Biobased economy
State-of-the-art assessment

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The interest in the biobased economy stems from the possibility to substitute biologically derived materials and processes for the production of goods that will, therefore, result in a reduced use of petroleum and petro-chemistry. Other reasons are the reduction in the energy required in production processes or the more environmentally benign waste treatment channels for the production residues or discarded products at the end of their life cycle. The Ministry of Agriculture, Nature and Food Quality of The Netherlands has asked Wageningen UR (AFSG and LEI) to examine the contemporary market for biobased products and the potential growth of the biobased economy. This report is based on an analyis of the bio-based composition, actual and possible, as well as the market value of 780 non-food, non-feed products within the PRODCOM listing, which represent the potential for biobased production in NL and the EU25.

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Contents

Samenvatting

De biobased economy staat in Nederland hoog op de agenda. De verwachting daarbij is dat Nederland, door zijn ligging, de hoog ontwikkelde landbouw- en chemie sectoren, de havens en de goede logistiek vooral zal kunnen profiteren in het segment van de hoogwaardige toepassingen uit hernieuwbare grondstoffen.

Dit rapport concludeert dat er al een grote bestaande biobased-markt is, maar dat er daarnaast een grote groeipotentie is voor Nederland op het gebied van de productie van hoogwaardige producten uit bouwstenen van biomassa.

In deze studie is een inventarisatie gemaakt van de huidige en potentiële marktomvang van biobased-producten. De basis voor de inventarisatie zijn de tat data van geproduceerde goederen. Deze data bevatten op productniveau de waarde van zo'n 4.000 geproduceerde goederen voor de EU-25, ook uitgesplitst naar land. Deze data zijn gebruikt omdat ze de meest complete en consistente dataset vormen die beschikbaar is, en omdat de EU-25-landengroep als economische eenheid, naast Azië en de VS, een belangrijk deel van de wereldmarkt vormt, terwijl tegelijkertijd op basis van de data een adequate inschatting van de Nederlandse positie op deze markt kan worden gemaakt.

Een nadeel van de tat-data bleek te zijn dat sommige data er niet in staan omdat ze vertrouwelijk zijn. De schattingen zijn dus altijd aan de conservatieve kant

Bij de inventarisatie zijn alleen non-foodproducten geselecteerd; voeding en veevoer zijn buiten beschouwing gelaten en ook biomassa voor energieproductie is niet meegenomen. Wel zijn de transportbrandstoffen biodiesel en bioethanol meegenomen. Om de inventarisatie overzichtelijker te maken zijn biobased-producten ingedeeld in drie 'groepen' gerelateerd aan het productieproces: (1) materialen uit biomassa, hierin zitten de traditionele toepassingen als hout, papier en natuurlijke textielvezels, (2) stoffen uit biomassa, hierin zitten de toepassingen als oliën voor de verfindustrie, zetmeel voor verschillende technische toepassingen als lijmen, zetmeelplastics, enzovoort, en (3) bouwstenen uit biomassa: hierin zitten relatief nieuwe toepassingen waarbij de biomassa eerst (bio)chemisch wordt omgezet tot bouwstenen, waarna er hoogwaardige producten als kunststoffen, fijnchemicaliën, enzovoort. van worden gemaakt.

Overzicht van biobased-productie in 2005 volgens tat voor EU-25.

	Aantal product-categorieën	% product-categorieën geregistreerd	Totale geregistreerde waarde a) (miljard €)	Huidige aandeel biobased b) (miljard €)	Potentieel aandeel biobased b) (miljard €)
Materialen uit biomassa	323	78	250.6	187.7	211.6
Stoffen uit biomassa	101	60	47.9	23.2	38.5
Bouwstenen uit biomassa	356	33	155.2	34.5	81.6
Totalen	780	55	453.7	245.3	331.8

a) Exclusief de confidentiële data; b) Van de non-food, non-feed component, gebaseerd op expert oordeel.

