for this development is that most of the bio-composites concepts are almost fully competitive to existing fossil-based material solutions.

Bio-Composites in the EU 2010 (in tonnes)

	Estimated Quantities in the EU 2010	Forecast EU 2020 (under favourable political framework)
Compression moulding	**190,000**	**370,000**
- with natural fibres (flax, hemp, kenaf, jute, sisal, abaca, coir): (>95% automotive)	40,000	120,000
- with cotton fibres: automotive, mainly lorries	100,000	100,000
- with wood fibres (WPC): mainly automotive	50,000	150,000
Extrusion and injection moulding	**172,000**	**550,000**
- Wood Plastic Composites (WPC): construction, furniture, automotive, consumer goods	167,000 (incl. Norway & Switzerland)	450,000 (incl. Norway & Switzerland)
- Natural Fibres Reinforced Plastics: construction, furniture, automotive, consumer goods)	5,000	100,000
Bio-Composites in total	**362,000 (= 14%)**	**920,000 (= 29%)**
Composites in total (glass, carbon, natural fibres & wood)	**2.5 Million**	**3.2 Million**

Source: nova-Institut 2010 & 2011, AMI 2011, AVK 2010, Ellis, P. 2010

Table 9: Use of Bio-Composites in the EU 2010, estimations by nova-Institute 2011.

Year	European Union		Germany	
	Construction & Furniture	Automotive	Construction & Furniture	Automotive
2005	37,000 t	50,000 t		
2010	167,000 t	50,000 t	71,000 t	30,000 t
2012	275,000 t			

Table 10: WPC use in the EU 2005, 2010 and 2012, Germany 2010 (nova-Institute 2011)

Bio-lubricants, Bio-solvents and Bio-surfactants

The table below shows the available data for bio-lubricants, bio-solvents and bio-surfactants:

Market data EU 2008	ERRMA 2012	IAR 2012
Bio-lubricants	137,000 t (hydraulic fluids 68,000 t, chainsaw lubricants 29,000 t, mould release agents 9,000 t and others)	150,000 t
Bio-solvents		630,000 t
Bio-surfactants		1,520,000 t

Table 11: Use of Bio-lubricants, bio-solvents and bio-surfactants in the EU 2008 (nova-Institute 2011)

ERRMA 2012 also reported the shares for the different bio-lubricants: For hydraulic fluids the share of bio-lubricants is 11%, chainsaw lubricants impressing 58% and for mould release agents 9%.

3. Investments in industrial biotechnology

A survey of company communications, press releases and news has been conducted in order to assess the investments in biotechnology made by European companies. It was not yet feasible to conduct an extensive assessment of the investments in the industrial biotechnology sector, so the evaluated data is not comprehensive and does not represent the whole sector. It does, however, illustrate recent trends and gives insights into actual tendencies.

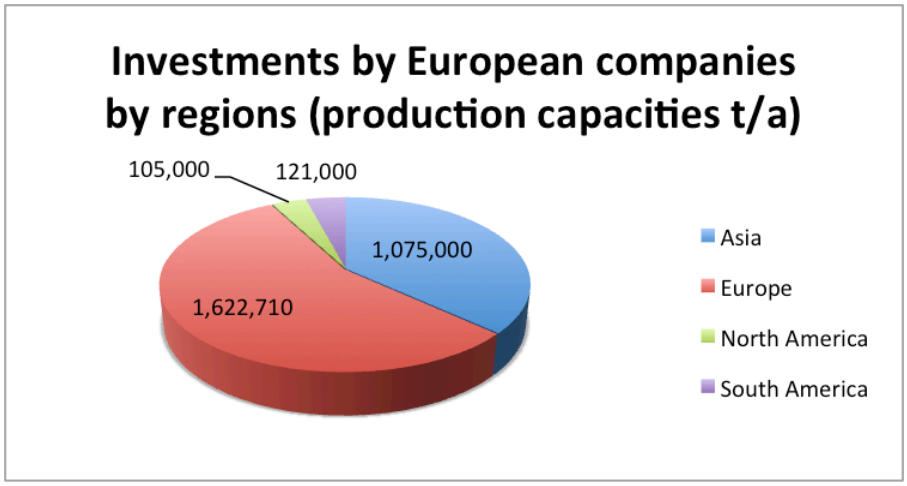


Figure 2: Investments by European companies by regions – production capacities (source: own research) New data from primary research

