Market demand for non-food crops

Inventarisation of the present situation

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Report 4FCrops task 1.3

Colophon

Title	Market demand for non food crops
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AFSG number	AFSG number
ISBN-number	ISBN number
Date of publication	Date of publication
Confidentiality	No
OPD code	OPD code
Approved by	Name of approving official

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The quality management system of Agrotechnology and Food Innovations b.v. is certified by SGS International Certification Services EESV according to ISO 9001:2000.

Summary

This report summarizes the results of task 1.3 of the 4FCrops project.

Methods
In this report an estimation is presented of the present day non-food markets for renewable materials. These markets cover a wide range of products, ranging from paper and wood to specialty chemicals and high value added plastics. Estimation of the market size was made starting from the Eurostat data of manufactures goods. This database covers production data of over 4000 (intermediary) products. From this list a selection was made of products that are nowadays partly or fully biobased or could become so in the future. Next, an expert guess was made on the present day percentage of biobased resource used in the product. Furthermore, an estimate of the potential use of biobased resources in the product was made. These values are all expressed in Euros.

In the next step an estimate was made of the present day and potential demand for crops from these non-food markets. To this end, in the Eurostat database the first intermediary products, from which other products are produced, were identified. For instance, consider the paper and board market: the total production volume of pulp is converted into paper, board and all kinds of products that are also included in the Eurostat product database, but to know the demand for resources one only needs to consider the total volume of pulp. The total present day and future production volume of the first intermediary product was recorded and linked to the biobased resource that they are made of.

A serious drawback of the Eurostat database is, however, that not all data are given, some data are confidential for reasons of market competition. This implies that the estimations in this report give the lower boundary of the actual market size.

In order to sort out the chaos in the wide range of markets, a classification of end-products was introduced based on the manner the biobased resource is applied:

- As materials, using the materials just as they grow in nature, with only slight modification, for example:
    - fibres for paper, fabrics and composites
    - wood for timber
- As ingredients, using the plant as a factory and isolating the substances, which can then be chemically modified in order to get the desired functionality, for example:
    - starch for plastics, glues and additives
    - natural oil for paints, inks and transport fuels
- As building blocks, breaking down the biomass into building blocks to make something new, for example:

- lactic acid for additives and polymers
- ethanol or butanol for fuel and plastics
- furanics for resins and fuels

The report

Market size of the different groups is presented in chapter 3 to 5. Chapter 6 is dedicated to the question of how to source the variety of feedstocks for producing non-energy biobased chemicals and product in Europe. Chapter 7 gives a short overview of the biofuels market, whereas chapter 8 and 9 are devoted to the feed and food markets respectively.

Results

Present and future market value of biobased (intermediary) products in the three application groups can be summarized as:

	Number of items	*% item values recorded*	*Total value for EU25* (thousand €)*	*Actual biobased value** (thousand €)*	*Potential bio-based value** (thousand €)*
Materials from biomass	286	76%	225.135.479	167.790.582	208.239.794
Ingredients from biomass	168	60%	78.968.609	25.813.317	37.819.695
Building block from biomass	334	34%	152.771.862	32.924.393	79.837.990
Totals	**788**	**55%**	**456.875.950**	**226.528.292**	**325.897.479**

* for known figures

** based on expert judgement of the non-food, non-feed component

It should be realized that especially for the building blocks group the estimation of the potential biobased value is far too low since all value data of the important future plastics market are missing.

Nevertheless it can be concluded that the present total value of biobased products produced is already impressive and there is ample opportunity for growth, especially in the building blocks group, which is potentially even much larger than is presented in the table.

Concerning the demand for resources the following estimations were generated from the Eurostat data:

Materials from biomass	**Volume actually bio-based (tons)**
Wood for pulp, timber etc.	72.704.063
Natural fibres for fabrics etc	1.692.637
Total	**74.396.700**

The demand for wood is definitely an underestimation since the total roundwood production is approximately twice as large.
These applications are however markets that exist today. It is likely that growth will be accommodated within the existing production chains. With the further development of the 2nd generation technologies, side streams of the timber industry as well as the paper industry could be used for the production of building blocks.

Ingredients from biomass	Volume actually bio-based (tons)
Cellulose for polymers	519.732
Natural oils for a variety of non-food applications, paints, surfactants, lubricants etc.	2.807.579
Proteins for glues etc.	342.073
Free sugars	1.560.682
Starch for glues, paper finishing, drilling fluids etc.	3.238.795
Totals	**8.468.861**

It is thus estimated that, keeping in mind that this is a lower limit due to the missing data, approximately 8.5 Million tons of biomass is in Europe used in existing non-food products next to fibres and paper and pulp. This is not including the demand for biofuels. Growth within this group of established applications is possible but will presumably be mainly accommodated within the existing chains. Natural rubber is not included in this listing since separate data could not be extracted.

For the demand from the chemical industry, which is not yet exisiting the following approximation can be made:

Building blocks from biomass	Volume possibly bio-based (tons)	Estimated resource demand (Mton)
Base chemicals from carbohydrates	**46.750.570**	**58**
Base chemicals from lignin	**10.901.839**	**14**
Base chemicals from natural oil	**2.178.433**	**12**
Base chemicals from proteins	**10.359.233**	**14**
Base chemicals from unspecified biomass	**17.254.644**	**21**
Totals	**87.444.719**	**119**

This implies that the application of biomass for non-food products might increase by over 15-fold, when the chemical industry will start to seriously change their feedstock from naphtha to biomass. On the other hand this demand is of the same order of magnitude as present demand for wood and fibre. Also, this shift in demand will definitely not occur overnight, since technology needs to be developed further and existing installation need to be depreciated before new investments are done.
In 2010 the biofuels market is mainly referring to the first generation biofuels (biodiesel and bioethanol). The biodiesel market was estimated to 3.2 Mtoe, while the corresponding market for bioethanol was quite lower 0.7 Mtoe. The solid biomass market is 74.5 Mtoe in EU27. It should

be pointed out that the contribution of the energy crops in total biomass is very small (4% including biofuels and only 0.4% (0.05 Mtoe) considering only the direct burning of solid biomass (about 50-60 Mtoe).

These numbers can be compared to the feed demand of the EU, which is presented in chapter 8. In total the annual consumption of compound feed is approximately 143 Mton. Almost half of this amount is covered by feed cereals, wheras over 30% comes from oil (cakes) and fats. This amount is in the same order of magnitude as the total extra demand from the chemical industry. Other feeds, mainly roughage, but also simple concentrates and raw materials which are directly used on farm, are estimated to add up to between 45 and 200 Mton of dry matter. Total feed demand is thus estimated to be roughly twice as high as the potential demand from the chemical industry.

Food markets in the EU break down to approximately 50 Mton of cereals, about 6-7 Mton of vegetable oils, approximately 0.9-1 Mton dry pulses, approximately 30 Mton of potatoes plus an additional 6 Mton potatoes in the form of processed products, and approximately 15 Mton of sugar. Next to this comes a smaller range of vegetables, fruits and nuts. In total it adds up to approximately 140 Mton of biomass for human consumption (the dry matter content is obviously lower).

Conclusions

Concluding we can state that the present non-food markets exist and do have a considerable size. The use of biomass is for the largest part covered by wood, although a market for other non-food crops exists, in terms of volume of resource input this market is about 1 tenth of the wood and fibre market. It can be expected that when the chemical industry will start to use more biomass instead of naphtha, an additional market of similar size as the present day non-food market arises.

Regarding the use of the fuel crops for biofuels it should be mentioned that the target for 10% biofuels by 2020 is expected to lead to the cultivation of 25 Mha (AEBIOM): 15 Mha will be used for liquids biofuels (biodiesel and bioethanol), 5 Mha for biogas and 5Mha for solid biofuels. In 2007 the total biomass consumption to primary energy consumption in the EU was 89 million tons oil equivalent.

Compared to the present day feed and food markets, especially the feed market stands out as it is the biggest in volume. Food markets are of a similar volume as the new to be expected non-food markets.

Content

1 Introduction

Realizing the potential benefits of non-food crops depends crucially on the development of markets, with products competing effectively on cost as well as environmental grounds, to pull innovation through to commercial application. These applications will not only be based on novel crops but also on existing mainstream arable crops and on side streams. Whereas the petrochemical industry has developed many new products that have replaced products that were originally produced from renewable resources there is still a large number of commercial applications that are fully or partially made from biobased resources. Next to this, many new applications are expected to be developed in the coming years.

However, the lack of predictions on future competitive demands for food, feed, fiber and fuels could have a negative effect on the implementation of projects relating to non-food uses. While no predictions will ever be precise, in this report a market review is presented to provide information on the existing food and non-food markets, based on Eurostat data.

The 4FCrops project is devoted to surveying and analyzing all the parameters that will play an important role in successful non-food cropping systems in the agriculture of EU27 alongside the existing food crop systems. Therefore, it is essential to map the expected developments towards new biobased, non-food products. To this end, a preview will be presented on the kind of developments that can be expected in the years to come
This market review will act as a base line for the scenario's that are developed in WP 6.

2 Market size of non-food products

2.1 Introduction

Non-food products from renewable resources are very diverse. Therefore it is difficult to get a good overview of the market size. Very few studies that focus on this aspect of the biobased economy are available. DG AGRI has performed a study on Non-food uses of agricultural biomass: markets and perspectives [1] of which in Table 2.1 some results are presented.

Table 2.1. Markets for biobased products as presented by the European Commission

	Current markets	Growth
Biofuels	EU: 3,2 Mtoe (biodiesel); 0,7 Mtoe ethanol	Average annual growth 28,2 % biodiesel; 12,8% ethanol
Fibre-based/composite materials (Construction; car industry, ..)	50 Ktoe automobile industry; 3,5 Ktoe construction;	100 Ktoe in auto ind. by 2010; bio-based could reach total share of 5-30% in 2020
Paper (wood fibres/starch) and paperboard	EU paper/cardboard: 40 Mtoe	
Bioplastics; Biopolymers	EU: 50 Ktoe out of total of 73 Mtoe	30% production increase in recent years; 5% market share of packaging plastics by 2010
Surfactants	EU: 30% of total of 2,5 Mtoe	new markets: Plant health products; 60-65 of of detergents could be of vegetal origin
Biosolvents	Currently 1.5% of total (60.000 tons out of 4 Mtoe)	Could grow to 12%-40%
Biolubricants	2 % of total (100 Ktoe out of 5 Mtoe); mainly in hydraulic sector; low use in automotive sector	30% market share by 2010; max potential could be up to 90%
Pharmaceutical products incl. vaccines	Currently high value/low volume niche markets. Plant derived pharmaceuticals market is €30billion, 10-25% of prescription medicines sales	New product opportunities with high market/growth potential such as plant based vaccines
Enzymes	53Ktoe in 2001 (3/4 in EU)	5% annual growth rate

However we would like to have some more specific data on the markets and products in order to identify which crops are possibly needed for the various products.

2.2 Methodology

In order to make an estimation of the demand for resources for non-food products a chain inversion approach is taken. Where many studies focus on the crops produced, in this report we start from the end markets of products that are fully or partially biobased. From this approach it is possible to extend towards expected market developments and make estimations of the structure of future non-food chains. This work is based on a previous study performed by Nowicki et al [2], however the data collected by Nowicki et al. have been further refined and reanalysed, with additional attention paid on the total biomass demand determined on weight basis rather than price basis.

Eurostat data on manufactured goods

In 1970, the «Nomenclature générale des activités économiques dans les Communautés européennes» (NACE - General Industrial Classification of Economic Activities within the European Communities) was compiled. As its name implies, it is a classification covering the whole range of economic activity.

The revision of the original classification system began in 1986, and was adopted in a Council of Ministers in 1990. The implementing Regulation was published in the Official Journal of the European Communities No L 293 of 24.10.1990 as Regulation (EEC) No 3037/90. The Regulation made the use of NACE Rev. 1 obligatory from 1 January 1993.

For an effective single market, it is essential, for macro- and micro-economic analysis and for commercial marketing, to have a single up-to-date classification system that can be used in all Member States and by the Community institutions.

A *product classification* is designed for categorizing products (goods and services) that have common characteristics. This classification provides the basis for preparing statistics of the production, distributive trade, consumption, foreign trade and transport of such products.

Source: Eurostat (1996)

The methodology is performed in two steps, both focusing on potential biobased products and their markets. In the first step, based on the Eurostat database (see box 1), which contains over 4000 manufactured products, a selection was made of non-food, non-feed products that are now fully or partially biobased or could become so in the future. The data from Eurostat are organised by product categories structurally related to market sectors, which facilitates the screening of the individual products for which there are annual statistics collected on the basis of either direct sales or total production (if the production is for intermediary products in a production chain). Information is given in terms of both the volume and the value of production.
For the selected products estimation was made on the percentage biobased resource used in the production. In the second step an estimation of the potential use of biobased material was made; the focus here was both on existing product categories and on the range of novel products. From this approach it is possible to assess the market demand, market penetration and market value of biobased products.
Identification of potentially biobased products in the Eurostat database was performed in order (a) to *keep* only those products that were to some degree used for other purposes than food or feed and (b) to *eliminate* those products which would definitely not be likely to contain some

biobased component in the future. As an outcome of this screening process, 788 products are retained for further analysis.

Especially for chemicals there exists a potential to replace the current feedstock by a biobased feedstock. The potential % substitution/replacement of a current product with a bio-based alternative was estimated using the following considerations:

- what is the current (petro)chemical process (if known) for the production of the chemical in question?
- what is the initial starting material for this process (such as benzene, ethylene etc...) and is it possible to prepare this in a bio-based way (for example ethylene may-be produced from bio-ethylene)?
- considering the subsequent steps (thus the same as the current process), do these involve the use of co-reagents (e.g. chlorine, hydrogen etc...) and can these be obtained from a bio-based origin?

While it is possible to arrive at an estimate for the % substitution (on paper), this does not mean that this is equal to the potential market! Consider 2 factors:

- A large % substitution of a bulk or commodity chemical will require large amounts of biomass, and in some cases specific biomass. Thus there is a question: is this biomass available? Is it also possible to process/transport, etc., this amount of biomass in order to meet the demands to produce this chemical?
- The connection to the current production route is considered in the above approach. However it may be possible to improve the overall use of biomass in the chemical industry if new routes from the building blocks from the biomass to the final product are developed. This will require major investment in research, development, infrastructure and general approach of industry. It could lead, however, to a larger level of substitution and increased market possibilities.

The estimates for total present and future production capacity in terms of economic value include all products from the Eurostat database. However for the estimates of the present and future biomass volumes are based on the production volume of the "first intermediary product" in the production chain. There are a few base intermediary products, like pulp, from which many intermediary and end products are produced. For an indication of the amount of resources input one thus needs to look at the base intermediary products. (for instance the total production volume of pulp is converted into paper, board and all kind of products that are also included in the Eurostat product database, but to know the demand for resources one only needs to consider the total volume of pulp).

The decision to use Eurostat data on manufactured goods is based on two premises: that the Eurostat data set would provide the most exhaustive and consistent data available; and that, as an

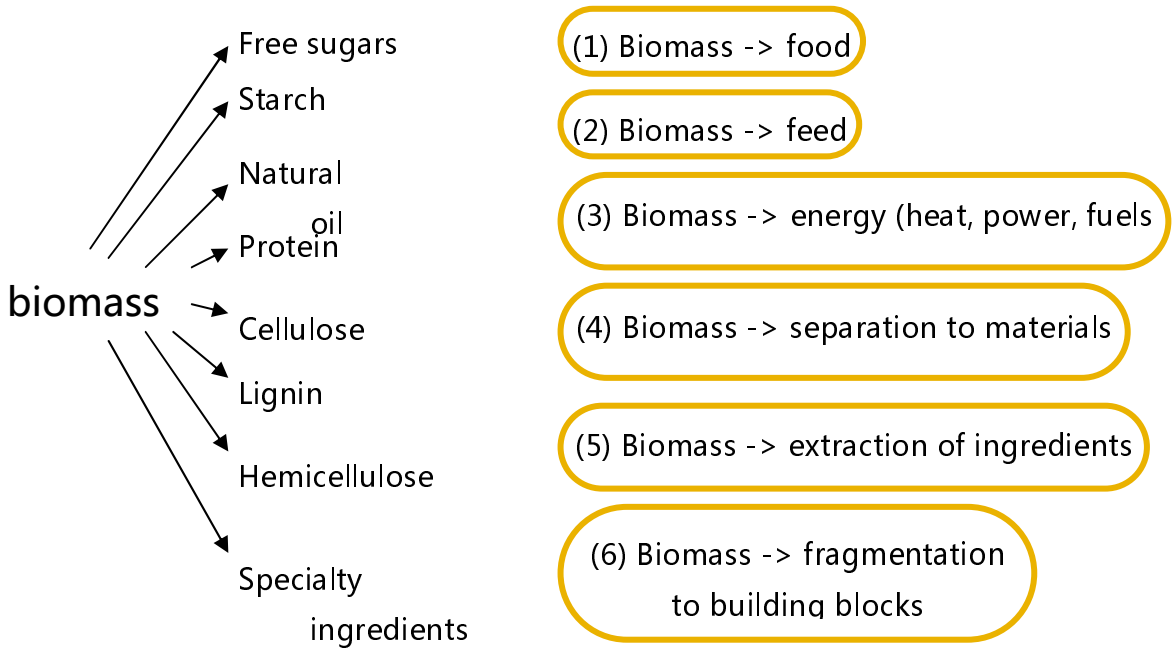
economic area, the EU25 group of countries is representative of the global market potential for biobased goods.

A serious drawback of the Eurostat database, however, is the fact that not all data are given, some data are confidential for reasons of market competition. Despite efforts through the Dutch Ministry of Agriculture, we have not been successful to collect information on the confidential data.

2.3 Applications of biobased resources

In order to organize the products into internally consistent groupings to get a better grip on the variety of markets, the products are further grouped according to the way in which the biomass resource is processed and used in the final product. Here, 6 types of production process can be identified (Figure 2.1; described in Bos and van Rees, [3]). Of these 6, the last three are directly relevant for the manufactured non-food products contained within the Eurostat listing.

Figure 2.1 Resources processes and applications underlying a biobased economy



Biobased resources are applied in a wide variety of non-food products, ranging from soaps, paints, plastics, building materials to specialty chemicals and pharmaceuticals. A convenient way to categorize the variety of applications can be made by realizing that biomass supplies us with (Figure 2.1):

- Materials, using the materials just as they grow in nature, with only slight modification, for example:
    - fibres for paper, fabrics and composites
    - wood for timber
- Ingredients, using the plant as a factory and isolating the substances, which can then be chemically modified in order to get the desired functionality, for example:
    - starch for plastics, glues and additives
    - natural oil for paints, inks and transport fuels
- Building blocks, breaking down the biomass into building blocks to make something new, for example:
    - lactic acid for additives and polymers
    - ethanol for fuel and plastics
    - furanics for resins and fuels

The logic of this classification comes from the fact that the industries and industrial chains involved are different, and this is of importance for the 4FCrops project:

- Materials from biomass:
    - Mostly old established applications and relatively simple processes
    - Can be big (f.i. Paper industry), but also a lot of SME
- Ingredients from biomass:
    - Often using relatively simple chemical conversions
    - Partly in present food industry (f.i. AVEBE), also SME
- Chemical building blocks from biomass:
    - Mostly using combination of white biotechnology and chemistry
    - New products and processes
    - Focal point of the chemical industry
    - Biggest potential for biomass applications

Of course there are grey area's in between these three different classes, but as a general framework of thinking it is very useful. Also it helps to design non-food chains starting from the application (and thus the market demand) and not from the crop, which is a more fruitful approach (Bos et al [4]). An important observation is furthermore that the three different groups will have different requirements concerning the crops that are needed and thus ask for a different approach in designing the non-food crop chains.

3 Materials from biomass.

3.1 Introduction

The category of materials from biomass contains many very old applications, including wood for timber and natural fibres for fabrics. In recent years also some new applications were developed and introduced in the market, such as isolation blankets for building applications made from flax or hemp fibres and composite materials of plastics or bioplastics reinforced with natural fibres, which have found applications in for instance the automotive industry.

3.2 Markets and market values

Since the group materials from biomass focuses on the material structure that nature supplies us with, it is not surprising that the main resources underlying this group are wood (lignocellulose), plant fibres and skins and leather. Within this group there is no competition between food and non-food applications, since non of the resources are edible.
The intermediary and end products in this group are all for a very large part (50% or more) based on renewable resources. The lowest content of renewables one finds in for instance the fibre board applications where fibres are mixed with a plastic or resin which is usually not (yet) biobased.
An existing product that seems to be missing in this listing are isolation blankets from flax or other natural fibres.

An overview of the economic value of the items that range under this group is given in Table 3.1 In the table the applications are divided into 8 groups:

Biomass: 1 item.

> This single entry regards the use of animal and vegetable waste for fertilizer. No value is given, but a volume of some 2.700.000 tonnes at the EU25 level is recorded. There is no specific priority associated with biomass. (In this regard, it is worthwhile noting that all biodegradable materials can be recycled as compost, which is in itself a valuable resource for agriculture and which can 'close the loop' in the biobased economy.)

Chemicals: 1 item.

> This entry refers to wood charcoal, a 100% biobased product by nature, with nearly 222.000 tonnes produced annually within the EU25. With an average value of 0.43 € per kg for a total market of 94 million euro, it is a mature product without much prospect for future development.