Analyse van de huidige marktomvang van de drie groepen (zie bovenstaande tabel) laat zien dat er al een bestaande biobased-markt is. Marktomvang van de productie die momenteel helemaal of deels biobased is, wordt geschat op circa 450 miljard Euro, het aandeel biobased hierin wordt geschat op 250 miljard Euro. (Vergelijk met 460 miljard Euro voor voeding -exclusief dranken- en veevoer, EU-25, 2005.) In totaal 45% van de data is echter confidentieel (zie kolom 3 voor aandeel wel geregistreerd), waardoor deze productiewaardes niet zijn meegenomen in de telling. Er kan worden geschat dat het werkelijke huidige aandeel biobased wellicht zo'n 315 miljard Euro kan bedragen.

Op basis van een expert-inschatting van de mogelijke substitutie van de nu gebruikte grondstoffen door biomassa, wordt verwacht dat het aandeel biobased grondstoffen in huidige producten kan groeien met zo'n 86 miljard Euro (tot wel 120 miljard, gegeven de mogelijke bijdrage van confidentiële data). Ruim de helft van deze groei wordt verwacht in de derde groep 'bouwstenen', met potentieel meer dan een verdubbeling van het aandeel biobased. In de eerste groep 'materialen' en tweede groep 'stoffen' is minder groei te verwachten omdat het hier om producten gaat die traditioneel al voor een groot percentage uit biobased grondstoffen worden gemaakt.

Deze inschattingen zijn gemaakt op basis van de technologische potentie om de huidige grondstoffen van producten (deels) te vervangen. Het moment waarop dit werkelijk zal gebeuren is vanzelfsprekend afhankelijk van de ontwikkeling van de grondstofprijzen, de beschikbaarheid van grondstoffen op een bepaalde plaats en de verdere kostprijsdaling van de omzettingstechnologie.

Voor veel producten blijkt Nederland al een groter dan proportioneel aandeel te produceren. Gegeven de gunstige uitgangssituatie van Nederland, wat betreft kennis en infrastructuur, lijkt de conclusie dus gerechtvaardigd dat Nederland kan profiteren van de ontwikkeling van een biobased economy.

Summary

The following report on the biobased economy is intended to assess the potential to produce manufactured goods with biobased materials, and equally the potential for the agricultural sector and manufacturing industry within The Netherlands to participate in the development of the biobased economy.

The Government of The Netherlands takes into account the 3 Ps - People, Planet and Profit - in its policy making and action programmes. The present study is motivated by the knowledge that the production of biobased materials directly benefits the rural economy as well as the general economy (energy and natural resource savings), and thus this study focuses on the Profit aspect.

The current level of the production of materials that are entirely or partially biobased has a market value of around 450 billion in the EU-25 manufacturing sector it is estimated that the real value could be even one-third more, or 610 billion .

When analysing the current value of the truly biobased part of these manufactured goods, a conservative estimate is 250 billion ; this could be as much as 315 billion .

Finally, it is estimated that the potential for biobased components in manufactured goods could rapidly grow by 86 billion (based on known figures) or by 120 billion (considering a reasoned extrapolation of known figures). This growth could occur either through substitution of materials or by novel product development.

The study has found that with regard to many products The Netherlands is already producing a greater than proportional share of EU-25 output. It is known that The Netherlands has many advantages in terms of agricultural capacity and industrial knowledge when compared to other EU countries, along with transportation infrastructure and research institutions. It is therefore considered that a significant benefit can be realised by encouraging the development of the biobased economy.

The encouragement of the biobased economy should accelerate existing market growth capacities, and should not intervene in a counter-productive manner by directing resources towards biobased product lines that do not have true market potential. Because not all biobased materials have the same possibility to succeed in the market, carefully considered investments are necessary by product type.

A first step to understand investment opportunities is made in this study with the analysis of product 'families', which are logical clusters of products, such as 'fabrics' or 'polymers'. The information available in many cases already gives a good idea of the potential market situation, and the position of The Netherlands within the EU-25 market. More comprehensive, and exact, information requires further research to fill data gaps.