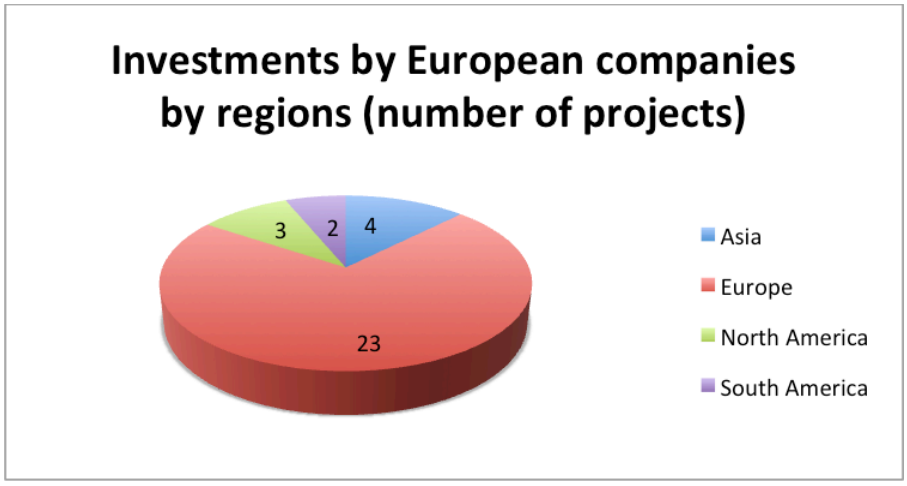


Figure 3: Investments by European companies by regions – number of projects (Source: own research) New data from primary research

This comparison shows that even though European companies invest into a big number of industrial biotechnology projects within Europe, the production capacity reached by these facilities is small compared to those capacities reached by only a few plants in Asia, North America or South America. This means that as a tendency, pilot and demonstration plants are built in Europe, whereas the up-scaling to industrial scale production of bio-based products is mostly done in other parts of the world. Especially Asia stands out as an apparently attractive region for investments. (In the given time, it was not possible to appropriately assess the amount of money invested, as the information is often not publicly disclosed by companies.) A more extensive research project would give the opportunity to collect much more detailed data on which investments are made where in order to correctly depict today's economic developments of the industrial biotechnology sector while also going into more detail on the reasons for these trends.

4. Summary and outlook

In conclusion I would like to point out a few open questions. Based on extensive experience with market data in the field of the industrial material use of biomass, it was possible to risk making a few quick & dirty estimations based on a solid methodology. To make the data more detailed and solid, a lot of additional and extensive work has to be done.

- In order to really calculate the bio-based share of certain industrial sectors and their macro-economic effects, extensive research is needed. This would have to include partners from all EU member states that could do first-hand research with experts, companies and associations.

- The same applies to a project that would determine in detail the biomass flows and the different applications of biomass on an EU-27 level.

- In order to get a clearer view of the recent investment situation in the industrial biotechnology sector, a world-wide research project would make sense, since the information collected within the short time of this paper could only be fractional. The innovative and promising field of bio-based industries has global impacts that need to be monitored if Europe wants to make informed decisions.

- While previous in-depth studies have been made with a focus on Germany, such an assessment is lacking for Europe. While a thorough assessment for Europe is not possible in the framework of this assignment, a first attempt in this direction is made in this study. In order to compare value added and employment effects, these must be on a per feedstock mass basis. Such an assessment is relatively easy for the energy sector, since this sector is quite well covered.

- The silver bullet would be to have a biomass flow chart for each raw material from cultivation and import to the final application, including the sectors food, feed, energy and industrial material use (see for an example on sugar and starch in Germany Annex I).

- The study by Carus et al. 2010 has found that the industrial material use of biomass generates employment and added value that is higher than the effects generated by energy use by a factor of 5-10 (per t of biomass or hectare), mainly due to longer and more complex value chains. A similar assessment for Europe would be desirable to evaluate these findings.