Table 3.1. Total overview in economic value of the Materials from biomass group

Materials from biomass	*Number of items*	*% item values recorded*	*Total value for EU25* (thousand €)*	*Actual biobased value** (thousand €)*	*Potential bio-based value** (thousand €)*
Biomass	1	0%			
Chemicals	1	100%	94.320	94.320	94.320
Fabrics	21	100%	9.469.465	9.340.708	9.469.465
Fibres	29	100%	5.908.151	5.908.151	5.908.151
Lignocellulose	1	100%	544.890	27.244	27.244
Pulp & paper	137	73%	139.666.809	98.522.731	125.851.321
Skins & leather	19	26%	1.346.874	1.259.538	1.303.206
Wood & ligneous materials	77	79%	68.104.970	55.510.555	65.586.087
Totals	**286**	**76%**	**225.135.479**	**167.790.582**	**208.239.794**

* for known figures

** based on expert judgement of the non-food, non-feed component

Fabrics: 21 items.

These are the traditional fabrics, made from cotton, carded wool, silk, flax, and hemp. The total EU25 market is almost 9,5 billion euro. For certain companies with high value-added products there is growth potential, but there is also fierce competition from synthetic fibres.

Fibres: 29 items.

The fibres included here are all of natural origin (cotton, silk, wool, etc.). The EU25 volume is slightly over 2,1 million tonnes per year, with a value of nearly 6 billion euro. Growth might be possible here, especially with regard to potential substitution in products in fibres that are presently made from petrochemicals that would have similar uses. But this will depend on price and especially functionality. At the same time there is ongoing competition from synthetic fibres replacing the fibres from natural origin.

Lignocellulose: 1 item.

This item refers to beet-pulp: bagasse and other sugar manufacturing waste, representing nearly 10 million tonnes of annual production, but of which only 5% would be for non-food, non-feed applications. Here it is to be noted the big potential of use of lignocellulose in 2nd generation bio-refineries, which would move this product to the "building blocks" group.

Pulp & paper: 137 items.

Although not all individual product volumes and values are given, this very large industrial sector represents more than 135 billion euros in annual sales value, of which 70% is biobased, and an additional 20% could be.

Skins & leather: 19 items.

The information regarding this market sector is too inconsistent, concerning either volume or value, to come to conclusions, except that for 30% of the items concerned a greater part of the finished product could be biobased to a small extent (although most of the products listed are already fully biobased).

Wood & ligneous materials: 77 items.

A large market sector in terms of quantity of products that are by nature biobased. The EU25 market value is some 68 billion euros, of which over 80% is biobased and more than 95% could be. Considering that because of public demand for forest area with regard to leisure pursuits, there is the increasing potential to harvest wood on a regular basis in many countries. This category includes wood for timber and construction as well as wood for paper and board applications.

3.3 Crops serving these markets

Wood

For wood three main product lines can be distinguished:
- wood for timber and construction, including plywood
- wood as basis for pulp for paper
- wood fibres for board applications

There are a few base intermediary products, like pulp, from which many intermediary and end products are produced. For an indication of the amount of resources input one thus needs to look at the base intermediary products. (for instance the total production volume of pulp is converted into paper, board and all kind of products that are also included in the Eurostat product database, but to know the demand for resources one only needs to consider the total volume of pulp).

Known volume data of the base wood based intermediary products are given in table 3.2. It is obvious that there are data missing, which is a serious drawback of this database, as stated before. These data can be compared to the Eurostat generic data of forestry in EU (Table 3.3Table).
A number of conclusions can be drawn.
- From the Eurostat intermediary product listing a total production of 31.8 Mton of the various pulps can be calculated. This is only about one third of the total paper and board production in

Table 3.2. Production of wood based intermediary base products

Products according to Eurostat	Volume actually bio-based (tons)
Thermo-mechanical wood pulp	
Semi-chemical wood pulp	
Pulp of other fibrous cellulosic material	4068981
Mechanical wood pulp (excluding thermo-mechanical wood pulp)	3061148
Unbleached non-coniferous chemical wood pulp; soda or sulphate (excluding dissolving grades)	
Unbleached coniferous; chemical wood pulp; sulphite (excluding dissolving grades)	
Semi-bleached or bleached coniferous chemical wood pulp; soda or sulphate (excluding dissolving grades)	9990151
Semi-bleached or bleached non-coniferous chemical wood pulp; soda or sulphate (excluding dissolving grades)	8508918
Unbleached coniferous chemical wood pulp; soda or sulphate (excluding dissolving grades)	4112539
Chemical wood pulp; dissolving grades	832258
Semi-bleached or bleached coniferous chemical wood pulp; sulphite (excluding dissolving grades)	762729
Semi-bleached or bleached non-coniferous chemical wood pulp; sulphite (excluding dissolving grades)	498254
Unbleached non-coniferous chemical wood pulp; sulphite (excluding dissolving grades)	0
Spruce wood (Picea abies Karst.); fir wood (Abies alba Mill.)	
Wood; sawn or chipped lengthwise; sliced or peeled; of a thickness > 6mm; excluding coniferous and tropical woods and oak blocks; strips and friezes	
Wood wool; wood flour	
Coniferous wood in chips or particles	
Non-coniferous wood in chips or particles	
Sawdust	23650962
Wood waste and scrap (including agglomerated in logs; briquettes; pellets or similar forms) (excluding sawdust)	17199708
Pine wood: Pinus sylvestris L.	18415
Total	**72.704.063**

Where no data are given, data are confidential

EU of circa 97 Mton. So the missing data in Table 3.2 could present a part of these values, but also a significant amount of paper is produced from recycled paper.

- Total roundwood production in EU-25 in 2005 of 433 Mm^3(Table 3.3), is converted into wood

Table 3.3. Forestry in EU.

Total roundwood production	**433.757.000 m^3**
Total sawnwood production	103.182.000 m^3
Total paper and paperboard production	96.887.000 ton

products and fibres and waste streams. From Table 3.2 production of paper and paperboard 31.8 Mton plus production of sawdust 23.6 Mton plus production of woodwaste 17.2 Mton gives a total of 73 Mton.
This equals 146 Mm^3 (taking a density of 0.5 kg/dm^3), adding this to the sawnwood production of 103 Mm^3 (Table 3.3), which cannot be found in the Table 3.2 data, gives a total of 249 Mm^3, which implies that for 42 % of the roundwood production the application cannot be derived from the Eurostat data on intermediary products. This is more or less in line with the fact that 29% of the pulp and paper data and 21% of the wood data are missing.
These applications are however markets that exist today. It is likely that growth will be accommodated within the existing production chains. With the further development of the 2nd generation technologies, side streams of the timber industry as well as the paper industry could be used for the production of building blocks (see Chapter 5)

Fibres
For plant fibres other than wood fibre the Eurostat intermediary product database gives the data presented in Table 3.4.

Table 3.4. Eurostat data on vegetable fibre production.

crop	Products according to Eurostat	Volume actually bio-based (tons)
bast fibre	Vegetable bast fibres (excluding flax); processed but not spun (including yarn waste; garnetted stock)	13243
bast fibre	Yarn of vegetable or bast fibres (excluding flax); paper yarn	12495
cotton	Cotton yarn of uncombed fibres; n.p.r.s.	375653
cotton	Yarn of uncombed cotton; n.p.r.s.; for woven fabrics (excluding for carpets and floor coverings)	262438
cotton	Cotton; carded or combed	230477
cotton	Cotton yarn of combed fibres; n.p.r.s.	173431
cotton	Yarn of combed cotton; n.p.r.s.; for knitted fabrics and hosiery	102678
cotton	Yarn of uncombed cotton; n.p.r.s.; for knitted fabrics and hosiery	79878
cotton	Yarn of combed cotton; n.p.r.s.; for woven fabrics (excluding for carpets and floor coverings)	41045
cotton	Cotton yarn; p.r.s. (excluding sewing thread)	35462
cotton	Yarn of uncombed cotton; n.p.r.s.; for other uses (including carpets and floor coverings)	33336
cotton	Yarn of combed cotton; n.p.r.s.; for other uses (including carpets and floor coverings)	29709
cotton	Cotton sewing thread; n.p.r.s.	1855
cotton	Cotton sewing thread; p.r.s.	1034
flax	Flax broken; scutched; hackled or otherwise processed but not spun; flax tow and waste (including yarn waste; garnetted stock)	266942
flax	Flax yarn; n.p.r.s.	31573
flax	Flax yarn; p.r.s.	1388
	Total	**1692637**

Wool and silk are not considered in this project.
Much of the cotton presumably is imported and most of the flax is exported after scutching. These are existing markets where no dramatic changes are to be expected in the years to come, although slight growth seems possible.
The fibres are primarily used for production of fabric. New applications are however emerging: the German automotive industry used in 2005 12.200 ton of flax fibre, in composite applications (Nova Institut) and 5000 ton of hemp fibre, however this is only a very small part of the total agrofibre production (Table 3.4)

Skins and leather fall outside the scope of this project.

3.4 Conclusions

The category "materials from biomass" contains many old and established applications. Some growth is possible in existing applications which presumably will be taken up by the existing chains. In the paper industry generally a rise in demand is foreseen[5], but also this is likely to be accommodated by the existing production chains, although increased use of forest resources might arise. New applications for wood might be possible as construction material in replacing steel, stone and concrete. However, external drivers, like high prices for the presently used materials or policy measures will be needed to reach a significant substitution.
An existing new application is the use of agrofibres in composite materials, this has especially taken off in the automotive industry, and some production chains have been established in the previous decade. However, the demand from these chains is small compared to the demand for fibres applied in fabrics.

4 Ingredients from biomass.

4.1 Introduction

The second group, ingredients from biomass, is more complicated than the first group presented in the previous chapter. This group contains the applications of renewable resources where the functionality of the plant ingredients is the reason for application, the plant thus synthesises useful substances for us, it acts in a way as a factory or chemical plant. This also implies that applications can be specifically tuned to the plant ingredients and the ingredients could be difficult to replace.

4.2 Markets and market values

An overview of the economic value of the items that range under this group is given in Table 4.1 In the table the applications are divided into 13 groups, some of which contain mainly base products, some mainly intermediary products.

Additives: 8 items

The additives in this group are all based on starch; they are for instance used for the paper industry. The amount of biobased in this group could possibly increase.

Biodiesel: 1 item.

Biodiesel is a currently topical item, with a strong growth potential assured over the coming years because of the EU policy mandate to increase the incorporation rate of biofuels into the fuel stocks used for transportation. In spite of the prefix 'bio', the actual percentage of the finished product is now 70% biobased, but can increase to 95%. More information about biofuels can be found in chapter 7.

Chemicals: 17 items:

Two of the items are glycerol based, a co-product of biodiesel production. Thirteen of the items are fatty acid based, thus produced from natural oil. The total volume involved for the 5 items is about 1.6 million tonnes. EU25 values are given for only 2 of the items. All that can be stated is that there is considerable potential to use these chemicals as building blocks (which would take them to the building blocks category).

Cosmetics: 11 items.

It is difficult to make an assessment because either the volume of production is given (for 2 items) or the value is given (4 items), and there is no information for the rest (5 items). The only remark to be made is that the percentage of bio-based components used within

the production process can increase between 5 and 20 percent, for a range of products that are largely biobased already.

Free sugars: 10 items.

Already a fully biobased market, the non-food and non-feed applications are in the order of 10% of total production. But sugar is a potential 'new' platform chemical for products in the building blocks group.

Glue: 7 items.

A variety of renewables based glues are made from different feedstock, like casein, starch etc. It is to be noted that the percentage of biobased components can increase from a level of 70% to 90% throughout this product family.

Table 4.1 Total overview in economic value of the ingredients from biomass group

Ingredients from biomass	*Number of items*	*% item values recorded*	*Total value for EU25* (thousand €)*	*Actual biobased value** (thousand €)*	*Potential bio-based value** (thousand €)*
Additives	8	63%	663.951	373.646	591.674
Biodiesel	1	100%	6.647.825	4.653.477	6.315.433
Chemicals	17	12%	386.107	281.436	366.801
Cosmetics	11	24%	2.428.273	1.214.136	1.699.791
Free sugars	10	80%	15.606.826	1.560.683	1.560.683
Glue	7	86%	1.286.205	900.344	1.157.585
Lubricants	17	76%	5.344.504	2.857.958	3.982.408
Oils & fats	23	78%	10.676.675	406.251	406.251
Paints & inks	26	84%	20.030.090	4.269.747	12.129.765
Pharma & neutraceuticals	14	79%	2.405.181	2.032.742	2.346.407
Polymers	9	56%	4.236.910	2.118.455	2.118.455
Proteins	2	50%	348.283	104.485	104.485
Solvents & detergents	16	50%	6.241.165	4.012.976	4.012.976
Starch	7	86%	2.666.614	1.026.981	1.026.981
Totals	**168**	**60%**	**78.968.609**	**25.813.317**	**37.819.695**

* for known figures

** based on expert judgement of the non-food, non-feed component

Lubricants: 17 items.

The products concerned are waxes, polishes and creams for maintaining goods such as shoes and furniture, as well as biobased additives for petroleum-based compounds. This market sector is not small – 3,5 million tonnes worth more than 5 billion euros – and an additional 20% of this value could be biobased. There is, in addition, a considerable interest in this biobased development for environmental reasons.

Oils & fats: 23 items.

These items contain two groups.

Three of these oils and fats are basically wood-related (ie, resin based).

Twenty one items are mostly oils coming from plants, although there are a few references derived from animal fats. Although most of the use is for human consumption, there are products used for skin care and therapeutic uses. The products are now all 100% biobased.

Paints & inks: 26 items.

There is rather considerable potential for an increase in the biobased part of paint composition, which varies from 10-60% now and could be above 80% in many cases.

Pharma & neutraceuticals: 14 items.

One item concerns prepared culture medium for development of micro-organisms. The EU25 market is less than 200 million euros for less than ten thousand tonnes of annual production.

The rest of the family concerns vitamins and related items. A general remark is that the degree of biobased components is already 85%, but could increase to 100%, with a potential market value on the order of several billion euros. The exact figure is difficult to determine, considering that some of the data, such as for vitamin B12, is confidential.

Polymers: 9 items.

These items are largely cellulose based products. The EU25 figures for the volumes of 2 items are confidential and also the value for another 4 items. These products are already fully biobased, and the demand for them could expand, although large changes are not to be expected..

Proteins: 2 items.

One item, casein and caseinates, is totally used for non-food, non-feed applications. Volume and market value is not given. The second item, wheat gluten, is for the majority used for food or feed, but the 30% remaining has a value of over 100 million euros per year.

Solvents & detergents: 16 items.

Although not all figures are available for market volume and value at the EU25 level this market sector represents more than 15 million tonnes of annual production, of which 70% is biobased (and will remain at the level). The known part of market value is a little more than 6 billion euros for EU25 as a whole.

Starch: 7 items.

Little more than 30% percent of the use of starch is for non-food, non-feed purposes, representing a slightly over 2 million tonnes of annual production and 1 billion euros of market value. Starch is a very important platform for the development of the bio-economy.

4.3 Crops serving these markets

Introduction

Along the same lines as in chapter 3, we consider in this chapter the base materials that underlie many of the intermediary products, since for an estimation of crop volume used only the base products need to be considered.

Table 4.2. Products from cellulose

Products according to Eurostat	Volume actually non-food (tons)
High tenacity filament yarn of viscose rayon; n.p.r.s. (excluding sewing thread)	42814
Cellulose acetates; in primary forms	91451
Cellulose nitrates; in primary forms (including collodions)	66366
Cellulose ethers and cellulose and its related derivatives; in primary forms (excluding cellulose acetates; cellulose nitrates)	319101
Total	**519.732**

Cellulose crops

A number of polymers are made by modifying cellulose. From the Eurostat database the data presented in Table 4.2 can be derived.

Thus about a half Mton of cellulose polymers are produced in EU-25. It is not expected that this number will increase considerably, since cellulose polymers are an existing market, with limited options for expansion.

Table 4.3. Production of natural oil, the estimated non-food part.

Products according to Eurostat	Volume actually non-food (tons)
Refined cotton-seed oil and its fractions (excluding chemically modified)	
Sesame oil and its fractions (including refined; excluding chemically modified)	
Vegetable waxes (including refined) (excluding triglycerides)	
Refined rape; colza or mustard oil and their fractions (excluding chemically modified)	788175
Refined palm oil and its fractions (excluding chemically modified)	427936
Refined sunflower-seed and safflower oil and their fractions (excluding chemically modified)	369963
Vegetable fats and oils and their fractions partly or wholly hydrogenated; inter-esterified; re-esterified or elaidinized but not further prepared (including refined)	316521
Refined soya-bean oil and its fractions (excluding chemically modified)	268258
Refined olive oil and its fractions (excluding chemically modified)	125800
Oils and their fractions obtained solely from olives (including those blended with virgin olive oil; refined) (excluding virgin olive oil; chemically modified)	86008
Refined coconut (copra) oil and its fractions (excluding chemically modified)	70376
Other fixed vegetable fats and fractions (excluding chemically modified); n.e.c.	69636
Degras; residues resulting from the treatment of fatty substances or animal or vegetable waxes	164074
Animal fats and oils and their fractions partly or wholly hydrogenated; inter-esterified; re-esterified or elaidinized; but not further prepared (including refined)	27800
Refined palm kernel or babassu oil and their fractions (excluding chemically modified)	16945
Refined ground-nut oil and its fractions (excluding chemically modified)	16042
Refined linseed oil and its fractions (excluding chemically modified)	12386
Wool grease and fatty substances derived therefrom; including lanolin	12942
Castor oil and its fractions (including refined (excluding chemically modified)	169
Tung oil and its fractions (excluding chemically modified)	0
Gum; wood or sulphate turpentine oils; pine oil and other alike	34548
Total	**2.807.579**

Oils and fats producing crops

In table 4.3 it can be seen that most of the volume figures of this category are given. Oils and fats have known a wide variety of non-food applications since a very long time. Important application areas are: solvents and detergents, adhesives, thermoplastics and thermosets, paints, lubricants, surfactants and plastics additives. Oils and fats vary in the composition of their fatty acids, which gives them a range of physical and chemical properties. Some oils and fats are not edible, like

Table 4.4. Industrial fatty acids

Products according to Eurostat	Volume actually non-food (tons)
Industrial tall oil fatty acids	283516
Mixtures of mono-; di- and tri-; fatty acid esters of glycerol (emulsifiers for fats)	58096
Industrial stearic acid	
Industrial oleic acid	68417
Industrial monocarboxylic fatty acids distilled (excluding stearic; oleic tall oil)	347248
Industrial monocarboxylic fatty acids (excluding stearic; oleic; tall oil; distilled)	195068
Palmitic acid	
Salts and esters of palmitic acid	3343
Salts of stearic acid	92848
Stearic acid	55357
Esters of stearic acid	
Lauric acid and others; salts and esters	0
Oleic; linoleic or linolenic acids; their salts and esters	54827
Total	**1.158.719**

tung oil and castor oil and are fully used for non-food (or medicinal) applications. On the whole, it is estimated that roughly the application of fats and oils in non-food is 20%, and these figures are presented in the table. This 2.8 Mton of fats oils are used in a variety of applications as discussed above. This value is similar to the values given in Appendix-table 12 for industrial use, which is on average 2.6 Mton between 2004 and 2006.
Table 4.4 shows the production of fatty acids, which are derived from the natural oil. Some figures are obviously confidential, but is is clear that the application of the fatty acids (which are molecules derived from the natural oils) is an important outlet for the non-food use of natural oils.
Next to the traditional applications new developments are underway. Since in these development the oils and fats are basically used as building blocks, these will be considered in the next chapter.

Protein crops
About 0.3 Mton of proteins are used in glues and other applications(see Table 4.5), mainly from animal origin (gelatines or caseins). An important application area for proteins are glues, these are rather long-standing applications, but they are in continuous competition with glues from petrochemical origin, since these offer in many applications better performance for a lower price [6]. Proteins thus find limited applications in the non-feed, non-food markets.

Table 4.5. Non-food application of proteins

Products according to Eurostat	Volume actually non-food (tons)
Casein and caseinates	
Wheat gluten (excluding wheat gluten prepared for use as a glue or as a glazing or dressing for the textile industry)	141806
Peptones and their derivatives; other protein substances and their derivatives; hide powder including glutelins and prolamins; globulins; glycinin; keratins; nucleoproteids; protein isolates	34020
Casein glues	18623
Caseinates and other casein derivatives (excluding casein glues)	35977
Gelatin and its derivatives; isinglass (excluding casein glues and bone glues)	97139
Bone glues; other glues of animal origin (excluding casein glues)	14508
Total	**342.073**

Starch and sugar crops.

Non-food use of free sugars is estimated at 1.5 Mton (table 4.6) and not much growth is expected within this product group, except for the building blocks approach, which will be discussed in the next chapter.