1. Introduction

The biobased economy is an orientation towards the substitution of biologically derived materials and processes for the production of goods that seeks to reduce the use of extracted minerals and petro-chemistry. There are additional attributes, such as the reduction in the energy required in production processes or a more benign waste treatment channel for production residues or discarded products.

The Ministry of Agriculture, Nature and Food Quality of The Netherlands has been interested in the past to give support for biobased product development, as a complementary vector to encourage agricultural production-and therefore farmer income. In order to determine to what degree such support should be continued, or even reinforced, a request has been made to Wageningen (AFSG and LEI), to examine the contemporary market for biobased products and, by extension, the potential for the biobased economy.

The project team decided to base its analysis on detailed information, beginning with the individual product; the products are then aggregated into categories according to market sectors and also within groups of products depending on production process. According to this method, based on the tat PRODCOM coding, 780 products were identified and treated in the analysis. 2005 is the reference year for the data, as the data for 2005 are the most recent that is available; the market area taken into account is the EU-25, in relation to which the NL production is contrasted. This method clearly establishes the market share and potential market for each product, and also for each market sector. The grouping by production process allows further conclusions to be established about the capacity for NL technology to promote the market development for biobased materials.

If one considers the structure of the Dutch economy, in table 1.1, it is apparent that agriculture is a relatively small sector within The Netherlands. Industry, by contrast, is seven times more important. But in terms of relative performance in the 'knowledge economy', figure 1.1 shows that agriculture is ahead of industry in The Netherlands when compared at the European level. Thus promoting the biobased economy is the most direct way of creating a lock-in relationship between industrial and agricultural production, and secondly to stimulate the development of industrial knowledge added value and its application. In this way, policies that will promote the use of biobased products (see box below) will have a catalytic effect on two sectors of the economy at the same time; this joint benefit is made possible by the intrinsic synergies associated with the use of biologically derived materials and processes that can apply to the non-food, non-feed part of agricultural production. According to the data presented in figure 1.2, by 2010 as much as 10% of the chemicals produced in Europe could be biobased, increasing from a value of €77 billion in 2005 to €125 billion in 2010. This represents a 62% increase within 5 years.

Table 1.1 Structure of the Dutch economy compared to EU-25 in 2005 (million €)

NACE Sector	EU-25: €/sector	NL: €/sector	NL sector/ NL total %	NL sector/ EU-25 sector%
Agriculture, hunting and forestry	177,333	9,595	2.1	5.4
Fishing	7,545	184	0.0	2.4
Mining and quarrying	87,660	14,061	3.1	16.0
Manufacturing	1,685,398	63,152	14.1	3.7
Electricity, gas and water supply	185,969	6,731	1.5	3.6
Construction	-	24,503	5.5	-
Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	1,108,439	57,003	12.7	5.1
Hotels and restaurants	286,544	8,279	1.8	2.9
Transport, storage and communication	684,416	31,788	7.1	4.6
Financial intermediation	516,158	33,374	7.4	6.5
Real estate, renting and business activities	2,155,431	89,696	20.0	4.2
Public administration and defence; compulsory social security	611,778	32,914	7.3	5.4
Education	502,275	21,435	4.8	4.3
Health and social work	667,304	40,073	8.9	6.0
Other community, social, personal service activities	373,079	14,354	3.2	3.8
Activities of households	49,334	1,899	04	3.8
Totals for 2005	9,098,663	449,041	100.0	-

Source: tat.