5. References

Reference	Commentary
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Carus, Michael et al. 2011: Policy Paper on the Bio-based Economy in the EU – Level Playing Field for Bio-based Chemistry and Materials. Hürth, July 2011.	Argues for an equal position for the material use (politicially and economically) to the energetic use, list of supporters to this position.
Clever Consult BVBA 2010: The Knowledge Based Bio-Economy (KBBE) in Europe: Achievements and Challenges – Full report. Meise, September 2010.	Analysis of the bio-based economy, points out challenges, recommends policy measures. Table with economic data often quoted by other studies.
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Jering, Almut et al. 2010: Use of renewable raw materials with special emphasis on chemical industry. ETC/SCP report 1/2010. Copenhagen, March 2010.	Overview of the industrial use of renewables; some data on the amount of biomass used for different sectors.
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Nieuwenhuizen, Peter J. et al. 2009: A rose in the bud? Anticipating opportunities in industrial biotechnology, in: Arthur D Little (ed.), Prism 2 / 2009, pp. 39-55.	Analysis of biotech sector and different scenarios for biochemicals, data on biochemicals 2007.
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USDA – U.S. Department of Agriculture, Foreign Agricultural Service 2011: EU-27 Annual Biofuels Report. The Hague, June 2011.	Detailed data on crops and shares of biofuels.
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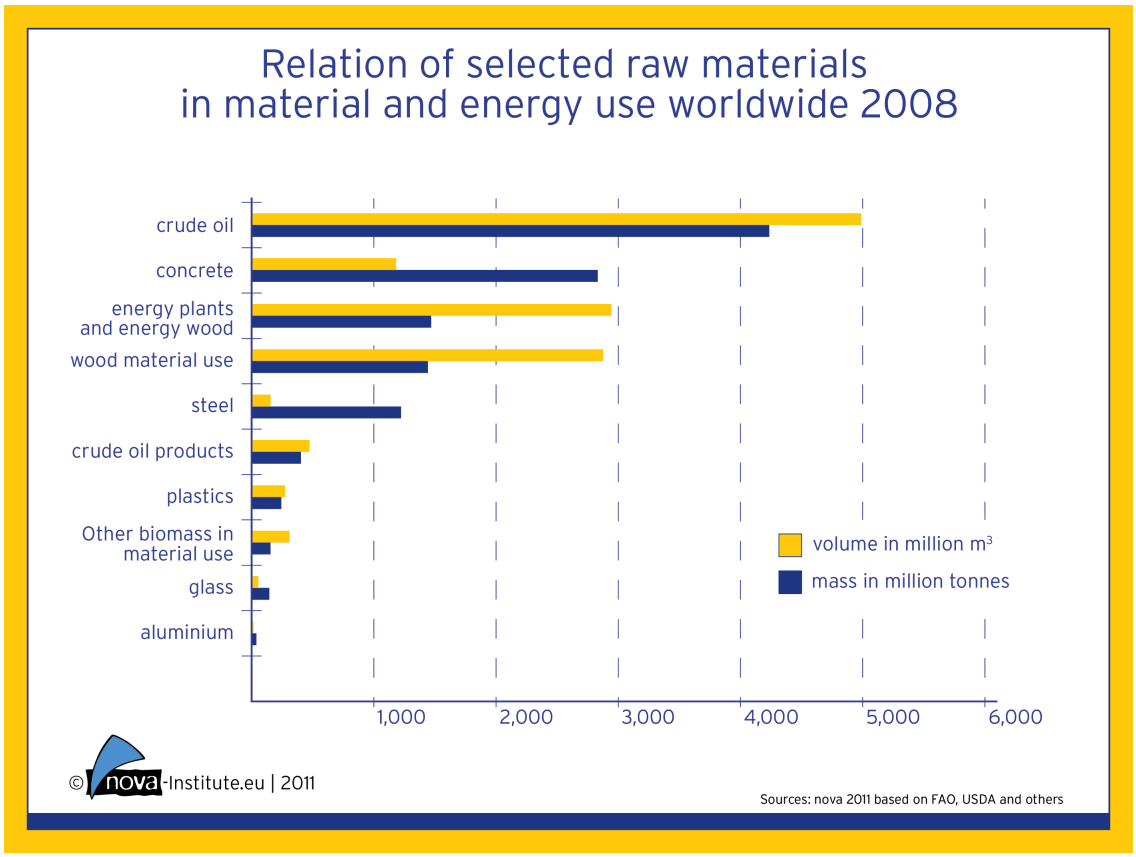
Annex I: Methodology examples for assessing biomass flows – research done for World and Germany by Raschka et al. 2012