Table 4.6. Non-food free sugars

Products according to Eurostat	Volume actually non-food (tons)
Glucose and glucose syrup (excluding with added flavouring or colouring matter)	156038
Chemically pure fructose in solid form; fructose and fructose syrup; containing in the dry state > 50% of fructose; iseglucose excluding with added flavouring or colouring matter	37595
Inulin	
Raw cane and beet sugar in solid form; not containing added flavouring or colouring matter	139334
Refined white cane or beet sugar in solid form	1168427
Refined cane or beet sugar in a solid form (excluding white sugar)	12259
Refined cane or beet sugar containing added flavouring or colouring matter	14788
Cane molasses	2175
Molasses obtained from the extraction or refining of sugar (excluding cane molasses)	30066
Sugars; pure (excluding glucose; etc.); sugar ethers and salts; etc.	
Total	**1.560.682**

Table 4.7. Non food starch

Products according to Eurostat	Volume actually non-food (tons)
Finishing agents; etc; with amylaceous basis (< 55%)	17842
Finishing agents; etc; with amylaceous basis (? 55% < 70%)	
Finishing agents; etc; with amylaceous basis (? 70% < 83%)	
Finishing agents; etc; with amylaceous basis (? 83%)	
Finishing agents; etc.; used in the textile industry	509248
Finishing agents; etc.; used in the paper industry	403984
Finishing agents; dye carriers and other preparations; n.e.c.	109408
Sorbitol (excluding D-glucitol)	
Glues based on starches; dextrins or other modified starches	62615
Crude maize (corn) oil and its fractions (excluding chemically modified)	52441
Refined maize (corn) oil and its fractions (excluding chemically modified)	
Wheat starch	264311
Maize (corn) starch	469081
Potato starch	427891
Starches (including rice; manioc; arrowroot and sago palm pith) (excluding wheat; maize (corn) and potato)	
Dextrins and other modified starches (including ester/etherified; soluble starch; pregelatinised/swelling starch; dialdehyde starch; starch treated with formaldehyde/epichlorohydrin)	921974
Total	**3.238.795**

Starch plastics are not recorded as a separate product in the Eurostat database. However it is known that approximately 100 kton of starch plastics are produced in the EU-25, and the production capacity for starch plastics is rapidly expanding. Other production and use of starch is reported as approximately 3.2 Mton (see Table 4.7). data for an important chemical produced from starch: sorbitol, are however missing.

In the appendix-table 10 total cereals industrial use adds up to 15.5 Mton. This figure refers to cereals for industrial uses other than bakery etc.. Assuming a maximum 60% starch content this would be approx 9 Mtons of starch. If we use a more conservative figure (accounting for industrial yields, etc..) of 45 %, it would make 7 Mt of starch. This is still higher than the number from table 4.6.
The AAF (Association des Amidonniers et Féculiers**;** [7]) indicates an overall consumption of starch of 9.3 Mtons in 2007. The breakdown they declare is:

32% confectionery and drinks	3.0 Mt
28 % Processed food	2.6 Mt
28% Corrugating and paper making	**2.6 Mt**
7% Pharmaceuticals	**0.6 Mt**
4% other non food uses	**0.4 Mt**
1% feed	0.1 Mt

The overall non-food use in this listing is 3.6 Mton, which is quite similar to the results from table 4.7, especially considering that some data are missing in table 4.7.

Starch as a resource for the production of building blocks will be discussed in the next chapter.

Other
No volume information of chemicals and cosmetics can be derived, but they can be expected to be small. The pharma and neutraceutical category consists of vitamins, no volume information is available.

4.4 Conclusions

This category of ingredients from biomass contains many existing applications. Especially the non-food applications of oil crops and starch spring into view, these are partly already old and established applications where a limited growth potential can be expected. New applications for, for instance, starch plastics however are growing. Other new concepts of producing (specialty) ingredients in plants may provide economically interesting options, and will require new non-food crop chains. This will be further explored in task 6.

5 Chemical building blocks from biomass, recent developments within the chemical industry

5.1 Introduction

Present use of biomass in the chemical industry as building blocks for f.i. polymers or additives is still limited. Examples of recent developments are NatureWorksPLA, which is marketed as a new material for packaging and fibre applications, Sorona, a product from DuPont which is approximately half biobased-half petrochemical based. However, when the chemical industry seriously starts to source from renewables, this can have an enormous implication.

5.2 Markets and market values

An overview of the economic value of the items that range under this group is given in table 5.1 In the table the applications are divided into 12 groups, all of which contain mainly intermediary products:

Additives: 34 items.

The key characteristic of this product family is that although in most cases the biobased component is 0%, in almost all cases this could be as high as 90%. The total production volume is 1,1 million tonnes, so more than a million tonnes of biobased components could be involved, a gigantic substitution from the perspective of the actual 90 kilo tonnes. There is no basis for estimating the total EU25 market value for this product family.

Agrochemicals: 4 items.

Although there are indeed many products that fall within this family, only very few have the possibility to have some biobased component, and no greater than 20% within an individual product. No market values are given, even for EU25.

Base chemicals: 2 items.

The common characteristic for these two items is that the current part of biobased components is 0%, but could be 100%. No values are given for this family.

Bioethanol: 1 item.

Bioethanol will be highlighted in a separate chapter

Chemicals: 119 items.

A large product family, in which the contribution of biobased components is already 90% for 7 items, but currently 0% for the rest. The capacity for a substitution by biobased

Table 5.1. Total overview in economic value of the Building blocks from biomass group

Building blocks from biomass	*Number of items*	*% item values recorded*	*Total value for EU25* (thousand €)*	*Actual biobased value** (thousand €)*	*Potential bio-based value** (thousand €)*
Additives	34	35%	6.038.916	0	5.435.024
Agrochemicals	4	0%			
Base chemicals	2	0%			
Bioethanol	1	100%	354.746	283.797	354.746
Chemicals	119	7%	1.810.465	229.196	710.110
Cosmetics	9	89%	10.290.596	2.627.543	5.145.298
Enzymes	1	100%	933.696	746.957	933.696
Fabrics	14	29%	6.737.505	494.067	3.904.020
Fibres	37	81%	9.704.653	0	4.269.021
Paints & inks	2	50%	558.556	167.567	390.989
Pharma & neutraceuticals	68	56%	116.342.729	28.375.266	58.695.086
Polymers	43	0%			
Totals	**334**	**34%**	**152.771.862**	**32.924.393**	**79.837.990**

* for known figures

** based on expert judgement of the non-food, non-feed component

components exists, however, to an equivalent level of biobased composition (of 80%) for 43% of these remaining products. A considerable increase in substitution is possible for the others. Hardly any market values are given, but where these are then it is obvious that the unit value per kg of product is higher than for most other products covered in this study. The total EU25 volume of production is more than 140 million tonnes, of which almost a 100 million tonnes could be biobased components.

Cosmetics: 9 items.

Two items are currently 50% biobased, and the rest are 10%; all could be at the 50% level. Little information is given with regard to volume of output, even at the EU25 level: only for two items. The values, however, are given for eight, amounting to more than 10 billion euros in total. The biobased market value could double and be above 5 billion euros.

Enzymes: 1 item.

This is a market which is already well-structured and difficult to penetrate. The

production is essentially biobased – 80% at present and potentially 100% – with a total market value of slightly under a billion euros for the EU25 output.

Fabrics: 14 items.

Although currently most of the 6,9 million tonnes of annual production is not biobased, the potential is for more than half (3,7 million tonnes) to be so. The market value is about 7 billion euros, of which about a 7% is already for biobased components.

Fibres: 37 items.

This product family, representing some 3,8 million tonnes of output, has a common characteristic that although the current biobased composition is 0%, the potential composition is on the order of 50%. The available value figures give a total of 6 billion euros, of which 2,5 billion euros could be for biobased components.

Paints & inks: 2 items.

These are both 30% biobased and could be 70%. The current EU25 production level is just above one million tonnes.

Pharma & neutraceuticals: 68 items.

It is impossible to make an assessment by volume of output, but enough values are given to conclude that the market for this product family is extremely interesting: well over the 166 billion euros actually revealed. The one conclusion that can be drawn, however, is that the potential part for biobased components can increase to quite an extent, from an average of 10% up to a general level of 50% biobased composition (in a few cases the level is already more than this, up to 100%).

Polymers: 43 items.

No values for output are given at all, indicating the economic sensitivity concerning this product family. The volume of output is high, more than 70 million tonnes. Although only three items currently have biobased components, the potential for the others ranges between 20 and 80 percent. A big future market is expected.

5.3 Production structure and crops possibly serving these markets

The present production structure of the petrochemical industry is based on a limited number of base chemicals. A simplified overview of the organic chemical industry
is presented in Figure 5.1. The main basic hydrocarbons used are methane (C_1), ethylene (C_2), propylene (C_3), butene and butadiene (C_4), and the aromatics benzene, toluene and xylene.

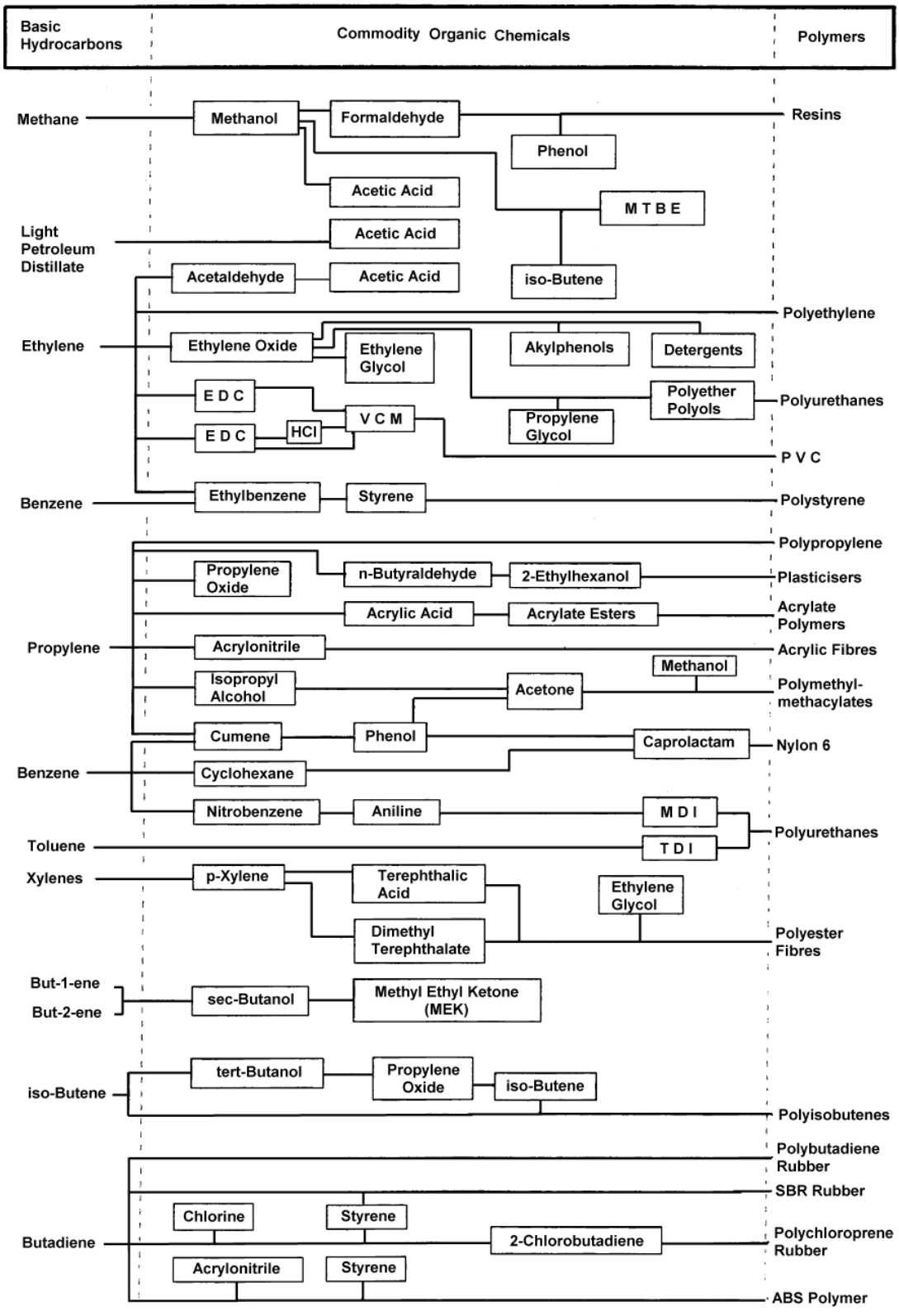


Figure 5.1. Pathways in the organic chemical industry EC [8].

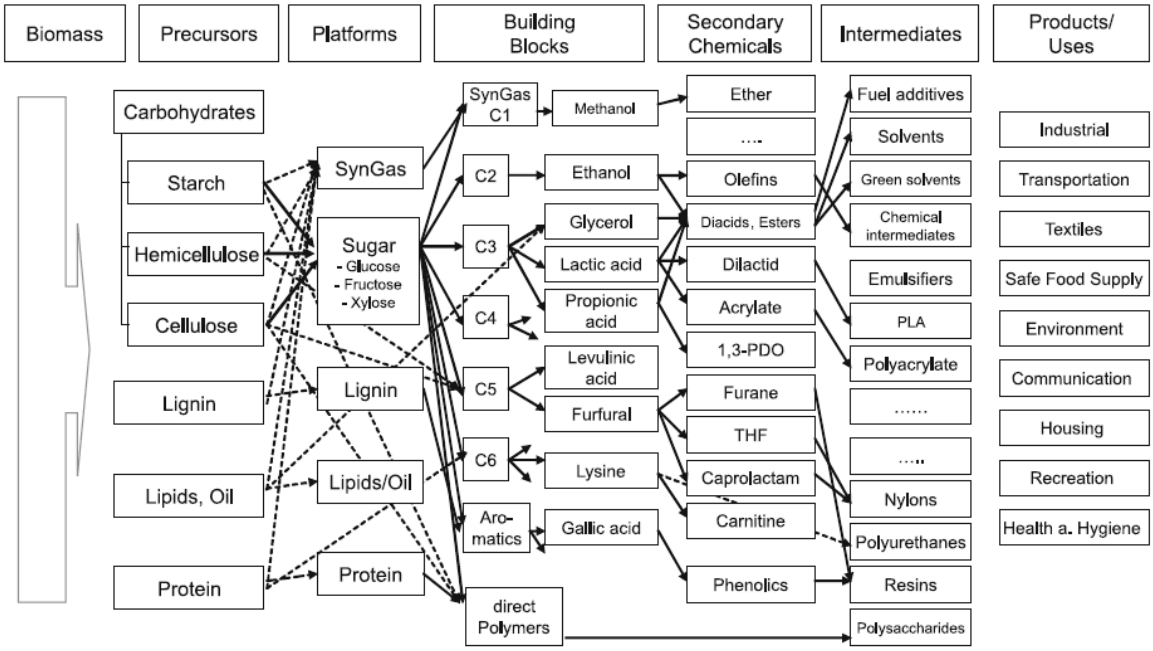


Figure 5.2 . Schematic flow-chart of a selected number of current and future biomass transformations analogous to the petrochemicals flow chart. Kamm and Kamm[9].

Analogous to this flow chart a number of authors have presented a similar flow chart for a biobased economy. (see Figure 5.2). As can be concluded from Figure 5.2, the demand for resources can be specified in terms of carbohydrates, oils, proteins etc. The total demand for biomass input for the chemical industry can be estimated by adding up the total present production of the base chemicals as defined in figure 5.2 and adding some specialties and the nitrogen based materials. Even if this is probably an underestimation due to the fact that data are missing in the Eurostat database, it gives some insight in the relative demand for each of the crop ingredients.

Carbohydrate crops

From the Eurostat database thus the information collected in Table 5.2 can be gained:
The selection was made on the basis of the input chemicals presented in Figure 5.1. Citric acid was added because it is already made from biomass and this will presumably not change and methanol and methanol are added as representatives for the C_1 chemicals. So approximately 47 Mton of chemicals production in EU-25 could possibly be made from carbohydrates. For this the resource can be either sugar or starch, or when the second generation fermentation technologies are in place also cellulose. The bioethanol for fuel production is not included in this figure, this will be presented in chapter **Error! Reference source not found.**. Also it should be kept in mind that this value is probably an underestimation because the Eurostat database is not complete due to the confidentiality of certain data. On the other hand this maximum demand

Table 5.2 Base chemicals from carbohydrates:

Products according to Eurostat	Volume possibly bio-based (tons)
Unsaturated acyclic hydrocarbons; ethylene	20346426
Unsaturated acyclic hydrocarbons; propene (propylene)	13829107
Unsaturated acyclic hydrocarbons; butene (butylene) and isomers thereof	2889012
Unsaturated acyclic hydrocarbons; buta-1.3-diene	2862456
Citric acid and its salts and esters	385131
Methanal (formaldehyde)	4052977
Methanol	2385461
Total	**46.750.570**

from the chemical industry is not likely to be fulfilled only with biomass within the coming decade.
For some of the products, especially the chemicals produced from propene, thus containing 3 carbon atoms, an alternative feedstock is glycerol. Glycerol is produced form natural oils, and is for instance a side product during the production of surfactants or biodiesel.
Many of these chemicals will find their way into plastics, for comparison Figure 5.3 shows the production of plastics in the EU 27, Norway and Switzerland. The data lie within the same order

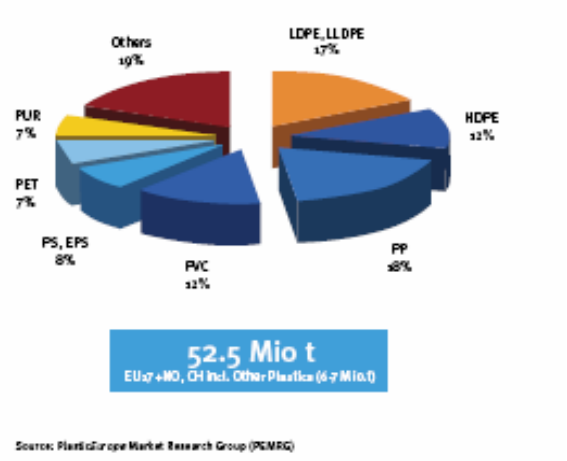


Figure 5.3, Plastics production in Europe, APME 2007 [10]

of magnitude as the carbohydrate based chemicals estimate. In principle carbohydrates can serve as one of the main resources for these products, although this will definitely not happen at a large scale within the near future. However, it must be mentioned that Braskem in building a

production facility in Brasil for the production of LLDPE and HDPE from ethanol [11], and Solvay is constructing a production plant for biobased PVC[12].

Lignin crops

Lignin is the only aromatic compound found abundantly in a variety of crops. Therefore the so called BTX-fraction from naphtha, the fraction containing benzene, toluene and xylene, and all the derivatives that are nowadays made from this fraction can be produced from lignin. For the volume of the basic molecules that can be produced from lignin the data in Table 5.3 can be derived from the Eurostat database.

Table 5.3. Base chemicals from lignin.

Products according to Eurostat	Volume possibly bio-based (tons)
Benzene	6084165
Toluene	1567756
Xylenes (o,m,p)	3249918
Total	**10.901.839**

So at least 11 Mton of basic chemicals production in EU-25 could possibly be made from lignin. Next to this some other applications are possible like the production of carbon fibres. Eurostat, however, does not give data on the present production of carbon fibres.

Oil and fat producing crops

Natural oil is already used within the chemical industry for a variety of products. Oils and fats give basically two kinds of building blocks: glycerol (also called glycerine), a tri-alcohol, and the glycerides (fatty-acids). Each crop gives oils with different fatty acids, and the possible applications of the fatty acids as building blocks are very much dependent on their chemical structure.

For chemicals based on glycerol a demand of approximately 2.2 Mton can be estimated from the present production data (Table 5.4). It should be noted that also some of the C_3 chemicals derived from propylene (Table 5.2) can be produced from glycerol. On the other hand, ethylene glycol can also be produced from carbohydrates. Which of the resources, carbohydrate or oils, will be used will depend on availability and price.

The fatty acids are traditionally used for surface active compounds, lubricants and additives (see chapter 4, table 4.4). There are new developments using vegetable oils as building blocks for the chemical industry, for instance using the glycerol that is a by-product of biodiesel production as raw material for the production of epichlorohydrin (the Epicerol technology from Solvay [13]). Another example which is already older is the use of castor oil as the building block for nylon-11,

Table 5.4. Base chemicals from natural oil

Products according to Eurostat	Volume possibly bio-based (tons)
Ethylene glycol (ethanediol)	667620
Diols and polyhydric alcohols (excluding ethylene glycol and propylene glycol; D-glucitol)	535193
Propylene glycol (propane-1.2-diol)	578957
Glycerol (glycerine)	396665
Totals	**2.178.435**

a polymer that is used in a number of high value-added applications in a.o. the automotive industry. To this end the fatty acids from the castor oil are modified to produce the building block. This kind of modification can also be performed on other natural oils and some new developments can be expected, but it is as good as impossible to predict total demand and the specific crop needed for these developments. It will most certainly be small compared to the demand for biodiesel (chapter **Error! Reference source not found.**).
Soy bean oil and linseed oil can be modified, epoxidised, to yield epoxidised linseed oil and epoxidised soy bean oil. These products are used for instance as plasticisers in PVC. They can also form the resource from which thermosetting resins are made, materials that can be used for the production of structural composites for a variety of engineering applications. These are already existing markets which might grow in the future. The Eurostat database, however, gives no information on these materials.
The demand for fatty acids will presumably be smaller than the demand estimated for glycerol which is produced from the same step resource.

Protein crops
For the production of chemicals functionalised with a nitrogen group the basis building block is anhydrous ammonia. However, most ammonia is used for the production of fertilizers. It is not likely that protein crops will be used for this source. Therefore, the amount of chemicals that can potentially be produced from proteins is estimated by estimating the amount of bound nitrogen in the base chemicals used for production of polymers and resins. (Table 5.5) From this the demand for proteins can be estimated, without taking into account at this moment the exact source of the proteins, since this will be done in task 6. A minimum of 10 Mton of chemicals might be produced from proteins. The weight of nitrogen bound is circa 2.3 Mton, taking into account mean nitrogen content in proteins of 16 %, a total of 14 Mton of proteins would be needed.