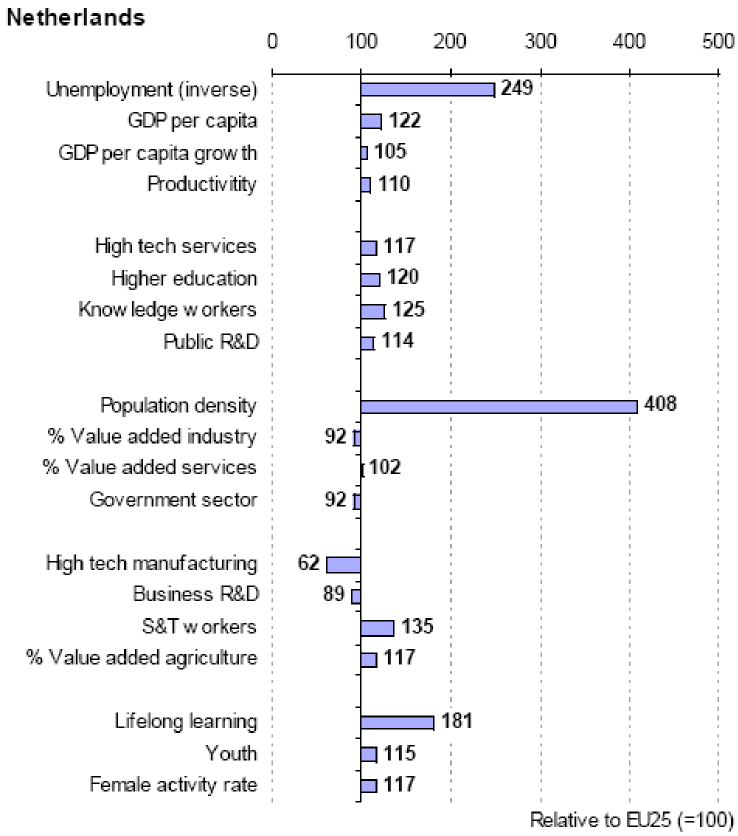

Figure 1.1 Relative performance for key knowledge economy indicators
Source: Wintjes (2006), citing calculations of MERIT based on available tat and national data from 2002-2003 depending on the indicator.

Biobased Products

Biobased products refer to non-food products (energy or industrial materials) derived from biomass (plants, algae, crops, trees, marine organisms and biological waste from households, food/feed production, etcetera). Biobased products may range from high-value added (usually low volume) fine chemicals such as pharmaceuticals, cosmetics, food/feed additives, etcetera, to high volume materials such as biopolymers, biofuels, fibres, etcetera It may include existing biobased products, such as paper and pulp, detergents, lubricants, construction materials, or new ones, such as vaccines made from plants or second generation bio-fuels.

Biobased products offer the following advantages:

- use of unexploited agricultural productivity and/or residues from agriculture or forestry and some organic municipal wastes;
- increased reliance on products and processes that are more environmentally sustainable;
- development of less expensive, better performing or currently unavailable products (compared with petroleum-based products);
- use of molecular biology to modify the raw materials for easier processing and to reduce economic and environmental costs of processing;
- enhanced economic and social stability of rural communities through production and processing of the plant raw materials;
- reduced potential for economic and social disruption due to dependence on imported raw materials;
- improved local and global ecological systems due to production and processing of plant raw materials.

Source: Dale (2003).