Relation of selected raw materials
in material and energy use worldwide 2008
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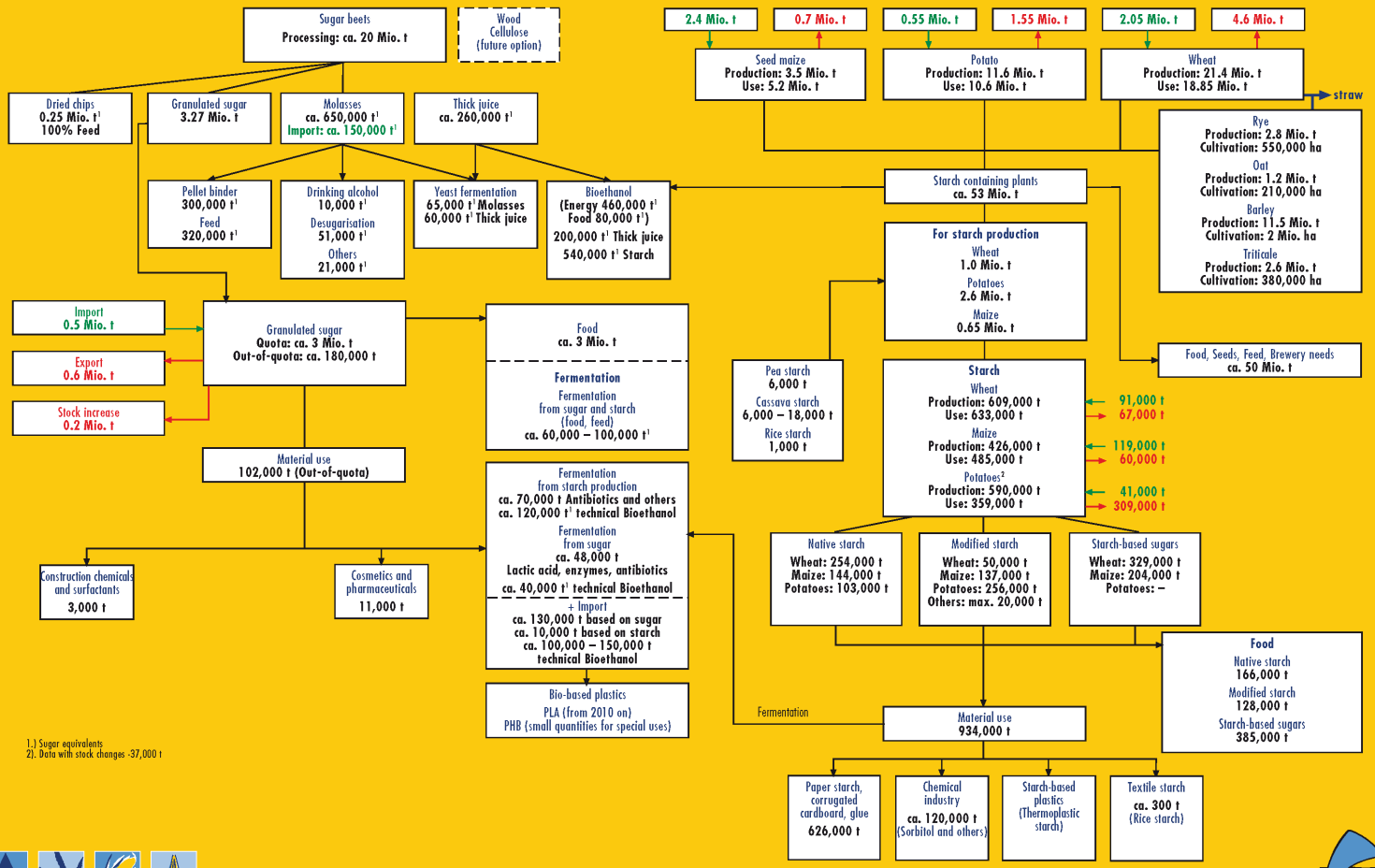
5,000
6,000
volume in million m³
mass in million tonnes
©nova-Institute.eu | 2011
Sources: nova 2011 based on FAO, USDA and others

Material use of sugar and starch in Germany

(Production, import and use; campaign 2007)



Sources: März 2009, FNR 2010