.Table 5.5 Base chemicals from proteins:

Products according to Eurostat	Volume possibly bio-based (tons)	Est. % of nitrogen	Weight of nitrogen bound (tons)
Methylamine; di- or trimethylamine and their salts	352224	0,30	105667
Diethylamine and its salts	23645	0,30	7094
Ethylenediamine and its salts	170267	0,40	68107
Hexamethylenediamine and its salts	792660	0,24	190238
Amino-alcohols; their ethers and esters with only 1 oxygen function and their salts excluding monoethanolamine and its salts; diethanolamine and its salts; triethanolamine and its salts	152283	0,23	35025
Acrylonitrile	727435	0,26	189133
Melamine	396804	0,67	265859
6-Hexanelactam (epsilon-caprolactam)	1928826	0,12	231459
Urea resins and thiourea resins; in primary forms	4183224	0,23	962142
Isocyanates	1631864	0,14	228461
Total	**10.359.233**		**2.283.185**

Unspecified biomass

The last category to include would be the production of syngas, as specified in Table 5.6.
So 17 Mton hydrogen and carbon dioxide could be made from more or less unspecified biomass.

Table 5.6 Base chemicals from unspecified biomass

Products according to Eurostat	Volume possibly bio-based (tons)
Hydrogen	11251338
Carbon dioxide	6003306
Total	**17.254.644**

5.4 Scenarios

Two extremes can be envisioned by which the transformation to a biomass based chemical industry may take place [14]:

1. Biomass will be refined and 'cracked' into the familiar platform chemicals (*i.e.* ethylene, propylene, C4-olefines and BTX) and synthesis gas ('syngas', a mixture of mainly carbon monoxide and hydrogen gas). From these one- to six-carbon building blocks, all other chemicals and materials can be produced. Provided that efficient processes will become available by which oxygen-rich biomass of a varying composition can be transformed into

basic hydrocarbon building blocks, the big advantage is that the current petrochemicals infrastructure and processes can be used. The fossil feedstock refining companies of today may then become the biorefineries of tomorrow. However, in many conversion processes towards the basis chemicals a lot of mass is lost as for instance CO_2 , so from the point of view of efficiency this might not be the preferred scenario.

2. A wide range of bio-based building blocks, in which as much of the functionality of biomass as possible has been retained, become the raw materials from which all other chemicals and materials are made. Not a few refineries that produce a limited number of platform chemicals will be present, but a large number of (smaller scale) biorefineries that produce a whole array of building blocks.

Between these two extremes lies a whole spectrum of non-exclusive scenarios that are perhaps more realistic. As a less extreme example of the first scenario: ethylene, one of the current platform chemicals, can be produced from (bio) ethanol. As mentioned, the Brazilian company Braskem and also US based Dow Chemical will each start commercial production of polyethylene from bioethanol. Both companies will locate their plants in Brazil, the world's most competitive bioethanol producing country. Bioethanol is currently made from sugar or starch. In the future, it is expected that ethanol will be made from the more abundant lignocellulosic or 'woody' biomass.
The real transformation to a bio-based chemical industry is going to have aspects of both extreme scenarios. The different components of biomass are transformed by many different processes into many different intermediates. Some are first broken down into one- to six-carbon building blocks; others are directly converted into polymers.

A transition to a society, where much more of our fine chemicals are based on biomass, is already under way. Examples are the biotechnological production of vitamins and other food-additives and pharmaceuticals (inspired by technological advances). This leads to a bio-based fine chemicals sector which is small in terms of volumes, but large in terms of turnover/sales. In the Netherlands, DSM and Organon (the latter now part of Schering-Plough) are leading companies in this area. DSM claims to already generate one quarter of its turnover in this area on processes based on biomass.

5.5 Potential players in the bio-based chemical industry

A more bio-based chemistry will almost surely lead to new alliances between the chemical industry and the agro-food sector [14]. New alliances will be made, broken up and restored in different formats. Examples of such alliances are the cooperation (until recently) between Dow Chemical and Cargill in the field of polylactic acid chemistry ('NatureWorks®') and product launching. This alliance was broken up, but more recently a new alliance between Cargill and Teijin was established, with the aim to further promote market potential of PLA based products. Other examples are the cooperation between Dupont and Tate & Lyle on the development and production of 1,3-propanediol for fibres and the cooperation between Roquette (French starch

manufacturer) and Dupont on isosorbide, with the aim to produce more bio-based PET plastics. Also, new trade relations are being established, such as Shell and SABIC buying bio-ethanol for ETBE production.
In this transition process both existing multinational industries as well as newcomers are likely to be willing to invest in building new chains and product portfolios.
Newcomers in the area of (precursors for) bulk chemical production will almost surely also be companies from the agro-food sector such as ADM, Cargill, Tate & Lyle, Abengoa, Cosun, Roquette, Südzucker, Campina, KEMIRA, BER, Blue Ocean, and Danisco/ Genencor. All these companies are in the process of defining their future strategy towards non-food products and intensifying their activities with regard to the potential production of bulk chemicals.
In addition to the established chemical companies and the agro-food sector, a third sector will be the catalyst producers, currently offering 'enabling' technologies to the chemical industries. These include producers of biocatalysts (enzymes, micro-organisms) and producers of catalysts for the petrochemical industry, such as Engelhardt (BASF), Albemarle and Grace Davison. These companies will increasingly become interested in exploring the possibilities of catalytic conversion of biomass and the development of new optimised catalysts.
A fourth class of companies will be (new start-up) companies that today have neither a business in the agro-food sector nor the chemical sector.
Apart from the examples given earlier, it is currently too early to predict what the new chemical value chains will look like. Agro-food companies may become producers of bulk chemicals, established chemicals producers may keep this role, or both. It is important to develop realistic scenarios and analyse their potential, which will be taken up in task 6..

5.6 Recent developments in the field of biobased polymers

In line with the developments presented in the previous paragraphs, recently numerous new world-wide developments in the field of biobased polymers have taken place, of which a short overview is presented here [15]. Some of the examples were also discussed in paragraph 5.3.

Polytrimethyleneterephthalate (PTT)
Partially biobased PTT can be produced from petrochemical terephthalic acid and biobased 1,3-propanediol (PDO). Biobased PDO is produced by DuPont in a plant with a capacity of 45.000 ton/year. The partially biobased PTT is marketed as Sorona®, a polymer which exists for 37% of renewable resources. Sorona® is applied in apparel and garments like sportswear and fine underwear, but also in carpets and cars.
Similar to this, Coca-cola has announced it will use a partially biobased PET for the bottles of their DASANI brand water [16] The ethylene glycol, which is the biobased building block, is made from carbohydrates.

Polyamides

Biobased polyamides are presently produced at an industrial scale. Production data are confidential, generally production is estimated to amount to some 30-50 kton/year.
Arkema produces biobased polyamides (for example Rilsan®PA-11) based on castor oil, this polymer was always biobased. The polyamides are chemically, thermally and mechanically highly resistant and can be processed in a variety of ways.
Another example is Pebax®Rnew, a biobased block-copolymer of polyamide-11 en polyether segments.
Polyphtalamide (PPA) is the high-performance variant of the biobased polyamides. This thermoplastic material can replace metals which are used in for example high temperature under-the-hood applications in the automotive industry. Arkema produces a PPA of which 70% of the carbon content comes from renewable resources (Rilsan®HT).
Arkema also markets a co-polyamide hot-melt glue produced from 100% renewable resources (Platamid® Rnew).

Polyhydroxyalkanoates (PHAs)

PHAs are bioplastics produced by micro-organisms. Due to their biodegradability the PHA scan be used in a wide range of applications, especially in the pharmaceutical and medical industry, but due to their high price, commercial applications of PHAs have remained limited up till now. The commercial PHAs often are butyrate/valerate co-polymers (PHB-V).
In the USA presently a plant is built by Metabolix and ADM with a production capacity of 50.000 ton/year. The plant will produce PHA for application in high value-added products like packaging for cosmetics.
Tianan in China has announced to increase the present capacity of 2.000 ton/year to 22.000 ton/year.
DSM has announced it will invest in the Chinese plant GreenBio which will produce 10.000 ton/year of PHA from 2009 on.

Biobased polyvinvylchloride (PVC)

Ethylene from bioethanol can serve as a raw material for the production of PVC. Solvay has announced to invest $135 million in a production plant in Brazil for the production of 60.000 ton/year of biobased ethylene as basis for the production of biobased PVC.

Polyurethanes (PUR)

PUR based on polyols (chemicals with several alcohol groups) from vegetable oils is commercially available from many PUR producers like Cargill, Dow, Bayer en BASF. These polyurethanes contain a maximum of 50% renewable resources.

Epoxy resins

Epoxy resins are applied as coatings or as binders in composites for strong, light-weight

materials. For the production of epoxy resins epichlorohydrin is used. Petrochemical epichlorohydrin is produced from propene and chlorine gas.
Solvay has developed a process that uses glycerin as raw material for the production of epichlorohydrin. Glycerin (or glycerol) is a co-product of biodiesel production from, for example, rapeseed oil. This process (Epicerol®) is presently optimised in France on industrial scale.
Dow is building a production plant in Sjanghai, with a capacity of 150.000 Mton/year epichlorohydrin from glycerin. This process gives less waste water and uses less chlorine.

Polyester resins
Unsaturated polyester (UP) based on mineral oil is usually produced from propyleneglycol (1,2-propaandiol).
Ashland and Cargill have announced in 2007 to build a production plant with a capacy of 65.000 ton/year of propyleneglycol from glycerol.
Ashland also produces a polyester with biobased PDO (1,3-propaandiol) from DuPont; volumes of production are not known.

Conclusions
Worldwide there are many ongoing developments in the field of bioplastics and bioresins. Existing plastics can be (partially) produced from renewable resources, but also completely new plastics like the PHAs are produced at ever increasing scale. Resources for these plastics and resins are often starch, sugar or vegetable oil. The scale of production is still limited but will rapidly become more substantial in the years to come.

5.7 Conclusions

Many new developments in the field of non-food use of biomass focus on application of renewable resources as building blocks in the chemical industry. The estimated demand for the various resources is shown in Table 5.7. This category of biomass applications is for the larger part not (yet) existing, however, together with the possible biofuels demand it is relatively large

Table 5.7. Estimated potential volume of chemicals from biomass

Biomass type	Potential volume of base chemicals from biomass (Mton)
Carbohydrate	47
Lignin	11
Natural oil	2
Protein	10
Unspecified	17

and can thus have a serious impact on the way the production chains are organised. Also the crop requirements may be different from other applications. For the carbohydrate, lignin and "unspecified" demand the crops can probably be regarded as bulk, whereas for natural oil and protein demand specialty crops, requiring specific production chains are more likely to arise.

6 Sourcing of feedstocks for producing non-energy biobased chemicals and products in Europe.

6.1 Introduction

In the previous chapter estimates have been made on the possibilities to use biomass instead of fossil fuels to produce chemicals and related products in Europe in the long term, beyond 2020 to 2030. Based on the outcome of chapter 5 the following table can be drawn up:

Table 6.1 New potential demand for biomass feedstock from the chemical industry

Biomass type	Potential volume of chemicals from biomass (Mton)	Estimated conversion efficency [%]	Estimated resource demand (Mton)
Carbohydrate	47	80	58
Lignin	11	80	14
Natural oil	2	15	12
Protein	10	71	14
Unspecified	17	80	21

The choice for the conversion efficiency of 80% is arbitrary, but producers can be expected to optimize this parameter. The conversion efficiency for oils is based on the glycerol fraction, the conversion efficiency of proteins is based on the nitrogen bound.. The question to be addressed would now be how we are going to source this additional biomass demand.

6.2 Carbohydrates: How to source 58 million tons of carbohydrates for production of chemicals?

At this moment the option for sourcing carbohydrates is limited to sugar and starch crops. In Table 6.2 the most relevant conventional carbohydrate crops in the EU are presented.

Table 6.2 Conventional carbohydrate sources in the EU-27 based on 2008 data.

Crop	Total production	Carbohydrate content	Carbohydrate yield	Area harvested	
	Million tons	%	Ton /ha	Million ha	
Wheat	150,514				
Coarse grains	160,062				
Sugar beet	112,974		62,139	1,818	
Sweet Sorghum					
Potato	61,994		27,891	2,222	

(USDA, Febr, 2009); FAOSTAT for 2007, February 2009)

In the coming years depolymerization of lignocellulosic materials will also yield carbohydrates. The main options will be straw from cereals and maize, biomass grasses (Miscanthus and switchgrass) and short rotation coppice (willow).

Table 6.3. Lignocellulosic biomass crops/by-products in the EU-27 projected for beyond 2020.

Crop	Biomass yield	Carbohydrate content	Carbohydrate yield	Biomass needed for 63 million tons carbohydrates	Area needed for 63 million tons carbohydrates
	Ton /ha	%	Ton/ha	Million tons	Ha
Good conditions					
Energy grasses	15	70	10,5	90	6
SRC	12	60	7,2	105	8,75
Straw	5	70	3,5	90	18,0
Marginal conditions					
Energy grasses	10	70	7,0	90	9,0
SRC	8	60	4,8	105	13,1
Straw	3	70	2.1	90	30,0
Wood (forest/residues)		60		105	

References [17, 18, 19] and personal estimates

Straw availability

In the EU in recent years some 300 million tons of wheat and course grains were produced. The amount of straw produced should be at least 200 million tons per year. How much of this straw is actually available is hotly debated. The availability of straw (wheat, barley, etc) and corn stover is determined by many factors[18]. Such as productivity per ha, grain to straw ratio (which declines as grain production increases) and alternative uses (bedding for animals, substrate for mushroom production, etc). Furthermore at lower production per ha more straw biomass needs to be incorporated into the soil to maintain soil quality. Overall an estimated 50 to 100 million tons of straw could be available in the EU for energy and chemical applications in the coming decades. This could be sufficient for supplying the 58 million tons of carbohydrates.

Overall availability of biomass in the EU

EEA [19] estimates that by 2030 some 250 to 300 million TOE of biomass could be available by 2030. This is equivalent to 580 to 700 million TOE. This includes wastes, forestry and agricultural biomass. Siemons et al [20] estimated that by 2020 204 million TOE biomass would be available in 2020 in the EU 27. This is equivalent to 470 million tons of biomass.

Therefore we conclude that 58 million tons of carbohydrates would require some 100 million tons of lignocellulosic biomass which would require about 20% of all available biomass in the EU by 2030. Competing uses would be current demand (building material, pulp, electricity and heat and second generation biofuels).

6.3 Lignin: How to source 14 million tons of lignin for production of chemicals?

Lignin is currently a by-product of pulp production and will be a product of pretreatment of lignocellulose for production of second generation biofuels production (lignocellulosic ethanol). At the start of this century an estimated 50 million tons of lignin was produced in paper pulp production worldwide (Gosselink et al. [21]). Of this amount only 2% was used for other uses than energy generation at the mill. Modern mills generally produce an excess of energy (from black liquor) making it possible to export energy or sell part of the lignin for chemical products on the market. We estimate that worldwide 25 to 50 % of the lignin from pulp mills could be available, if black liquor would be used only for efficient mill energy production. The excess could then be sold. Assuming at least a 20% increase in pulp production in the coming decades this would make at least 15 to 30 million tons of lignin available for chemical products worldwide. Assuming that in the coming decades 20% of the (chemical) pulp production would be produced in the EU some 3 to 6 million tons of lignin could be available for production of chemicals.

The remaining 11 to 7 million tons of lignin could be imported or sourced from lignocellulosic biofuel plants which are also expected to produce an excess of lignin.

At this moment the EU aims to replace 10% of the fuels by biofuels in 2020. With a total transport fuel demand of 250- 300 MTOE. This would require up to 30 MTOE of biofuel by 2020 and beyond. Some 10 million TOE of gasoline will have to be replaced by biofuels (probably ethanol). Some 20 million TOE diesel will be replaced by Fischer Tropsch diesel. We assume that in the long run all biofuels will be sourced from lignocellulosic biomass and 10 TOE (30%) would be sourced from a pretreatment process of lignocellulose (i.e. ethanol or butanol).

The availability of lignin from lignocellulosic based biofuel plants would depend on type of feedstock and energy need for own operation. We assume that low lignin feedstocks such as straw have a lignin content of 20% and high lignin feedstocks such as wood have a 30% lignin content. In Table 2 the ethanol and lignin production from lignocellulosic ethanol production is presented. If 10 million TOE of ethanol biofuel would be made from equal amounts of straw and wood the total lignin amount

10 million TOE of ethanol is equal to 20 million m^3 of ethanol. 10 million m^3 would require 32,25 million tons of straw (or energy grasses) also yielding 3,22 million tons of lignin. 10 million m^3 would require 32,25 million wood also yielding 7,41 million tons of lignin.

Table 6.4. Expected lignin availability from lignocellulose to ethanol plants, assuming 100 kg lignin per ton input would be needed for energy in the plant and the remainder could be applied elsewhere.

	Lignin	Carbohydrates	Ethanol	Lignin	Available lignin	Ethnol production	Lignin available
	%	%	liter/ton DM	kg/ton DM	kg/ton DM	Million m^3	Tons DM
Straw / energy grass	20	70	310	200	100	10	3,22
Wood / wood crops	30	60	270	300	200	10	7,41

1 TOE = 2000 liter ethanol.

We conclude that in the EU at least 3 to 6 million tons of lignin should be available from the wood based pulp industry in the coming decades. The remaining 11 to 7 million tons of lignin could be imported.

Alternatively 3,22 to 7,41 million tons of lignin could become available from lignocellulose to ethanol plants which are expected to be built in the coming decades. The competing alternative use of the lignin would be electricity or Fischer Tropsch chemicals and FT diesel.

Therefore lignin can probably be sourced from the pulp industry and in the longer run (2020 and beyond) from pretreatment process for lignocellulose (ethanol) production.

6.4 Vegetable oils: How to source 6 million tons of vegetable oils for production of chemicals?

The world vegetable oil production is currently (2007/2008) 128,22 million tons per year of which 50,81 million tons are exported (USDA [22]). As shown in the table below the main oil crops are in order of importance:
Palm,
Soybean,
Rapeseed,
Sunflower,
Peanut,
Cottonseed,
Coconut
Olive

Table 6.1. World vegetable oil production (USDA, 2008)

Item	2003/04	2004/05	2005/06	2006/07 1/	2007/08 2/
			Million metric tons		
Production					
Coconut	3.29	3.47	3.43	3.28	3.31
Cottonseed	3.85	4.78	4.66	4.87	4.87
Olive	3.06	2.97	2.59	2.99	3.02
Palm	30.00	33.40	35.95	37.02	40.80
Palm Kernel	3.68	4.14	4.38	4.48	4.81
Peanut	5.07	5.09	4.97	4.81	5.03
Rapeseed	14.17	15.77	17.27	17.60	17.95
Soybean	30.17	32.53	34.52	36.25	38.37
Sunflowerseed	9.19	9.17	10.50	10.72	10.08
Total	102.48	111.31	118.27	122.02	128.22
Exports					
Coconut	1.79	2.04	2.05	1.74	1.73
Cottonseed	0.14	0.12	0.11	0.17	0.18
Olive	0.66	0.64	0.57	0.69	0.65
Palm	21.61	24.48	26.71	26.84	29.32
Palm kernel	1.61	1.92	1.98	2.44	2.28
Peanut	0.24	0.17	0.19	0.16	0.15
Rapeseed	1.33	1.31	1.73	1.95	1.95
Soybean	8.83	9.12	9.82	10.67	11.17
Sunflowerseed	2.67	2.63	3.88	3.86	3.38
Total	38.85	42.44	47.04	48.51	50.81
Imports					
Coconut	1.68	1.87	1.98	1.84	1.84
Cottonseed	0.13	0.10	0.09	0.11	0.11
Olive	0.60	0.57	0.57	0.64	0.61
Palm	21.39	23.92	25.69	26.63	29.15
Palm kernel	1.49	1.58	1.73	2.01	2.05
Peanut	0.19	0.17	0.16	0.19	0.21
Rapeseed	1.36	1.20	1.46	2.22	2.45
Soybean	8.33	8.86	9.01	9.75	10.52
Sunflowerseed	1.92	2.17	3.24	3.29	3.05
Total	37.09	40.46	43.94	46.67	49.97
Consumption					
Coconut	3.24	3.34	3.45	3.42	3.43
Cottonseed	3.80	4.66	4.66	4.82	4.88
Olive	2.72	2.86	2.78	2.93	2.94
Palm	29.29	32.50	35.02	36.91	40.45
Palm kernel	3.61	3.78	4.03	4.28	4.45
Peanut	5.02	5.11	5.01	4.90	5.05
Rapeseed	14.33	15.60	16.96	17.99	18.48
Soybean	30.04	31.61	33.51	35.59	37.95
Sunflowerseed	8.37	8.53	9.80	10.44	9.88
Total	100.41	107.99	115.23	121.27	127.49
Ending stocks					
Coconut	0.41	0.37	0.28	0.23	0.21
Cottonseed	0.10	0.21	0.19	0.19	0.10
Olive	1.09	1.13	0.94	0.94	0.98
Palm	3.11	3.45	3.36	3.26	3.44
Palm kernel	0.38	0.40	0.50	0.28	0.41
Peanut	0.20	0.18	0.10	0.04	0.07
Rapeseed	0.46	0.51	0.56	0.43	0.40
Soybean	2.38	3.05	3.24	2.99	2.76
Sunflowerseed	0.57	0.75	0.81	0.52	0.39
Total	8.70	10.04	9.98	8.88	8.76

1/ Preliminary. 2/ Forecast.