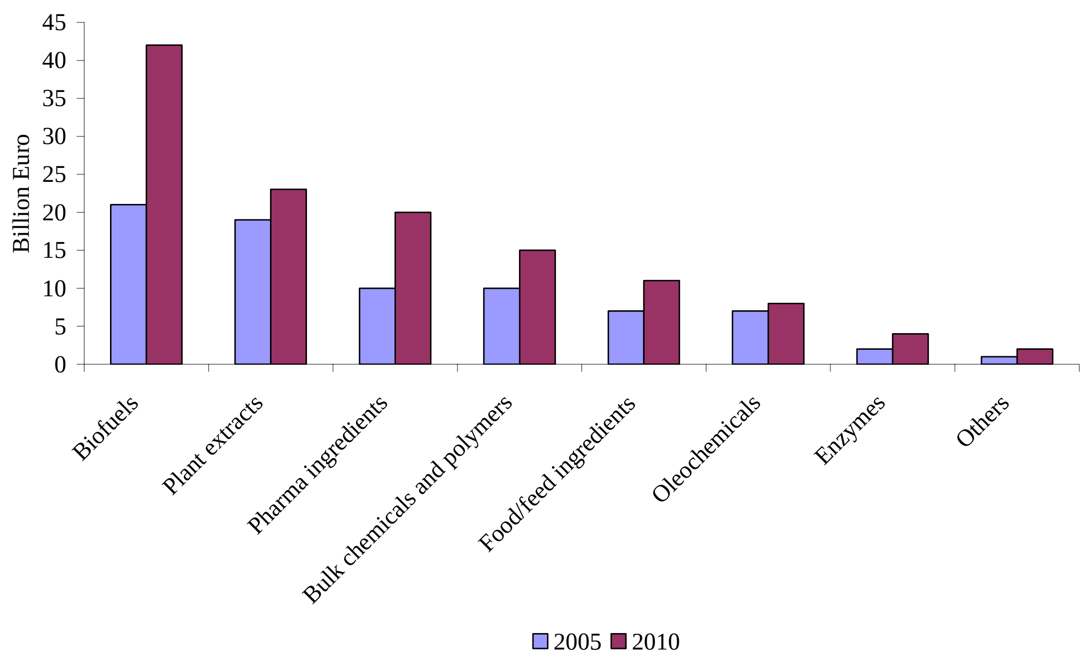

Figure 1.2 Short-term growth prospects of biobased materials
Source: McKinsey and Company (2006).

The present-day issue concerning the biobased economy is the degree to which products can be directly obtained or transformed from the solar-driven biological growth process, rather than from the particular reservoir of such growth-accrued over time-that is in the form of liquid petroleum or petroleum gas. Production based on petroleum is ultimately limited by the extent of the resource base; and as this resource base contracts through depletion, then markets respond with price increases for this resource. A secondary issue is that the use of petroleum-on the scale of modern industrial and transport use-releases far more carbon than can be absorbed by solar-driven, carbon-capturing, biological growth and therefore gives rise to global warming.

Examples of Agriculturally Based Materials Replacing Petrochemicals

- Soybeans, part of the fats and oils family, is the largest source of plant-based oil. Soy-based inks are replacing petro-based inks, particularly in the color ink market, where soybased color makes of 90% of market due to superior performance. The American Newspapers Publishers Associations developed soy-based inks in response to the oil shocks of the 1970s. In 1994, 75% of the 1,700 newspaper dailies used soy-based inks.
- Vegetable oils and plant resins can be used to produce paints, detergents and plastics. For example, citric acid can be a substitute for phosphates and petro-based chemicals used in detergents. Companies like Seventh Generation, create household cleaning products without the use of petro-based materials.
- In the alcohol and solvents family, lactic acid, produced from corn sugar, can replace chlorinated solvents used for cleaning and degreasing electronic parts.
- Natural fibers such as cotton, flax, jute, hemp, and kenaf can replace synthetic fibers used for rugs, textiles (clothing) and paper goods.
- Gums such as milkweed can replaced petroleum based adhesives.
- Meadowfoam, part of the oils and fats family, can replace petroleum-based cosmetics and lubricants.

Global biological growth represents an enormous material asset for mankind, on the order of 100 trillion kilograms of plant dry matter per year, or 10 times the total energy use of all forms in the world (Dale, 2003). Renewable raw materials have the potential to bring big economic, functional and environmental advantages to a range of industries. There is a rapid development of industrial biotechnology, biobased products and sustainable chemistry. By 2010, as much as 10% of the chemicals produced in Europe could be biobased, increasing from a value of €77 billion in 2005 to €125 billion in 2010, according to a presentation made by McKinsey and Company in 2006 (figure 1.2)[1]. In this five-year period, biofuel production is expected to double, as is the production of pharmaceutical ingredients and enzymes. The production of bulk chemicals and polymers should grow by

[1] The order of magnitude expressed by this figure is confirmed by a joint study sponsored by the US Departments of Energy and of Agriculture, which states that the 'production of chemicals and materials from biobased products will increase substantially from approximately 12.5 billion pounds or 5% of the current production of target US chemical commodities in 2001, to 12% in 2010, 18% in 2020, and 25% in 2030' (Perlack et al., 2005:1).