Source: *Oilseeds: World Markets and Trade*, Foreign Agricultural Service, USDA.

The EU-27 is a net importer of vegetable oils (7.85 million tons in 2008) with a local production of 15,2 million tons and a net consumption of 21,77 million tons (USDA, 2008). The main oil crop in the EU-27 is rape and sunflower.

If the vegetable oil were to be produced in the EU itself 12 million tons of vegetable oil would require between 6 million ha if and 12 million ha depending on the crop and productivity of the crop.

Still, a significant part of the biodiesel feedstocks needed in the coming years are expected to also be imported, mainly from South America and Malaysia/Indonesia. To source vegetable oils for chemical uses it may be expected that much of the oil will also be imported.

I all the oil were sourced from the most productive option, oil palm (5 ton oil/ha per year), some 2.400.000 ha would be required.

It seems likely that the chemical industry will require a wide range of specific oils with specific characteristics. This would require specific crops. i.e. linseed, castor, safflower, Palm Kernel Oil but also common crops like palm, soybean and rape.
On the other hand, the glycerol fraction will also become available from the biodiesel production, thus lowering the additional demand for oil.

In the coming decades algae biomass will also become an option that could yield up to 30 tons of oil per ha. This would mean that 12 million tons of oil would require 400.000 ha if these yields can be attained.

6.5 Proteins: How to source 14 million tons of proteins for production of chemicals?

The need for 14 million tons of protein translates into 2.3 million tons of (bound) nitrogen as was discussed in the previous chapter.
Nitrogen fixation is a first step in de production of proteins this can be obtained through biological N fixation by natural systems i.e. symbiosis with bacteria or alternatively through production of nitrogen fertilizer in factories. The nitrogen fixation process is an energy intensive process.
The worldwide nitrogen fixation is estimated at 175 million tons for biological nitrogen fixation, and 30 million tons for combustion and lighting [23]. Of the biological nitrogen fixation 90 million tons is produced on agricultural land. At the same time industrial N fixation has been expanding fast since the war and is estimated at 134 million tons per year [24].

The energy intensity of both biological and industrial nitrogen fixation plus the associated emissions of N2O, which is a very strong greenhouse gas (300 times stronger than CO2), makes efficient use of bound nitrogen essential. Especially if the purpose of utilizing proteins for

production of chemicals is to reduce fossil energy use and Greenhouse effect abatement. This means that it is worth while to try to produce chemicals from nitrogen (and protein) sources that are at the moment unused or underutilized.

Cases where protein is underutilized include:
1. Burning of animal proteins because of hygiene measures (BSE). We estimate that in the EU some 1 million tons of animal protein is burned (for energy) which could also be used for chemicals if proteins would be de-polymerized into amino acids adequately. The cost for these amino acids would essentially be the energy content, which is much lower than the energy cost of N-fixation.

2. In intensive animal production systems protein supply is higher than required [25]. This is explained by the fact that the amino acid supply in feed does not mach the amino acid profile needed by animals. Animals require a minimum of 9 essential amino acids. An oversupply of protein in feed is used for energy by the animal and N is excreted. Though fixed N is excreted (as urea and manure) by animals and partially used as fertilizer much is volatilized, leached and denitrified. The high levels of volatilization, leaching and denitrification in intensive animal production systems constitute a problem. Manure disposal is costly in intensive animal

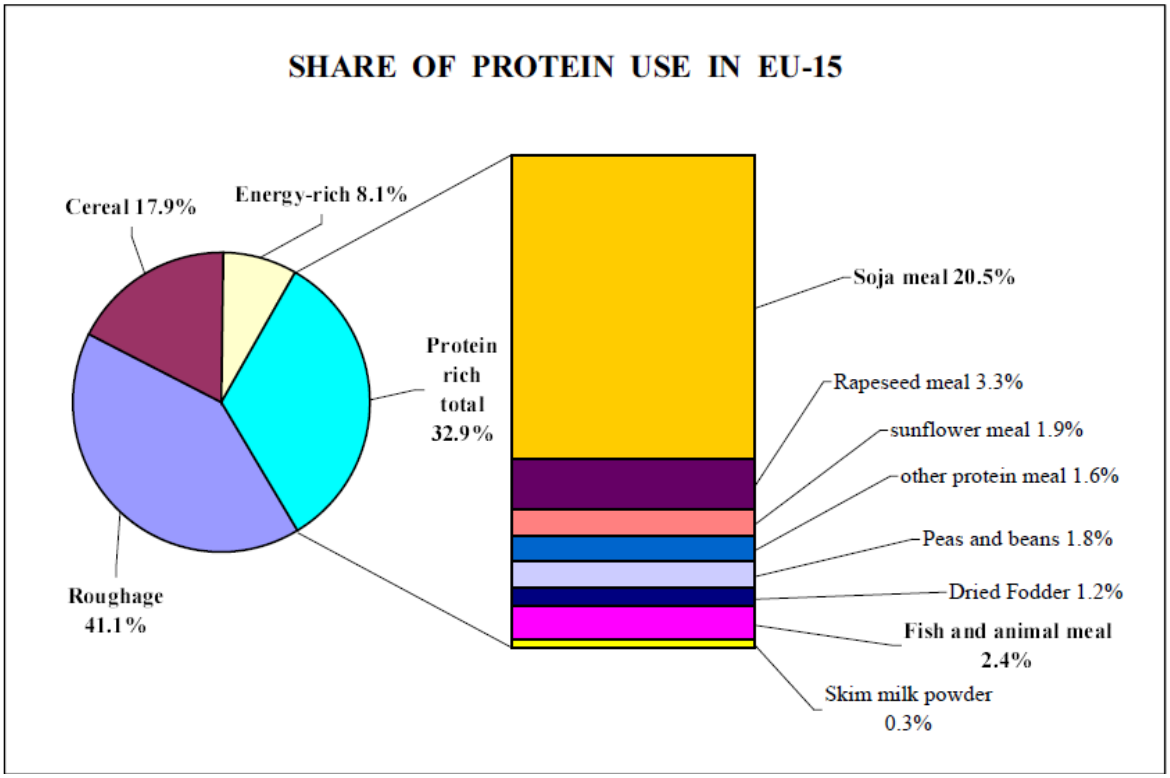


Figure 6.1. Share of crude protein in total animal feed in the EU-15 in 2001 based on a total protein use of 64 million tons [26]

production systems in the EU. This means that it would be attractive to decrease the protein intake of animals. On top of this the value of protein as a chemical is many times higher that the equivalent value as fertilizer. We estimate that at least 25 % of the protein in animal feed (in intensive animal systems) could be reduced while maintaining the essential amino acids in the feed. This requires biorefinery of the feed to obtain a lower protein feed containing the essential amino acids (and other characteristics). Non-essential amino acids could then used for production of N containing chemicals.

In figure 6.1 the share of protein use in the EU-15 is shown. Protein rich feeds accounted for 21 million tons of protein in 1999. In the 2005 protein rich feeds accounted for 23.5 million tons of crude protein in the EU-25 [26].

Obvious targets of biorefinery (of proteins and amino acids) would be:

- 50 million ha of intensive grazing land in the EU producing 500 million tons DM of grass. Which contains at least 15% protein = 75 million tons of protein. Protein levels in the grass are much higher than required by cattle. Biorefinery of grass and utilization of protein for other animals (pigs or poultry) or chemicals is then possible. Biorefinery of 20% of the grass would yield 25% amino acids for chemicals = 3.75 million tons of protein (for chemicals).
- High protein meals used mainly for animal feed (Copra, Cottonseed, Fish, Palm Kernel, Peanut, Rapeseed, Soybean, and Sunflower Meal). In 2008 the EU produced some 25.7 million tons per year and consumed 52.6 million tons [22]. If we assume a 50% protein content in meals [27,28] this would mean that the EU consumes some 25 million tons (see 23.5 above). Refining the material could yield (25 x 0.25) 6.25 million tons of amino acids for chemicals.
- Cereals for feed and DDGS (dried distillers grains and solids) could also be biorefined to yield feed with optimal amino acid levels and proteins for chemical production.

The above shows that biorefinery of grass and high protein feeds could yield at least 3.75 + 6.25 = 10 million tons of protein for chemicals. Bone and meat meal could also yield 1 million tons of protein for chemicals.

More protein for chemicals could be sourced from the by-products of the expanding biofuel production. This includes DDGS and rape meal.

Another option is specific protein crop production. Still, a good comparison to the chemical route would have to made to see if this is economically energetically and especially environmentally beneficial. Crops that could be used include alfalfa (luzerne), peas and lupins.

Production of proteins by algae should also be an option especially of the N source is manure from intensive animal production.

6.6 Other biomass: How to source 21 million tons of unspecified (i.e. Lignocellulose) biomass for production of chemicals?

As discussed above some 500 million tons of biomass could be available in the EU by 2020/2030. Competing demands from other chemicals, building material, pulp, electricity and heat and second generation biofuels are the main uncertainty issue.

7 Feed Markets

Feed include two main categories: Compound feed, which is mainly produced in industrial operations, and other feeds, mainly roughage but also simple concentrates and raw material which are directly used on-farm. Reliable balance data for compound feed from industrial origin are available, whereas for roughages, particularly permanent pastures and meadows, reliable data can only gathered for area, not for production.
Tables of this chapter are presented in Appendix A.

The average annual production of compound feed in EU25 between 2003 and 2007 was 144 million tonnes. Table 1, from FEFAC (European Federation of Feed Manufacturers), gives an estimate of the amounts of raw materials consumed by the feed industry in Europe. This large production of compound feed is mostly for consumption within the EU, since exports to third countries are less than 1.1 million tonnes (This figure is an upper bound; compound feed exchanges are declared under SITC 081.99 where some other products are also included). To meet their needs, feed industries in EU must import annually 34 Mt of raw materials, mainly, by-products of primary industrial transformation of different food commodities (26-27 Mt of oilseed cakes, 3.0-3.5 Mt of CGM and DDG, 1.5-2.0 Mt of molasses and 1.4-1.8 Mt of beet pulp and citrus pulp; table 2). Although, overall, the EU is self sufficient for cereals, 5.0-10 Mt of imported cereal grains are used by the feed industry annually.
The most remarkable deficiency in feed ingredients in EU are protein concentrates, which, except for pulses and dried forages, are produced domestically below 70% of our needs (see table 3).

Animal feed used 158 Mt of cereals annually in 2005-2007, one third of it through direct farm use and 48 % as compound feed ingredient. Common wheat, maize and barley are the most important, adding to 80% of the total used for feed (table 4). The contribution of rye, oats and triticale is less significant (20 %), and, to a great extent, they are used directly on farm. According to DGAgri, the projected increase in use of cereals for feed by 2014 amounts to 10 Mt (accounted mostly by wheat – 6.7 Mt – and maize – 6.1 Mt- with minor reductions in other coarse grains).(*In March 2008, DGAgri published a forecast of agricultural markets with data on cereal productions, the table of total cereals production is attached at the end of Appendix A).*

The average annual use of dry pulses for animal feed was 3.8 Mt (2003-2005), with more than half of it being peas (2.4 Mt; table 5). Overall, more than 75 % of pulses are utilized as animal feed with self sufficiency ranging between 79 and 120 %.

The feed industry absorbs the totality of oilcakes produced domestically (15-20Mt from both domestic and imported seed) as well as imported cake from third countries (an average of 18-20 Mt; table 6). The self sufficiency for oil cakes is 45-47 %, however, this estimate accounts as a

domestically available resource the cakes obtained by EU crushing industries from imported soybeans (around 14 Mt/year).

The most significant oilseeds are soy and rape; in Mediterranean countries, olive is also a mayor source of fat. Part of the available oilseeds, particularly soy and rape (1.5-2.0 Mt) are used as full-fat supplements for animal feeding, either raw or heat/mechanically processed, but the vast majority is processed for oil extraction. Fats are also added to animal feed in the form of fats and oils, the majority of them being imported palm products (0.25-0.28 Mt/year) and soy or rape oils (0.10 Mt each).

Among the remaining common feed ingredients produced in the EU territories, potatoes and their derivatives are the main amylaceous material. The EU is self sufficient for potatoes, 60 %which are marketed as a fresh vegetables and only 15-20 % (4-11 Mt; table 7) are used for animal feeding in different forms. The remainder 20-25 % is either processed to various food products, industry transformed for starch and alcohol or used as seed.

The sugar beet industry is also an important supplier of energy and fibrous concentrates. The main by-products of sugar milling are sugar beet pulp and molasses. The former is the dry or wet solid residue of beet root after sugar extraction. Assuming a 5% yield of dry pulp per unit of fresh beet processed, the total usable production would be 5-6 Mt/year (table 8), used mainly for ruminant feed and, to a lower extent, rabbits and pigs. Most pulp is used TMR component in dairy rations and there are no reliable data on the amount actually used. Molasses, the liquid by-product marketed with dry matter content around 75%, are a common ingredient of compound feeds. Approximately 2-3 Mt (50 to 60% of the usable domestic production) goes to animal feed.

Other industrial by-products used for animal feed are those from milling, brewing, distilling and starch industries, which in the ProdCom are classified as:

Milling	15.61.50.10,30, 90;
Brewing; Distilling and Starch	15.96.20

In 2005, the amounts of milling residues recorded in Prodcom data set were 0.38 Mt for maize, 0.40 for rye and 0.44 Mt for other cereals and 8.16 Mt for brewing, distilling and starch. Similarly, vegetable by-products and waste for animal consumption, mainly produced by the food industry, provides annually 1.3-1.7 Mt of fresh material with varying dry matter content.

Finally, a whole range of vegetable materials exclusively for animal feeding are summarized in the Crops supply balance sheets. The fodder products are divided into two main groups: fodder from arable land, be it annual or perennial, and fodder from permanent meadows and grasslands, as well as other minor permanent crops. The interpretation of data in these categories is difficult. On the one hand, surveys to gather the data are probably less systematic than for other crops, since fodder in these groups are in some cases harvested and consumed in the same farm

operation without reliable recordings on yields, while others are grazed. On the other hand, the products included in these categories, which are reported as green fodder production, cover a wide range of dry matter contents, making it very difficult to estimate the average energy content of the crops. These difficulties might be the reason why reporting by the different countries is not as systematic as for other crops, and there are several categories with data for only 5 or 6 countries.

The data on surface used for each category might be more useful for capacity studies because harvest and production areas are more systematically reported and they remain more or less constant through the years. Table 9 indicates the average area reported and the range of production for the period 2000-2007, as well as the average actual values for 2005. The area dedicated to permanent grasslands is similar (95-100 %) to that cropped for cereals. Arable land for green fodder represents one third of that used for cereals. The total amount of fodder obtained from this area ranges between 0.25 and 0.6 billion tons of fresh material which would correspond to 45 – 200 Mt of dry matter, albeit highly heterogeneous in composition and accessibility.

8 Food Markets

The basic data on the amount of different crops that are used for food purposes have been taken from Eurostat's balance sheets for the different crops. Here the resources available (the balance between domestic production, commercial exchanges with third countries and the variation in final stocks for each period) are partitioned to several different broad uses: seed, animal feed, industrial use, different types of processing, losses and gross human consumption. Initially, GHC accounts for most food uses; however, food products with specific supply balance sheet are not computed in GHC, but in processed products. As an example, estimated GHC of sugar beet is zero, while almost 92% of the available resources are processed to sugar, whose GHC amounts to 77% of the domestic production. For other commodities, like cereals, the milling to flour is not considered as industrial processing, and the GHC for cereals includes all uses of flour products. GHC of durum wheat is as high as 93%.
Tables of this chapter are presented in Appendix A.

Gross human consumption of the main agricultural crops is calculated in the different supply balance sheets. For each group of products the quantities dedicated to seed, animal feed, industrial uses, processing and human consumption, as well as losses are estimated.
"Industrial uses " refers to the quantities used by industries for the production of goods not intended for animal feed or for human consumption, including bear and alcohol industries, while "processing" refers to the quantities of product used for the production of a derived foodstuff for which an individual balance exists. Therefore, the Gross human consumption heading refers to all food used of the agricultural product, including processed food except those processed products which are specifically dealt with in a separate balance sheet.

Human consumption indicates the quantity of foodstuffs that are delivered unprocessed, processed or preserved, to the different market circuits (retail trade, community catering) or are consumed by producers.

According to Eurostat, the combined production of the main agricultural crops in EU-25 in 2005 was 417 Mt, with approximately 3/8 of it being fodder crops and a similar proportion being cereals.

Cereals partition among different uses in 2005 is given in table 10. In general terms, human consumption represented 24.9 % of the total domestic consumption in that year. This proportion remains rather stable: for the period 2001-2008 GHC was, on average 23.1% of domestic use (maximum 24.9 in 2005, minimum 21.3 in 2006). There are, however, neat differences among different cereals: Triticale is a feed cereal, with 88 to 93 % being consumed as animal feed (90.8 % in 2005) and the remainder being used for seed; while food uses of durum wheat are always over 80% of total use (87.8% in 2005).

The Gross human consumption calculated in the cereals supply balance sheets accounts for all food uses through milling and bakery products. Only starch and starch derivatives used in food industry are not included here, but in the heading "processing" along with other starch applications. The only cereal with a substantial contribution to food industry starch uses is maize. Even so, the percentage of maize used for this purpose ranges between 0.3 and 0.52 (0.43% in 2005), compared to direct food uses ranging between 5.8 and 14.0 % (0.188 Mt or 8.4 % in 2005).

Table 11 shows the production of milling, pastry and bakery products of different categories, each including a variable proportion of cereal based product. The totals in the last row correspond to the total human consumption of cereal products for the period.

Vegetable oil use in EU-25 is 11-12 Mt per year (table 12), with a clear self sufficiency for olive, rape and sunflower (although this can only be discussed for the entire oilseed complex). There is a clear deficiency for saturated vegetable oils, included under the heading "other oils" in the table. Gross human consumption can be estimated to be around 6-7 Mt/year, although the data sets available are quite incomplete for these products. The processed oil products marketed are shown in table 13, listed by Eurostat as "*Production and external trade of foodstuffs*". However,1) the entries shaded in grey are almost exclusively for industrial oil; the ones shaded in blue have significant industrial uses, although the food use is the main one; and 2) the totals are very close to the "total domestic use" derived from the supply balance sheets. On the other hand, the *"foodstuffs"* data set is more complete than the balance sheet data (less missing data).The "balances" in table13 represent, most likely, the amounts available for these products, regardless of their final use; they should be taken as total domestic use.

The average human consumption of **dry pulses** is 0.9-1.0 Mt/year (table 14), with peas representing one fifth to one fourth of the total. This includes the amount of preserved beans and peas, as well as flours of different legumes (0.9-1.5 Mt of fresh weight; table 15), since there is no "processing" entry in the pulses balance sheet.

Potatoes consumption of 30 Mt/year remains quite constant through the years, with an additional 6 Mt consumed in the form of processed products (table 7). The quantities in this table are slightly lower than those listed for "processed" potatoes in the supply balance sheet (table 16), because some of these products are in a dry form.

The consumption of **other products**, such as fruits, vegetables, sugar, wine, grapes and nuts, is given in table 17. A summary of gross human consumption of the main food items is presented in table 18.

9 Conclusions

Present and future market value of biobased (intermediary) products in the three application groups can be summarized as:

	Number of items	*% item values recorded*	*Total value for EU25* (thousand €)*	*Actual biobased value** (thousand €)*	*Potential bio-based value** (thousand €)*
Materials from biomass	286	76%	225.135.479	167.790.582	208.239.794
Ingredients from biomass	168	60%	78.968.609	25.813.317	37.819.695
Building block from biomass	334	34%	152.771.862	32.924.393	79.837.990
Totals	**788**	**55%**	**456.875.950**	**226.528.292**	**325.897.479**

* for known figures

** based on expert judgement of the non-food, non-feed component

It should be realized that especially for the building blocks group the estimation of the potential biobased value is far too low since all value data of the important future plastics market are missing.
Nevertheless it can be concluded that the present total value of biobased products produced is already impressive and there is ample opportunity for growth, especially in the building blocks group, which is potentially even much larger than is presented in the table above.

Concerning the demand for resources the following estimations were generated from the Eurostat data:

Materials from biomass	**Volume actually bio-based (tons)**
Wood for pulp, timber etc.	72.704.063
Natural fibres for fabrics etc	1.692.637
Total	**74.396.700**

The demand for wood is definitely an underestimation since the total roundwood production is approximately twice as large.
These applications are however markets that exist today. It is likely that growth will be accommodated within the existing production chains. With the further development of the 2nd generation technologies, side streams of the timber industry as well as the paper industry could be used for the production of building blocks.

Ingredients from biomass	Volume actually bio-based (tons)
Cellulose for polymers	519.732
Natural oils for a variety of non-food applications, paints, surfactants, lubricants etc.	2.807.579
Proteins for glues etc.	342.073
Free sugars	1.560.682
Starch for glues, paper finishing, drilling fluids etc.	3.238.795
Totals	**8.468.861**

It is thus estimated that, keeping in mind that this is a lower limit due to the missing data, approximately 8.5 Million tons of biomass is in Europe used in existing non-food products next to fibres and paper and pulp. This is not including the demand for biofuels. Growth within this group of established applications is possible but will presumably be mainly accommodated within the existing chains. Natural rubber is not included in this listing since separate data could not be extracted.

For the demand from the chemical industry, which is not yet existing the following approximation can be made:

Building blocks from biomass	Volume possibly bio-based (tons)	Estimated resource demand (Mton)
Base chemicals from carbohydrates	**46.750.570**	**58**
Base chemicals from lignin	**10.901.839**	**14**
Base chemicals from natural oil	**2.178.433**	**12**
Base chemicals from proteins	**10.359.233**	**14**
Base chemicals from unspecified biomass	**17.254.644**	**21**
Totals	**87.444.719**	**119**

This implies that the application of biomass for non-food products might increase by over 15-fold, when the chemical industry will start to seriously change their feedstock from naphtha to biomass. On the other hand this demand is of the same order of magnitude as present demand for wood and fibre. Also, this shift in demand will definitely not occur overnight, since technology needs to be developed further and existing installation need to be depreciated before new investments are done.

Regarding the use of the fuel crops for biofuels it should be mentioned that the target for 10% biofuels by 2020 is expected to lead to the cultivation of 25 Mha (AEBIOM): 15 Mha will be used for liquids biofuels (biodiesel and bioethanol), 5 Mha for biogas and 5Mha for solid biofuels. In 2007 the total biomass consumption to primary energy consumption in the EU was 89 million tons oil equivalent.

These numbers can be compared to the feed demand of the EU, which is presented in chapter 8. In total the annual consumption of compound feed is approximately 143 Mton. Almost half of this amount is covered by feed cereals, wheras over 30% comes from oil (cakes) and fats. This amount is in the same order of magnitude as the total extra demand from the chemical industry. Other feeds, mainly roughage, but also simple concentrates and raw materials which are directly

used on farm, are estimated to add up to between 45 and 200 Mton of dry matter. Total feed demand is thus estimated to be roughly twice as high as the potential demand from the chemical industry.
Food markets in the EU break down to approximately 50 Mton of cereals, about 6-7 Mton of vegetable oils, approximately 0.9-1 Mton dry pulses, approximately 30 Mton of potatoes plus an additional 6 Mton potatoes in the form of processed products, and approximately 15 Mton of sugar. Next to this comes a smaller range of vegetables, fruits and nuts. In total it adds up to approximately 140 Mton of biomass for human consumption (the dry matter content is obviously lower).

Conclusions
Concluding we can state that the present non-food markets exist and do have a considerable size. The use of biomass is for the largest part covered by wood, although a market for other non-food crops exists, in terms of volume of resource input this market is about 1 tenth of the wood and fibre market. It can be expected that when the chemical industry will start to use more biomass instead of naphtha, an additional market of similar size as the present day non-food market arises.
Regarding the use of the fuel crops for biofuels it should be mentioned that the target for 10% biofuels by 2020 is expected to lead to the cultivation of 25 Mha (AEBIOM): 15 Mha will be used for liquids biofuels (biodiesel and bioethanol), 5 Mha for biogas and 5Mha for solid biofuels. In 2007 the total biomass consumption to primary energy consumption in the EU was 89 million tons oil equivalent.
Compared to the present day feed and food markets, especially the feed market stands out as it is the biggest in volume. Food markets are of a similar volume as the new to be expected non-food markets.
In task 6 of the 4FCrops project future projection will be made on how these demands will be covered.

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Appendix Tables

Table 1
INDUSTRIAL FEED MATERIAL CONSUMPTION IN THE EU (*)(**)

1,000 t

	1999	2000	2001	2002	2003	2004	2005	2006	2007(***)
Feed Cereals	50,245	51,141	54,334	56,311	55,581	66,333	66,629	66,894	71,440
Oilcakes and Meals	31,569	31,225	33,508	34,862	35,293	38,369	38,410	38,313	40,898
Oils and Fats	2,255	2,151	1,936	1,932	1,998	2,202	2,009	2,074	2,278
Pulses	4,253	3,633	2,961	1,671	1,756	2,521	2,410	2,122	2,084
Dried Forage	2,489	2,046	2,249	2,521	2,449	2,344	1,817	2,046	2,246
Co-Products from Food Industry	17,038	17,412	17,201	16,846	16,935	18,676	17,803	17,736	17,441
Tapioca	3,537	3,316	2,696	1,633	1,730	2,197	591	414	691
Animal Meals	2,634	1,975	494	480	515	571	551	515	531
Dairy Products	1,517	1,433	1,316	1,317	1,290	1,296	1,307	1,123	1,139
Minerals, vitamins, etc.	3,551	3,492	3,616	3,574	3,309	3,910	4,057	4,116	4,513
All Others	5,958	6,522	5,879	6,035	5,294	5,596	6,352	6,764	7,083
TOTAL	**125,046**	**124,346**	**126,190**	**127,182**	**126,150**	**144,315**	**141,936**	**142,117**	**150,344**

(*) Without Luxembourg, Greece and Malta

(**) EU-25 as from 2004, EU-27 as from 2007

(***) Estimates

Source: FEFAC

Table 2
IMPORTS OF FEED MATERIALS IN THE EU (*)

1,000 t

	2001	2002	2003	2004	2005	2006	2007
Feed Cereals	5,000	13,000	11,000	6,000	6,100	5,500	13,500
Oilcakes and Meals	22,290	23,349	22,616	25,817	26,986	27,195	27,639
Pulses	749	480	321	1,174	1,382	1,141	273
Corn Gluten Feed	4,150	4,147	3,569	3,301	2,548	2,442	706
Maize Germ Meal	64	42	10	9	3	1	0
DDGS	700	867	779	670	722	575	442
Molasses	2,569	3,005	2,409	2,359	1,542	1,516	2,320
Dried Beet Pulp	427	427	406	396	262	33	574
Citrus pulp	1,296	1,348	1,047	1,414	1,041	925	1,181
Fishmeal	780	702	692	581	635	553	527
Tapioca	2,572	1,577	1,658	2,209	343	197	1,238
Miscellaneous	410	512	462	653	918	920	1,175
TOTAL	**41,007**	**49,456**	**44,969**	**44,583**	**42,482**	**40,998**	**49,575**

(*) EU-25 as from 2004, EU-27 as from 2007

Source: TOEPFER

Table 3
Balance sheet for protein rich ingredients en EU compound feed industry (2005/2006)

1,000 t

	EU production(*)		EU consumption (**)		**Selfsufficiency**
	Products	Proteins	Products	Proteins	
Soyabean meal	726	319	34,784	15,305	2%
Sunflower meal	1,988	381	4,503	1,225	31%
Rapeseed meal	8,291	2,079	9,254	2,868	72%
Cottonseed meal	512	179	511	198	90%
Copra-Palm meal	0	0	3,130	501	0%
Pulses	3,350	754	3,850	810	93%
Dried forage	4,600	736	4,400	784	94%
Corn gluten feed	2,193	430	4,550	893	48%
Miscellaneous	376	71	1,047	307	23%
Sub-Total		4,949		22,891	22%
Fishmeal	521	370	982	651	57%
Total		**5,319**		**23,542**	**23%**

(*) EU production from EU seeds

(**) Including consumption by the petfood industry and on-farm

Source: PROLEA

Table 4

Total domestic use of cereals and its partition to animal feed and human consumption (industrial uses and processing, not shown) 2005. (in parenthesis, n = number of countries accounted)

	Cereals Total		Wheat - Total		Common wheat		Durum wheat		Cereals other than wheat		Rye and maslin		Barley		Oats and mixed grains other than maslin		Maize		Triticale		Cereals n.e.s. (inluding sorghum)	
Tot domestic use *	**203,606**	**(19)**	**98,950**	**(19)**	**90,667**	**(19)**	**8,283**	**(19)**	**104,656**	**(19)**	**8,416**	**(19)**	**35,498**	**(19)**	**10,417**	**(19)**	**39,926**	**(19)**	**9,587**	**(19)**	**811**	**19**
- Animal feed (1000 t)*	124,653	(19)	45,483	(19)	45,310	(19)	199	(18)	79,144	(19)	3,634	(19)	26,172	(19)	8,585	(19)	31,224	(19)	8,868	(19)	660	(19)
%domestic use	*61,2*		*46,0*		*50,0*		*2,4*		*75,6*		*43,2*		*73,7*		*82,4*		*78,2*		*92,5*		*81,3*	
indigenous origin	74,426	(15)	32,780	(15)	32,652	(15)	128	(16)	41,646	(15)	1,902	(15)	17,392	(15)	2,703	(16)	14,152	(16)	5,238	(17)	258	(15)
on farm use	40,080	(15)	9,656	(15)	9,618	(15)	38	(14)	30,425	(15)	2,242	(15)	10,850	(15)	5,518	(15)	7,174	(15)	4,541	(16)	97	(15)
Intra-EU imports	7,309	(15)	3,142	(14)	3,116	(15)	27	(16)	4,166	(15)	210	(16)	923	(15)	218	(17)	2,492	(16)	302	(18)	50	(17)
- *Gross human cons.*	43,324	(18)	42,999	(19)	35,426	(19)	7,573	(19)	6,575	(18)	2,735	(19)	635	(19)	837	(19)	2,545	(18)	6	(19)	116	(18)

* missing data for BE, CZ, DK, ES, FI, SL, UK

Source: Eurostat.

Table 5

Total domestic uses of dry pulses (total and peas) and their partition to animal feed and human consumption (industrial uses and processing, not shown) in EU-25 during the period 2005-2007. (in parenthesis, n = number of countries accounted)

Dry Pulses	2000		2001		2002		2003		2004		2005		2006		2007	
Usable production (1000 t)	**5902**	**(24)**	**4949,8**	**(24)**	**4914,677**	**(23)**	**5045,737**	**(23)**	**4963,146**	**(23)**	**3807,722**	**(21)**	**3175**	**(19)**	**2361,085**	**(15)**
Domestic use	6320	(23)	5590,3	(23)	4886,53	(22)	4136,555	22	6289,688	(23)	4184,121	(21)	3714	(19)	2437,164	(15)
- Animal feeding	5811,8	(24)	4326,6	(23)	3829,505	(22)	3135,886	(22)	4887,861	(23)	3361,999	(21)	2938	(19)	1837,72	(15)
% of available	92,0		77,4		78,4		75,8		77,7		80,4		79,1		75,4	
- Gross human cons	1013,7	(23)	1068,3	(23)	879,978	(22)	829,507	(22)	934,625	(22)	534,914	(19)	534,2	(17)	418,314	(14)
Peas																
Domestic use	4713	(19)	4236,6	(19)	3272,302	(19)	2296,866	(19)	3498,708	(20)	2654,519	(18)	2251	(16)	1432,839	(14)
- Animal feeding	4161,5	(19)	3681,4	(19)	2797,305	(19)	1873,953	(19)	3052,256	(20)	2318,536	(17)	1966	(16)	1187,22	(14)
% of available	88,3		86,9		85,5		81,6		87,2		87,3		87,3		82,9	
- Gross human cons	252,1	(18)	279,6	(18)	221,377	(18)	183,307	(18)	207,765	(18)	156,955	(15)	143,5	(13)	137,874	(15)

Table 6

Total domestic uses of oilseeds and fruits (olive) and oilcakes with their partition to animal feed and human consumption in EU-25, 2006 campaign. (in parenthesis, n = number of countries accounted)

Oilseed / fruit	Total		Cottonseed		Flaxseed		Olives		Rape&turnip		Soya		Sunflower		Others	
Usable production (1000 t)	21.383	(16)	559	(14)	96	(15)	6.759	(15)	13.799	(16)	788	(15)	3.270	(15)	275	(16)
Domestic use	28.470	(16)	553	(14)	93	(15)	6.901	(17)	10.422	(15)	10.997	(17)	3.279	(17)	1.038	(17)
- Animal feeding	1.626	(17)	193	(14)	44	(13)	0	(15)	575	(16)	769	(16)	212	(16)	70	(16)
- *Processing*	24.432	(15)	356	(14)	22	(12)	6.585	(14)	9.156	(14)	9.268	(14)	2.824	(15)	440	(16)
% sel sufficiency	75	(16)	101	(5)	103	(14)	98	(14)	132	(14)	7	(16)	100	(17)	26	(16)
Oilcake																
Usable production (1000 t)	14,882	(15)			14	(15)	2,417	(14)	5,438	(13)	7,316	(15)	1,277	(14)	509	(15)
Domestic use	32,898	(17)			150	(15)	2,581	(14)	5,260	(14)	21,354	(16)	2,496	(15)	3,170	(16)
- Animal feeding	32,034	(16)			150	(15)	2,455	(14)	5,013	(13)	20,458	(15)	2,684	(14)	3,278	(15)
- *Industrial use*	41	(14)			0	(15)	9	(14)	0	(13)	0	(14)	0	(13)	41	(14)
% sel sufficiency	45	(16)			9	(9)	94	(4)	103	(12)	34	(15)	51	(13)	16	(13)

* * missing values for BE, CY, CZ, ES, FI, LV SL, PT

Table 6-b

Total domestic uses of oilseeds and fruits (olive) and oilcakes with their partition to animal feed and human consumption in EU-25, 2005 campaign. (in parenthesis, n = number of countries accounted)

Oilseed / fruit*	Total		Cottonseed		Flaxseed		Olives		Rape&turnip		Soya		Sunflower		Others	
Usable production (1000 t)	25.344	(20)	646	(20)	114	(20)	12.754	(20)	10.621	(20)	642	(20)	3.905	(20)	233	(20)
Domestic use	41.331	(20)	782	(20)	617	(20)	12.490	(20)	10.430	(20)	14.504	(20)	5.119	(20)	1.139	(20)
- Animal feeding	2.651	(20)	324	(20)	54	(20)	0	(19)	446	(20)	1.369	(20)	388	(20)	70	(19)
- *Processing*	37.134	(20)	449	(20)	527	(20)	11.994	(18)	9.623	(20)	12.977	(20)	4.338	(20)	712	(19)
% sel sufficiency	61,3	(20)	82,6	(06)	19	(16)	102,1	(17)	101,8	(19)	4,4	(18)	76,3	(19)	20,5	(19)

Oilcake																
Usable production (1000 t)	19.375	(19)			328	(20)	4.215	(20)	5.456	(18)	9.044	(20)	2.242	(19)	1.905	(20)
Domestic use	41.016	(19)			374	(19)	4.101	(18)	5.119	(18)	30.370	(19)	4.156	(19)	3.328	(19)
- Animal feeding	43.430	(18)			374	(19)	2.486	(18)	5.090	(17)	26.461	(18)	4.307	(17)	3.547	(18)
- *Industrial use*	50	(17)			0	(18)	9	(18)	0	(16)	23	(17)	0	(16)	1	(18)
% sel sufficiency	47.2	(18)			87,5	(13)	102,8	(07)	106,6	(15)	29,8	(18)	53,9	(16)	57,2	(16)

* missing values for CY, CZ, LV, SL, PT

Table 7

Total domestic uses of potatoes and their partition to animal feed and human consumption in EU-25, 2002-2007. (in parenthesis, n = number of countries accounted)

Potatoes	2002		2003		2004		2005		2006		2007	
Usable production (1000 t)	57.188	(22)	54.958	(21)	49.372	(22)	55.206	(22)	55.182	(23)	46.961	(21)
Domestic use	56.992	(21)	54.347	(20)	50.654	(22)	54.292	(22)	51.431	(23)	43.756	(21)
- Animal feeding	11.076	(23)	8.525	(22)	5.604	(22)	7.973	(21)	3.975	(21)	2.950	(19)
- *Processing*	5.901	(23)	6.391	(22)	5.682	(22)	6.674	(20)	6.162	(20)	5.278	(18)
- Gross human cons.	30.245	(23)	31.664	(22)	30.400	(22)	30.604	(22)	29.785	(22)	29.476	(21)
% sel sufficiency	100	(21)	101	(20)	97	(22)	102	(22)	107	(23)	107	(21)

Table 8

Total domestic uses of sugar beet and derived products with their partition to animal feed and human consumption in EU-25, 2000-2007. (in parenthesis, n = number of countries accounted)

Sugar beet roots	**2000**		**2001**		**2002**		**2003**		**2004**		**2005**		**2006**		**2007**	
Total domestic use (1000 t)	142.654	(22)	135.026	(22)	122.319	(22)	136.179	(21)	108.283	(19)	119.159	(19)	118.819	(17)	91.766	(15)
- Animal feed	331	(22)	211	(22)	233	(22)	276	(21)	319	(19)	232	(18)	241	(17)	234	(14)
- Processing to sugar	138.117	(22)	130.928	(22)	119.040	(22)	127.643	(21)	99.530	(19)	107.855	(18)	110.274	(17)	75.605	(13)
Sugar beet pulp																
- *Estimated production*	6.906		6.546		5.952		6.382		4.976		5.393		5.514		3.780	
Molasses																
- Usable production	5.271	(22)	4.738	(22)	4.464	(22)	4.487	(20)	3.670	(19)	2.713	(17)	-		-	
Total domestic use (1000 t)	7.866	(22)	7.378	(22)	6.377	(22)	5.348	(20)	4.740	(19)	3.199	(17)	-		-	
- Animal feed	3.728	(22)	3.264	(22)	2.314	(22)	2.118	(19)	1.794	(18)	1.058	(17)	-		-	

Table 9 Green fodder in EU-25, production and area. Period 2000-2007 and 2005 campaign. (in parenthesis, n = number of countries accounted)

	Period 2000 - 2007				Year 2005			
	Total production (1000t)			Area (1000ha)	Production		Area	
	Max	Min	Average	Average		n		n
Fodder - Total	**671,500**	**242,374**	**441607**	**62,266**	**440,137**	(24)	**62,830**	(25)
Fodder from arable land	**453,452**	**217,769**	**335972**	**16,925**	**349,108**	(24)	**17,929**	(25)
Annual green fodder	327,514	187,565	263070	6,728	275,935	(22)	6,921	(25)
Other annual green fodder	119,504	69,158	90675	2,442	92,336	(16)	2,237	(20)
Green maize	212,530	116,681	174166	4,601	183,599	(20)	4,638	(22)
Perennial green fodder	111,665	50,908	75200	11,156	73,173	(19)	11,007	(23)
Clover and mixtures	8,314	2,706	5742	791	6,740	(13)	795	(14)
Lucerne	35,534	13,451	19064	1,935	15,727	(14)	1,865	(16)
Other legumes (sainfoin, sweet clover)	8,465	5,252	6161	474	1,820	(8)	335	(11)
Temporary grasses and grazings	74,444	34,138	48993	7,879	42,339	(14)	7,592	(20)
Temporary grasses	43,379	25,798	34380	5,087	23,069	(6)	4,529	(8)
Temporary grazings	13,235	11,767	12308	384	56	(1)	325	(4)
Total of permanent grassland (pastures and meadows)	**245,651**	**82,844**	**148295**	**50,440**	**91,030**	(15)	**44,902**	(22)
Permanent meadows	158,614	59,145	85291	14,299	41,987	(6)	10,574	(11)
Permanent pasture	84,606	45,859	68538	24,224	29,349	(6)	22,903	(12)
Grassland	601	251	421	7,909	601	(1)	4,300	(5)
Common pasture, heathland, rough grazings	3	2	2	9,797	3	(1)	9,800	(6)
Carobs	18,827	18,760	18783	2	67	(2)	2	(1)
Other permanent crops n.e.s. (carob-tree, mulberry-tree, tea, coffee, etc)	165	95	123	86	89	(1)	93	(3)

Table 10

Total domestic use of cereals and its partition to animal feed and human consumption (industrial uses and processing, not shown) 2005. (in parenthesis, n = number of countries accounted)

	Cereals Total		Wheat - Total		Common wheat		Durum wheat		Cereals other than wheat		Rye and maslin		Barley		Oats and mixed grains other than maslin		Maize		Triticale		Cereals n.e.s. (inluding sorghum)	
Tot domestic use	204,400	(20)[1]	96,244	(21)[3]	91,209	(22)[3]	8,211	(22)[3]	111,596	(21)[2]	8,500	(22)[3]	39,935	(22)[3]	11,649	(22)[3]	43,462	(21)[2]	9,680	(22)[3]	1,013	(21)[2]
Seed - total (1000 t)	7,766	(22)	3,929	(22)	3,443	(22)	485	(22)	3,837	(22)	439	(22)	1,768	(22)	718	(22)	383	(22)	496	(22)	29	(22)
Losses (1000 t)	4,823	(22)	2,137	(22)	2,083	(22)	52	(22)	2,686	(22)	313	(22)	917	(22)	397	(22)	757	(22)	290	(22)	8	(22)
Animal feed (1000 t)	132,509	(22)	44,957	(22)	44,601	(22)	387	(22)	87,520	(22)	4,025	(22)	29,048	(22)	9,675	(22)	34,901	(22)	9,009	(22)	860	(22)
Industrial uses	15,574	(21)	4,034	(21)	4,034	(21)	0	(21)	11,539	(21)	632	(21)	7,629	(22)	15	(21)	3,502	(22)	39	(22)	2	(21)
Industrial: alcohol	1,216	(14)	499	(18)	499	(18)	0	(20)	726	(14)	624	(19)	4	(16)	0	(18)	72	(15)	27	(20)	2	(19)
Processing (1000 t)	178	(18)	0	(19)	0	(19)	0	(20)	178	(18)	0	(19)	0	(18)	0	(18)	188	(21)	0	(20)	0	(19)
Gross human consum	50,877	(20)	43,295	(21)	37,071	(22)	7,257	(21)	8,165	(21)	3,090	(22)	576	(22)	844	(22)	3,680	(21)	4	(22)	115	(21)
Net human consum (flour equiv)	21,968	(17)	18,199	(18)	15,665	(18)	2,534	(18)	3,996	(17)	1,456	(18)	191	(19)	566	(19)	1,868	(17)	3	(19)	34	(19)

1) missing data for CY, CZ, ES, FI, SL. 2) missing data for CY, ES, FI, SL. 3) missing data for CY, ES, SL.

Source: Eurostat.

Table 11. Processed cereal items produced in EU-25 and their foreign trade.

		2003	2004	2005	2006
Bakers' wares, no added sweetening (includingcrepes, pancakes, quiche, pizza; excluding sandwiches, crispbread, waffles, wafers, rusks, toasted, savoury or salted extruded/expanded products)	Sold production	1.995.272	2.158.847	2.229.124	2.252.611
	EU-25 exports	79.357	86.900	98.826	110.766
	EU-25 Imports	27.233	28.327	26.507	29.950
	Balance	**1.943.148**	**2.100.274**	**2.156.805**	**2.171.794**
Biscuits (excluding those completely or partially coated or covered with chocolate or other preparations containing cocoa, sweet biscuits, waffles and wafers)	Sold production	338.180	334.583	348.884	180.144
	EU-25 exports	14.629	18.784	17.724	20.732
	EU-25 Imports	9.350	9.247	9.145	9.113
	Balance	**332.901**	**325.046**	**340.304**	**168.525**
Broken rice (incl. enriched rice, parboiled rice) (tonnes)	Sold production	270.081	366.012	311.015	345.170
	EU-25 exports	2.916	2.435	2.483	3.809
	EU-25 Imports	183.686	134.959	125.664	196.189
	Balance	**450.852**	**498.536**	**434.196**	**537.550**
Cake and pastry products; other baker's wares with added sweetening matter (tonnes)	Sold production	4.009.067	4.190.086	4.529.238	4.807.553
	EU-25 exports	62.858	66.419	70.116	81.977
	EU-25 Imports	28.044	26.976	33.580	31.802
	Balance	**3.974.253**	**4.150.644**	**4.492.703**	**4.757.378**
Cereal flours (excl. wheat or meslin) (tonnes)	Sold production	2.373.154	2.267.654	2.203.233	2.150.070
	EU-25 exports	61.799	56.540	35.633	36.259
	EU-25 Imports	14.559	12.737	12.374	14.933
	Balance	**2.325.915**	**2.223.851**	**2.179.974**	**2.128.743**
Cereals in grain form; precooked or otherwise prepared (excl. maize) (tonnes)	Sold production	257.808	278.754	260.757	372.797
	EU-25 exports	7.291	6.122	10.424	12.553
	EU-25 Imports	6.042	5.761	6.562	11.622
	Balance	**256.559**	**278.393**	**256.895**	**371.867**
Communion wafers; empty cachets of a kind suitable for pharmaceutical use; sealing wafers; rice paper and similar products	Sold production	7.621	13.843	13.224	13.891
	EU-25 exports	469	531	379	561
	EU-25 Imports	5.304	4.870	5.241	4.285
	Balance	**12.456**	**18.182**	**18.086**	**17.616**
Cooked or uncooked pasta stuffed with meat; fish; cheese or other substances in any proportion (tonnes)	Sold production	768.060	752.476	743.743	806.728
	EU-25 exports	17.880	19.007	19.983	24.408
	EU-25 Imports	11.826	13.959	15.159	15.404
	Balance	**762.007**	**747.428**	**738.919**	**797.724**
Crispbread (tonnes)	Sold production	93.332	106.185	106.120	149.804
	EU-25 exports	15.305	16.782	17.307	17.713
	EU-25 Imports	1.048	1.051	1.887	1.933

	Balance	**79.075**	**90.454**	**90.700**	**134.024**
Dried; undried and frozen pasta and pasta products (incl. prepared dishes) (excl. uncooked pasta, stuffed pasta) (tonnes)	Sold production	852.598	935.059	864.589	902.914
	EU-25 exports	18.328	23.767	23.392	24.947
	EU-25 Imports	64.878	76.124	85.315	93.867
	Balance	**899.147**	**987.415**	**926.512**	**971.835**
Fresh bread containing by weight in the dry matter state <= 5% of sugars and <= 5% of fat (excl. with added honey; eggs; cheese or fruit) (tonnes)	Sold production	12.881.458	12.742.291	13.368.997	13.422.029
	EU-25 exports	38.133	44.867	48.969	51.909
	EU-25 Imports	3.235	4.759	3.554	4.146
	Balance	**12.846.560**	**12.702.183**	**13.323.582**	**13.374.266**
Germ of cereals; whole; rolled; flaked or ground (excl. rice) (tonnes)	Sold production	482.026	524.745	294.740	487.972
	EU-25 exports	1.777	1.836	3.402	2.170
	EU-25 Imports	828	509	613	1.202
	Balance	**481.076**	**523.418**	**291.951**	**487.005**
Gingerbread and the like (tonnes)	Sold production	205.774	208.590	202.568	206.217
	EU-25 exports	5.271	4.798	5.996	8.331
	EU-25 Imports	1.141	1.399	1.518	1.842
	Balance	**201.644**	**205.191**	**198.090**	**199.728**
Groats and meal of common wheat and spelt (tonnes)	Sold production	203.365	164.960	137.562	154.242
	EU-25 exports	1.821	4.112	4.510	3.533
	EU-25 Imports	414	213	95	96
	Balance	**201.958**	**161.061**	**133.147**	**150.806**
Groats and meal of durum wheat (tonnes)	Sold production	2.619.963	2.916.082	3.113.273	2.985.536
	EU-25 exports	127.648	141.140	157.577	153.546
	EU-25 Imports	416	270	184	166
	Balance	**2.492.731**	**2.775.212**	**2.955.881**	**2.832.157**
Groats and meal of other cereals (tonnes)	Sold production	817.967	770.843	805.700	756.477
	EU-25 exports	250.011	206.055	245.073	238.401
	EU-25 Imports	9.246	16.816	9.693	13.218
	Balance	**577.203**	**581.603**	**570.321**	**531.294**
Husked (brown) rice (tonnes)	Sold production	144.592	136.247	113.141	107.898
	EU-25 exports	10.476	10.575	14.741	13.054
	EU-25 Imports	724.527	726.442	767.151	744.396
	Balance	**858.643**	**852.114**	**865.550**	**839.240**
Matzos (tonnes)	Sold production	8.154	6.108	7.342	4.878
	EU-25 exports	2.493	3.342	3.745	4.445
	EU-25 Imports	811	946	1.221	1.495
	Balance	**6.472**	**3.712**	**4.818**	**1.928**

Mixtures and pastes for bakery, pastry making, biscuit factory (tonnes)	Sold production	1.674.729	1.234.068	1.225.985	1.232.436
	EU-25 exports	48.252	52.979	66.196	69.735
	EU-25 Imports	52.861	64.662	68.117	75.223
	Balance	**1.679.339**	**1.245.751**	**1.227.906**	**1.237.924**
Muesli type preparations based on unroasted cereal flakes (tonnes)	Sold production	91.026	98.027	89.069	98.921
	EU-25 exports	9.615	10.094	10.319	12.757
	EU-25 Imports	2.016	2.685	1.922	1.502
	Balance	**83.426**	**90.617**	**80.671**	**87.666**
Other prepared foods obtained by the swelling or roasting of cereals (tonnes)	Sold production	1.223.497	1.334.885	1.161.777	1.149.058
	EU-25 exports	71.062	99.161	160.721	125.243
	EU-25 Imports	11.574	13.975	14.298	14.144
	Balance	**1.164.009**	**1.249.700**	**1.015.354**	**1.037.959**
Rolled; flaked; hulled; pearled; sliced or kibbled cereal grains (excl. rice) (tonnes)	Sold production	2.152.763	1.782.173	1.351.293	1.478.988
	EU-25 exports	68.612	61.808	66.135	70.999
	EU-25 Imports	21.004	19.641	15.294	19.444
	Balance	**2.105.155**	**1.740.005**	**1.300.452**	**1.427.433**
Rusks; toasted bread and similar toasted products (tonnes)	Sold production	619.832	612.229	690.646	679.278
	EU-25 exports	15.989	17.348	19.711	18.905
	EU-25 Imports	3.757	3.462	3.929	4.269
	Balance	**607.600**	**598.343**	**674.865**	**664.642**
Savoury or salted extruded or expanded products	Sold production	340.327	410.791	363.518	366.932
	EU-25 exports	31.499	26.147	28.147	29.860
	EU-25 Imports	19.963	22.302	21.293	20.036
	Balance	**328.791**	**406.946**	**356.663**	**357.108**
Semi-milled or wholly milled (bleached) rice (incl. camolino rice) (tonnes)	Sold production	2.370.300	2.167.796	2.154.258	2.105.311
	EU-25 exports	225.426	180.144	183.538	127.029
	EU-25 Imports	331.267	291.686	195.031	260.184
	Balance	**2.476.142**	**2.279.338**	**2.165.750**	**2.238.466**
Sweet biscuits (incl. sandwich biscuits; excl. those completely or partially coated or covered with chocolate or other preparations containing chocolate) (tonnes)	Sold production	1.422.422	1.515.440	1.588.762	1.584.880
	EU-25 exports	129.861	126.740	113.770	125.264
	EU-25 Imports	22.544	24.083	25.187	26.501
	Balance	**1.315.105**	**1.412.783**	**1.500.178**	**1.486.117**
Sweet biscuits; waffles and wafers completely or partially coated or covered with chocolate or other preparations containing cocoa (tonnes)	Sold production	1.365.044	1.373.465	1.431.239	1.418.731
	EU-25 exports	86.831	90.003	95.760	100.858
	EU-25 Imports	18.791	18.256	20.234	22.670
	Balance	**1.297.005**	**1.301.717**	**1.355.713**	**1.340.543**
Uncooked pasta (excl. containing eggs,	Sold production	2.747.343	2.563.749	2.746.861	2.736.956

stuffed or otherwise prepared) (tonnes)	EU-25 exports	590.785	583.694	598.884	607.471
	EU-25 Imports	18.694	21.278	17.841	17.329
	Balance	**2.175.253**	**2.001.333**	**2.165.819**	**2.146.814**
	Sold production	778.164	735.911	794.054	776.141
	EU-25 exports	15.888	18.496	29.378	19.471
Uncooked pasta; containing eggs (excl.	EU-25 Imports	7.183	6.801	6.198	6.112
stuffed or otherwise prepared) (tonnes)	**Balance**	**769.458**	**724.217**	**770.874**	**762.783**
Waffles and wafers (including salted)	Sold production	244.910	274.701	276.879	304.374
(excluding those completely or partially	EU-25 exports	20.474	23.384	24.637	25.182
coated or covered with chocolate or other	EU-25 Imports	7.541	8.569	10.585	11.110
preparations containing chocolate)	**Balance**	**231.977**	**259.886**	**262.827**	**290.302**
Waffles and wafers with a water content >	Sold production	58.810	54.618	46.783	50.572
10% by weight of the finished product	EU-25 exports	526	106	256	289
(excluding ice cream cornets, sandwiched	EU-25 Imports	585	27	73	71
waffles, other similar products)	**Balance**	**58.870**	**54.538**	**46.600**	**50.353**
	Sold production	29.908.342	30.280.988	29.597.388	29.040.462
	EU-25 exports	2.132.360	1.759.810	1.507.292	1.523.646
	EU-25 Imports	4.281	6.983	6.278	7.619
Wheat or meslin flour (tonnes)	**Balance**	**27.780.263**	**28.528.161**	**28.096.374**	**27.524.435**

Total except flour	42.994.732	42.589.892	42.902.108	43.601.588
Total including flour	70.774.995	71.118.054	70.998.482	71.126.023

Table 12.- Uses of vegetable oils in EU 25

	2000		2001		2002		2003		2004		2005		2006		2007	
Vegetable oils (calendar year)																
Usable production (1000 t)	10.913	(15)	11.379	(15)	10.482	(15)	8.613	(16)	8.189	(14)	7.802	(12)	3.904	(9)		
Total domestic use (1000 t)	10.926	(15)	12.018	(15)	12.129	(15)	10.743	(16)	11.598	(16)	11.931	(14)	6.635	(9)		
Animal feed (1000 t)	707	(13)	1.179	(12)	1.194	(12)	1.097	(13)	988	(12)	749	(10)	288	(7)		
Industrial uses (1000 t)	1.725	(13)	1.814	(12)	2.064	(12)	2.322	(12)	2.818	(11)	3.669	(10)	1.390	(6)		
Processing (1000 t)	1.920	(11)	2.294	(11)	2.210	(11)	1.957	(12)	1.540	(11)	1.121	(9)	605	(6)		
Gross human consumption (1000 t)	**6.977**	**(12)**	**6.238**	**(11)**	**6.918**	**(12)**	**4.663**	**(11)**	**4.502**	**(12)**	**4.615**	**(10)**	**3.552**	**(6)**		
Vegetable oils (crop year)		(79)		(76)		(77)		(80)		(76)		(65)		(43)		
Usable production (1000 t)	11.672	(18)	11.494	(17)	9.661	(19)	7.373	(17)	7.736	(16)	4.505	(13)	3.952	(12)	3.800	(9)
Total domestic use (1000 t)	13.056	(18)	14.116	(17)	12.412	(19)	10.211	(17)	10.500	(17)	7.531	(15)	6.609	(11)	6.565	(9)
Animal feed (1000 t)	322	(14)	617	(13)	1.323	(15)	778	(13)	816	(14)	805	(12)	492	(9)	439	(8)
Industrial uses (1000 t)	2.316	(13)	2.705	(12)	2.867	(14)	2.195	(12)	1.712	(12)	1.531	(11)	1.486	(7)	1.679	(8)
Processing (1000 t)	5	(1)	391	(2)	399	(2)	351	(1)	734	(5)	935	(7)	902	(7)	975	(8)
Gross human consumption (1000 t)	**7.106**	**(13)**	**6.903**	**(12)**	**6.516**	**(14)**	**5.326**	**(12)**	**5.529**	**(12)**	**3.530**	**(12)**	**3.007**	**(8)**	**3.298**	**(8)**
Vegetable fats and oils - Maize kernels																
Usable production (1000 t)	165	(17)	167	(16)	162	(18)	160	(17)	151	(16)	118	(11)	135	(10)	137	(9)
Total domestic use (1000 t)	214	(16)	226	(15)	226	(17)	246	(16)	215	(15)	153	(11)	137	(11)	131	(10)
Animal feed (1000 t)	0	(11)	1	(11)	1	(12)	1	(10)	1	(9)	0	(7)	0	(9)	0	(8)
Industrial uses (1000 t)	29	(10)	33	(11)	34	(11)	24	(9)	39	(8)	24	(7)	30	(9)	25	(9)
Processing (1000 t)	0	(1)	0	(1)	0	(1)					0	(1)	5	(3)	2	(4)
Gross human consumption (1000 t)	**160**	**(10)**	**165**	**(11)**	**167**	**(11)**	**182**	**(9)**	**149**	**(8)**	**124**	**(8)**	**96**	**(8)**	**97**	**(8)**
Vegetable fats and oils - Olives (crop-year)																

Usable production (1000 t)	1.976	(18)	2.047	(17)	2.561	(19)	1.916	(20)	2.539	(17)	1.223	(12)	1.085	(11)	371	(10)
Total domestic use (1000 t)	1.789	(19)	1.881	(18)	2.161	(20)	1.950	(20)	2.117	(20)	1.521	(16)	1.368	(14)	445	(13)
Animal feed (1000 t)	0	(14)	0	(13)	0	(15)	0	(17)	84	(17)	0	(11)	0	(9)	0	(7)
Industrial uses (1000 t)	2	(13)	3	(12)	1	(15)	1	(16)	0	(16)	0	(10)	0	(9)	0	(7)
Processing (1000 t)	0	(1)	0	(2)	0	(2)	1	(2)	3	(2)	4	(2)	3	(2)	4	(2)
Gross human consumption (1000 t)	**1.670**	**(14)**	**1.795**	**(13)**	**2.077**	**(16)**	**1.784**	**(18)**	**2.052**	**(18)**	**1.436**	**(14)**	**1.296**	**(12)**	**421**	**(11)**
Vegetable fats and oils - Others																
Usable production (1000 t)	383	(18)	302	(17)	239	(19)	154	(18)	209	(17)	166	(13)	30	(8)	0	(2)
Total domestic use (1000 t)	4.081	(17)	4.554	(16)	4.255	(18)	3.648	(17)	3.887	(17)	3.267	(13)	1.586	(9)	19	(2)
Animal feed (1000 t)	74	(12)	219	(11)	550	(12)	256	(11)	283	(11)	291	(8)	140	(7)	0	(1)
Industrial uses (1000 t)	739	(9)	989	(9)	912	(9)	813	(8)	672	(8)	494	(7)	402	(6)	2	(1)
Processing (1000 t)	4	(1)	191	(2)	199	(2)	166	(2)	178	(2)	187	(3)	0	(1)		
Gross human consumption (1000 t)	**1.600**	**(9)**	**1.369**	**(9)**	**1.369**	**(9)**	**845**	**(8)**	**863**	**(9)**	**936**	**(8)**	**711**	**(6)**	**51**	**(1)**
Vegetable fats and oils - rape and turnip rape (crop-year)																
Usable production (1000 t)	4.159	(17)	3.808	(16)	3.806	(18)	2.193	(17)	2.063	(16)	1.511	(11)	1.769	(11)	2.050	(11)
Total domestic use (1000 t)	3.144	(17)	3.396	(16)	3.270	(18)	2.086	(17)	2.214	(16)	1.511	(11)	1.663	(11)	2.173	(11)
Animal feed (1000 t)	42	(10)	119	(9)	115	(10)	38	(9)	53	(10)	69	(8)	70	(8)	92	(8)
Industrial uses (1000 t)	879	(9)	983	(9)	1.114	(9)	619	(8)	504	(8)	322	(7)	526	(7)	607	(8)
Processing (1000 t)	0	(1)	67	(2)	79	(2)	106	(2)	192	(3)	241	(6)	225	(6)	189	(7)
Gross human consumption (1000 t)	**1.102**	**(9)**	**1.059**	**(9)**	**861**	**(9)**	**420**	**(8)**	**384**	**(8)**	**453**	**(8)**	**667**	**(8)**	**803**	**(8)**
Vegetable fats and oils - Soja (crop-year)																
Usable production (1000 t)	2.739	(18)	2.882	(17)	3.203	(19)	2.065	(17)	1.720	(15)	1.062	(10)	931	(10)	948	(9)
Total domestic use (1000 t)	1.531	(16)	1.756	(16)	2.030	(17)	1.466	(15)	1.364	(15)	907	(11)	1.025	(11)	1.172	(10)
Animal feed (1000 t)	110	(11)	183	(10)	287	(11)	98	(9)	84	(10)	87	(7)	97	(9)	87	(9)
Industrial uses (1000 t)	142	(10)	196	(10)	191	(10)	126	(8)	58	(8)	49	(6)	105	(8)	199	(9)
Processing (1000 t)	1	(1)	85	(2)	75	(2)	57	(1)	84	(2)	79	(4)	132	(6)	106	(7)

Gross human consumption (1000 t)	**928**	**(10)**	**933**	**(10)**	**881**	**(10)**	**693**	**(8)**	**559**	**(8)**	**578**	**(8)**	**569**	**(8)**	**667**	**(8)**
Vegetable fats and oils - Sunflower (crop-year)																
Usable production (1000 t)	2.011	(18)	2.072	(17)	1.641	(19)	1.326	(17)	1.582	(15)	983	(11)	822	(11)	924	(9)
Total domestic use (1000 t)	1.985	(17)	2.050	(16)	1.993	(18)	1.579	(16)	1.579	(15)	1.043	(12)	1.078	(10)	1.110	(9)
Animal feed (1000 t)	39	(11)	37	(10)	33	(11)	34	(9)	39	(10)	33	(7)	34	(8)	41	(8)
Industrial uses (1000 t)	174	(10)	207	(10)	193	(10)	151	(8)	132	(8)	35	(6)	64	(7)	89	(8)
Processing (1000 t)	0	(1)	48	(2)	46	(2)	48	(1)	89	(2)	116	(4)	132	(6)	140	(7)
Gross human consumption (1000 t)	**1.493**	**(10)**	**1.447**	**(10)**	**1.438**	**(10)**	**1.035**	**(8)**	**1.056**	**(8)**	**750**	**(8)**	**738**	**(7)**	**761**	**(7)**

Table 13. Production and external trade of vegetable oil products

Product		2.003		2.004		2.005		2.006	
Castor oil and its fractions (incl. refined (excl. chemically modified) (1000 t)	Sold	0,0	(22)	0,0	(22)	0,4	(20)	0,2	(1)
	Exprt	1,6	(18)	1,9	(18)	1,4	(19)	1,6	(18)
	Imprt	103,7	(24)	121,6	(25)	145,2	(25)	117,9	(25)
	Balance	**102,2**		**119,7**		**144,1**		**116,5**	
Margarine and reduced and low fat spreads (excl. liquid margarine) (1000 t)	Sold	2.201,9	(18)	2.167,1	(18)	2.011,3	(18)	1.948,6	(12)
	Exprt	121,7	(24)	111,0	(25)	88,8	(24)	91,4	(23)
	Imprt	4,2	(25)	4,6	(25)	3,0	(25)	3,4	(25)
	Balance	**2.084,4**		**2.060,8**		**1.925,5**		**1.860,6**	
Oils and their fractions obtained solely from olives (incl. those blended with virgin olive oil, refined) (excl. virgin olive oil, chemically modified) (1000 t)	Sold	363,2	(22)	451,6	(24)	349,7	(21)	379,5	(4)
	Exprt	43,0	(19)	37,7	(21)	46,2	(19)	47,9	(21)
	Imprt	0,0	(24)	5,6	(25)	2,4	(25)	5,7	(24)
	Balance	**320,3**		**419,6**		**305,8**		**337,3**	
Other edible preparations of fats and oils, incl. liquid margarine (1000 t)	Sold	557,6	(16)	526,2	(18)	549,0	(16)	560,9	(8)
	Exprt	71,6	(24)	99,2	(24)	150,3	(24)	178,1	(25)
	Imprt	4,8	(25)	5,2	(25)	8,2	(25)	8,0	(25)
	Balance	**490,8**		**432,2**		**406,9**		**390,8**	
Other fixed vegetable fats and fractions (excl. chemically modified), n.e.c. (1000 t)	Sold	247,7	(18)	308,3	(17)	277,2	(15)	272,9	(9)
	Exprt	17,6	(23)	17,9	(23)	23,5	(21)	33,7	(22)
	Imprt	29,5	(25)	24,8	(25)	33,6	(25)	29,9	(25)
	Balance	**259,5**		**315,2**		**287,4**		**269,1**	
Refined coconut (copra) oil and its fractions (excl. chemically modified) (1000 t)	Sold	110,0	(20)	288,2	(20)	304,1	(20)	359,2	(5)
	Exprt	41,6	(17)	36,4	(19)	32,8	(16)	16,4	(16)
	Imprt	19,1	(25)	22,2	(25)	11,7	(24)	11,7	(25)
	Balance	**87,4**		**273,9**		**283,0**		**354,5**	
Refined cotton-seed oil and its fractions (excl. chemically modified) (1000 t)	Sold	17,7	(25)	24,8	(25)	18,4	(20)	19,8	(1)
	Exprt	8,0	(14)	4,3	(16)	5,5	(15)	2,8	(13)
	Imprt	0,5	(21)	11,6	(18)	1,2	(21)	1,7	(18)
	Balance	**10,2**		**32,1**		**14,1**		**18,8**	
Refined ground-nut oil and its fractions (excl. chemically modified) (1000 t)	Sold	34,4	(18)	51,0	(18)	39,3	(18)	33,8	(2)
	Exprt	11,5	(18)	3,6	(17)	2,3	(18)	3,3	(15)
	Imprt	0,3	(24)	0,6	(25)	0,1	(24)	0,1	(23)
	Balance	**23,2**		**48,0**		**37,2**		**30,6**	
Refined linseed oil and its fractions (excl. chemically modified) (1000 t)	Sold	0,1	(20)	0,1	(22)	0,1	(21)	46,0	(2)
	Exprt	18,7	(20)	24,5	(21)	19,9	(22)	23,5	(19)
	Imprt	0,4	(25)	2,3	(25)	2,6	(25)	3,0	(25)

	Balance	**-18,2**		**-22,0**		**-17,2**		**25,4**	
Refined maize (corn) oil and its fractions (excl. chemically modified) (1000 t)	Sold	170,2	(16)	99,0	(17)	121,4	(15)	126,9	(3)
	Exprt	63,5	(19)	20,9	(21)	15,4	(19)	8,4	(18)
	Imprt	6,0	(25)	1,2	(25)	1,3	(25)	2,7	(25)
	Balance	**112,7**		**79,3**		**107,3**		**121,2**	
Refined olive oil and its fractions (excl. chemically modified) (1000 t)	Sold	604,4	(20)	632,0	(21)	555,1	(19)	479,0	(6)
	Exprt	141,6	(21)	152,5	(23)	138,1	(23)	124,2	(24)
	Imprt	40,5	(25)	30,4	(25)	34,6	(25)	28,6	(25)
	Balance	**503,3**		**509,9**		**451,6**		**383,4**	
Refined palm kernel or babassu oil and their fractions (excl. chemically modified) (1000 t)	Sold	63,9	(18)	14,5	(19)	58,2	(20)	40,5	(3)
	Exprt	1,3	(12)	1,2	(20)	1,6	(13)	0,4	(14)
	Imprt	94,2	(24)	84,8	(23)	109,1	(22)	81,2	(22)
	Balance	**156,8**		**98,1**		**165,7**		**121,4**	
Refined palm oil and its fractions (excl. chemically modified) (1000 t)	Sold	1.108,0	(21)	1.320,5	(19)	1.959,7	(20)	2.334,0	(6)
	Exprt	67,4	(20)	87,2	(22)	126,3	(20)	109,7	(22)
	Imprt	1.155,5	(25)	1.292,6	(25)	1.420,6	(24)	1.326,1	(24)
	Balance	**2.196,1**		**2.525,8**		**3.253,9**		**3.550,4**	
Refined rape; colza or mustard oil and their fractions (excl. chemically modified) (1000 t)	Sold	2.313,5	(14)	2.816,2	(15)	1.709,0	(11)	1.885,0	(6)
	Exprt	85,7	(20)	95,4	(21)	46,8	(21)	25,9	(21)
	Imprt	1,5	(25)	0,7	(25)	7,1	(25)	175,5	(25)
	Balance	**2.229,3**		**2.721,5**		**1.669,4**		**2.034,6**	
Refined soya-bean oil and its fractions (excl. chemically modified) (1000 t)	Sold	1.598,9	(18)	1.255,9	(20)	1.269,7	(17)	1.334,6	(9)
	Exprt	282,9	(23)	183,7	(23)	162,5	(24)	114,2	(24)
	Imprt	5,5	(24)	3,8	(25)	60,5	(24)	429,1	(24)
	Balance	**1.321,5**		**1.076,1**		**1.167,7**		**1.649,5**	
Refined sunflower-seed and safflower oil and their fractions (excl. chemically modified) (1000 t)	Sold	1.217,9	(17)	1.531,4	(18)	1.390,0	(15)	1.511,4	(10)
	Exprt	134,1	(24)	82,3	(24)	55,2	(24)	49,9	(23)
	Imprt	17,9	(24)	19,1	(25)	13,8	(25)	70,6	(25)
	Balance	**1.101,7**		**1.468,2**		**1.348,5**		**1.532,1**	
Sesame oil and its fractions (incl. refined; excl. chemically modified) (1000 t)	Sold	1,0	(23)	2,2	(23)	0,5	(21)	0,0	
	Exprt	0,9	(19)	0,9	(20)	0,8	(18)	1,2	(17)
	Imprt	5,1	(25)	5,4	(25)	6,3	(24)	6,5	(24)
	Balance	**5,3**		**6,6**		**5,9**		**5,4**	
Tung oil and its fractions (excl. chemically modified) (1000 t)	Sold	0,0	(25)	0,0	(25)	0,0	(23)	0,0	
	Exprt	0,2	(10)	0,1	(14)	0,1	(12)	0,0	(12)
	Imprt	4,0	(18)	3,7	(20)	4,4	(21)	4,0	(19)
	Balance	**3,8**		**3,6**		**4,3**		**4,0**	
Vegetable fats and oils and	Sold	1.348,5	(17)	1.289,6	(18)	1.405,2	(18)	1.042,0	(7)

their fractions partly or wholly hydrogenated; inter-esterified; re-esterified or elaidinized but not further prepared (incl. refined) (1000 t)	Exprt	234,9	(21)	196,4	(23)	136,4	(23)	104,9	(23)
	Imprt	49,1	(25)	52,9	(25)	52,8	(25)	60,6	(25)
	Balance	**1.162,7**		**1.146,1**		**1.321,6**		**997,7**	
Virgin olive oil and its fractions (excl. chemically modified) (1000 t)	Sold	1.195,3	(23)	1.435,7	(23)	1.385,8	(20)	1.303,7	(4)
	Exprt	156,4	(23)	177,7	(23)	188,5	(24)	187,1	(24)
	Imprt	61,2	(25)	206,1	(25)	158,4	(25)	199,8	(25)
	Balance	**1.100,2**		**1.464,1**		**1.355,7**		**1.316,4**	
Total (sum of all products)	Sold	**9.603,8**		**10.757,4**		**9.987,1**		**10.641,2**	
	Exprt	**1.127,2**		**1.001,0**		**996,0**		**903,2**	
	Imprt	**1.445,5**		**1.717,7**		**1.873,4**		**2.381,3**	
	Balance	**9.922**		**11.474**		**10.864**		**12.119**	

Table 14

Total domestic uses of dry pulses (total and peas) and their partition to animal feed and human consumption (industrial uses and processing, not shown) in EU-25 during the period 2005-2007. (in parenthesis, n = number of countries accounted)

Dry Pulses	2000		2001		2002		2003		2004		2005		2006		2007	
Usable production (1000 t)	**5902**	**(24)**	**4949,8**	**(24)**	**4914,677**	**(23)**	**5045,737**	**(23)**	**4963,146**	**(23)**	**3807,722**	**(21)**	**3175**	**(19)**	**2361,085**	**(15)**
Domestic use	6320	(23)	5590,3	(23)	4886,53	(22)	4136,555	22	6289,688	(23)	4184,121	(21)	3714	(19)	2437,164	(15)
- Animal feeding	5811,8	(24)	4326,6	(23)	3829,505	(22)	3135,886	(22)	4887,861	(23)	3361,999	(21)	2938	(19)	1837,72	(15)
% of available	92,0		77,4		78,4		75,8		77,7		80,4		79,1		75,4	
- *Gross human cons*	1013,7	(23)	1068,3	(23)	879,978	(22)	829,507	(22)	934,625	(22)	534,914	(19)	534,2	(17)	418,314	(14)
Peas																
Domestic use	4713	(19)	4236,6	(19)	3272,302	(19)	2296,866	(19)	3498,708	(20)	2654,519	(18)	2251	(16)	1432,839	(14)
- Animal feeding	4161,5	(19)	3681,4	(19)	2797,305	(19)	1873,953	(19)	3052,256	(20)	2318,536	(17)	1966	(16)	1187,22	(14)
% of available	88,3		86,9		85,5		81,6		87,2		87,3		87,3		82,9	
- *Gross human cons*	252,1	(18)	279,6	(18)	221,377	(18)	183,307	(18)	207,765	(18)	156,955	(15)	143,5	(13)	137,874	(15)

Table 15. Consumption of prepared or preserved pulses (peas and beans)

Preserved beans and peas (1000 t)		Year			
Balance item	**Product (1000 t)**	**2.003**	**2.004**	**2.005**	**2.006**
Sold production	Flour and meal of dried peas, beans, lentils, sago, manioc, arrowroot, salep, jerusalem artichokes, sweet potatoes or similar roots/tubers; flour, meal, powder of edible fruit, nuts	18	21	18	23
	Prepared/preserved peas (excl. by vinegar or acetic acid, dried, frozen)	339	331	499	500
	Prepared/preserved shelled beans (excl. by vinegar or acetic acid, dried, frozen	361	426	860	844
	Prepared/preserved unshelled beans (excl. by vinegar or acetic acid, dried, frozen)	392	392	379	343
Total Sold production		***1109***	***1170***	***1756***	***1710***
Exports	Flour and meal of dried peas, beans, lentils, sago, manioc, arrowroot, salep, jerusalem artichokes, sweet potatoes or similar roots/tubers; flour, meal, powder of edible fruit, nuts	1	1	2	2
	Prepared/preserved peas (excl. by vinegar or acetic acid, dried, frozen)	103	93	98	99
	Prepared/preserved shelled beans (excl. by vinegar or acetic acid, dried, frozen	42	52	53	62
	Prepared/preserved unshelled beans (excl. by vinegar or acetic acid, dried, frozen)	19	20	18	23
Total exports		***165***	***167***	***172***	***186***
Imports	Flour and meal of dried peas, beans, lentils, sago, manioc, arrowroot, salep, jerusalem artichokes, sweet potatoes or similar roots/tubers; flour, meal, powder of edible fruit, nuts	10	10	11	13
	Prepared/preserved peas (excl. by vinegar or acetic acid, dried, frozen)	3	2	1	1
	Prepared/preserved shelled beans (excl. by vinegar or acetic acid, dried, frozen	2	3	3	2
	Prepared/preserved unshelled beans (excl. by vinegar or acetic acid, dried, frozen)	36	39	38	42
Total imports		***51***	***54***	***53***	***58***
Balance		**995**	**1057**	**1637**	**1581**

Table 16.- Processed potatoes production and external trade.

Potato products (1000 t)		Year			
Balance item	**Product**	**2.003**	**2.004**	**2.005**	**2.006**
Sold production	Dried potatoes in the form of flour; meal; flakes; granules and pellets	220	208	212	109
	Dried potatoes whether or not cut or sliced but not further prepared	3	4	5	6
	Frozen potatoes; prepared or preserved (incl. potatoes cooked or partly cooked in oil and then frozen; excl. by vinegar or acetic acid)	3098	3230	2901	3144
	Potatoes prepared or preserved (incl. crisps; excl. frozen, dried, by vinegar or acetic acid, in the form of flour; meal or flakes)	1526	1613	1617	1695
	Potatoes prepared or preserved in the form of flour; meal or flakes (excl. frozen, dried, crisps, by vinegar or acetic acid)	211	216	177	193
Total Sold production		***5058***	***5271***	***4912***	***5147***
Exports to third countries	Dried potatoes in the form of flour; meal; flakes; granules and pellets	44	45	56	62
	Dried potatoes whether or not cut or sliced but not further prepared	2	1	1	1
	Frozen potatoes; prepared or preserved (incl. potatoes cooked or partly cooked in oil and then frozen; excl. by vinegar or acetic acid)	268	294	375	420
	Potatoes prepared or preserved (incl. crisps; excl. frozen, dried, by vinegar or acetic acid, in the form of flour; meal or flakes)	31	27	39	37
	Potatoes prepared or preserved in the form of flour; meal or flakes (excl. frozen, dried, crisps, by vinegar or acetic acid)	7	8	10	14
Total exports to third countries		***353***	***376***	***481***	***533***
imports from third countries	Dried potatoes in the form of flour; meal; flakes; granules and pellets	3	3	2	3
	Dried potatoes whether or not cut or sliced but not further prepared	0	0	1	1
	Frozen potatoes; prepared or preserved (incl. potatoes cooked or partly cooked in oil and then frozen; excl. by vinegar or acetic acid)	5	5	3	6

	Potatoes prepared or preserved (incl. crisps; excl. frozen, dried, by vinegar or acetic acid, in the form of flour; meal or flakes)	2	3	5	4
	Potatoes prepared or preserved in the form of flour; meal or flakes (excl. frozen, dried, crisps, by vinegar or acetic acid)	1	1	1	1
Total imports from third countries		***11***	***13***	***12***	***14***
Balance		**4716**	**4908**	**4442**	**4629**

Table 17.- Gross human consumption of main fresh and preserved fruits and vegetables

Product	2000	2001	2002	2003	2004	2005	2006	2007
Apples (1000 t)	7.356,8	7.041,0	8.453,9	8.571,4	6.924,3	6.976,9	6.638,7	6.816,3
Cauliflowers (1000 t)	1.506,8	1.453,4	1.544,0	1.364,1	1.479,8	1.396,2	1.428,0	1.419,4
Citrus fruit (1000 t)	10.012,4	10.037,3	11.044,8	10.153,0	10.112,7	10.423,2	10.357,1	9.621,0
Dried fruit (1000 t)	222,9	240,4	301,4	254,7	301,1	296,7	275,6	311,3
Fresh peaches (1000 t)	2.340,1	2.451,7	2.458,4	2.046,4	1.803,3	2.697,8	2.478,6	2.516,8
Fresh tomatoes (1000 t)	5.920,5	6.214,8	5.361,2	4.362,0	4.351,8	4.139,7	5.428,1	5.429,9
Grapes (1000 t)	2.466,1	2.014,6	2.207,2	2.178,9	2.364,4	2.271,0	2.602,2	2.385,3
Nuts (1000 t)	1.292,9	1.217,9	1.321,2	866,8	916,7	955,4	883,4	926,6
Oranges (1000 t)	8.644,7	8.569,0	9.312,1	8.062,0	12.182,5	12.867,6	12.902,9	12.552,1
Pears (1000 t)	2.164,0	2.106,8	2.139,9	2.234,8	1.882,3	1.811,4	2.511,8	1.893,2
Processed peaches (1000 t)	669,4	657,1	750,4	454,2	245,7	220,5	330,9	327,5
Processed tomatoes (1000 t)	6.882,3	5.782,5	6.114,5	6.653,4	6.847,9	7.621,2	6.411,5	19.973,5
Rice - total (1000 t)	2.198,4	2.315,4	2.372,0	2.371,8	2.203,4	1.283,0	1.214,9	1.109,6
Sugar (equivalent white sugar) (1000 t)	15.227,0	15.411,0	32.146,0	14.922,1	14.643,8	14.408,4	10.703,9	6.920,9
Vegetables (excluding potatoes) (1000 t)	34.942,7	36.953,4	28.831,8					
Wine (1000 hl)	136.234,2	127.371,8	127.610,8	131.227,1	126.393,5	130.235,3	133.738,0	126.440,5

Table 18.- Gross human consumption of main agricultural foodstuffs

Product	2000	2001	2002	2003	2004	2005	2006	2007
Apples (1000 t)	7.357	7.041	8.454	8.571	6.924	6.977	6.639	6.816
Cereals (excluding rice) (1000 t)	53.953	54.610	57.001	56.760	55.925	50.877	43.324	40.928
Citrus fruit (1000 t)	10.012	10.037	11.045	10.153	10.113	10.423	10.357	9.621
Dried fruit (1000 t)	223	240	301	255	301	297	276	311
Dried pulses (1000 t)	1.015	1.069	882	831	936	536	537	484
Fresh peaches (1000 t)	2.340	2.452	2.458	2.046	1.803	2.698	2.479	2.517
Grapes (1000 t)	2.466	2.015	2.207	2.179	2.364	2.271	2.602	2.385
Nuts (1000 t)	1.293	1.218	1.321	867	917	955	883	927
Oranges (1000 t)	8.645	8.569	9.312	8.062	12.182	12.868	12.903	12.552
Pears (1000 t)	2.164	2.107	2.140	2.235	1.882	1.811	2.512	1.893
Potatoes (1000 t)	34.169	34.068	33.576	35.055	33.730	30.507	29.641	29.329
Processed peaches (1000 t)	669	657	750	454	246	220	331	327
Rice - total (1000 t)	2.198	2.315	2.372	2.372	2.203	1.283	1.215	1.110
Sugar (equivalent white sugar) (1000 t)	15.227	15.411	32.146	14.922	14.644	14.408	10.704	6.921
Vegetable fats and oils (1000 t)	7.106	6.903	6.516	5.326	5.529	3.530	3.007	3.298
Vegetables (excluding potatoes) (1000 t)	34.943	36.953	28.832					
Wine (1000 hl)	136.234	127.372	127.611	131.227	126.394	130.235	133.738	126.441

Table 19: Total cereals balance sheet in the European Union, 2004-2014 (mio t)

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Usable production		**286,2**	**253,1**	**242,3**	**256,0**	**294,4**	**288,2**	**293,6**	**297,6**	**300,7**	**303,9**	**305,7**
of which	EU-15	223,4	195,0	192,4	193,0	210,3	204,8	207,5	210,2	211,5	212,4	214,1
	EU-10	62,8	58,1	50,0	52,1	59,1	58,4	60,3	60,7	62,6	64,6	64,5
	EU-2				10,9	25,0	25,0	25,8	26,7	26,6	26,9	27,2
of which non-food set aside		0,0	0,0	0,0	0,0	0,0	1,7	1,8	6,5	6,4	6,4	8,5
Consumption		**243,0**	**246,9**	**247,4**	**265,6**	**270,6**	**271,7**	**272,9**	**275,5**	**278,7**	**282,9**	**285,5**
of which food and industrial		78,4	76,9	78,6	86,6	87,9	88,0	88,1	88,1	88,2	88,3	88,3
of which feed		153,2	154,9	153,7	165,2	166,5	167,8	167,9	168,6	168,8	168,6	168,5
of which bioenergy		0,7	2,7	2,5	1,9	4,8	4,5	5,5	7,5	10,3	15,7	18,4
of which	EU-15	190,8	198,0	199,3	200,1	199,6	201,0	202,3	205,2	208,5	213,0	215,9
	EU-10	52,2	48,9	48,2	48,3	48,7	48,6	48,5	48,2	47,9	47,5	47,3
	EU-2				17,2	22,3	22,1	22,2	22,2	22,2	22,3	22,3
Imports		10,1	9,9	10,9	16,9	11,6	9,9	9,3	9,0	9,3	10,4	11,0
Exports		23,3	23,5	21,7	18,0	27,7	28,2	29,0	29,7	28,8	28,2	28,9
Beginning stocks		44,3	74,4	67,0	51,0	40,4	48,0	46,1	47,1	48,5	51,0	54,2
Ending stocks		74,4	67,0	51,0	40,4	48,0	46,1	47,1	48,5	51,0	54,2	56,6
of which intervention		17,4	15,6	2,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	of which EU-15	11,8	5,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	of which EU-10	5,6	9,6	2,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	of which EU-2				0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

EU-10: Member States that joined the European Union on May, 1st 2004
EU-2: Bulgaria and Romania