50%. In contrast, the growth in the production of oleo-chemicals may only be on the order of 15%, considering the actual maturity of the biobased production process for this group of products. But in general, this represents a 62% increase in 5 years, a strong indication of the slope of the knowledge curve.

These figures reveal that the market conditions for an increasingly biobased economy have materialised, after a 200-year period when there was a shift in primary economic reliance first on coal and then on oil (along with their respective co-products in the extraction process). This shift offers a significant opportunity for an economy such as that of The Netherlands, which has solid foundations in agriculture, the processing of agricultural commodities and in the manufacture of chemicals. This combination allows a synergy in the adaptation of plant growth, their processing and the use of derived intermediary products in a high turn-over industrial framework, either in bulk or high value added production. The Netherlands also possesses an infrastructure for the importation of raw materials and the export of intermediary or finished products, and the size of the chemical sector itself in The Netherlands provides a sizable market for biobased products, as almost 40% of chemical output is an intermediary product to be incorporated in final output.

Biomass Intermediate	Building Intermediate	Products		
Feedstocks	Platforms	Blocks		
	Fuel oxygenates	Antifreeze and deicers		
Starch	Methanol	Solvents	Industrial	
	Syn Gas	Mixed alcohols	Green solvents	
	H2 + CO	F-T diesel	Speciality	Transportation intermediates
Hemicellulose	C1-C2	Emulsifiers	Textiles	
	EG	Chelating agents		
	Ethanol	AminesSafe food		
	C3	Plasticizerssupply		
Cellulose	Sugars	Glyceraol/PG	Polyvinyl acetate	
	Glucose	Lactic acid	Resins	Environment
	Fructose	C4	Polyvinyl alcohol	
	Xylose	Succinic acid	Polyacrylates	Communication
Lignin	Arabinose	C5	Polyacrylamides	
	Lactose	Levulinic acid	Polyethers	Housing
	Sucrose	Itaconic acid	Polypyrrolidones	
	C6	Polyesters	Recreation	
Oil	Sorbitol	Nylons		
	Citric acid	Polycarbonates	Health	
	HMF	Polyurethanes		
		Polysaccharides		

Figure 1.3 Production sequence for value-added chemicals from biomass feedstocks
Source: Baker and Petersen (2006).

The biobased economy is structured around a broad range of products, of which those related to the bulk or fine chemical industry are only a partial illustration. The basic pillar is of course agriculture in terms of quantity of output, but agriculture represents only 4% of gross value added in the European economy (for in depth treatment of this subject, see Nowicki et al., 2007). Beyond satisfying needs for food and feed, the biobased economy meets the requirements for a large range of primary and combined materials, be they in the form of fibres or structural matter for building or transformation in furniture, furnishings, etcetera The use of biobased materials for a broad range of processed matter has already been touched upon in the example of the chemical industry; the range of use is more fully illustrated in figure 1.3. Finally, biobased materials can serve for heating, generating electricity and providing fuels for transportation; an important aspect is the possibility to use harvest residues (especially from forestry) and waste streams from biobased production processes. (figure 2.1 gives an overview of the resources and processes underlying a biobased economy.)

In terms of an economic comparison between biobased and other production systems, the basic structure of analysis is the cost of raw materials, on the one hand, and the cost of the conversion process, on the other (Dale, 2003). The petro-chemical industry has benefited from a low cost for crude oil, and on this basis has been able to promote research towards the production of a considerable number of derived products. There are few opportunities today for further cost reductions in the conversion of crude oil into derived products, a characteristic of a 'mature' industry. But there is considerable volatility with regard to the price of the raw material, with the projection for the price of crude oil at a minimum of USD50 per barrel until 2016 (FAPRI, 2007). As can be seen in table 1.2, the opposite case is true for the production of biobased materials: raw material prices are low, by comparison to petrol, and stable (sugar, a refined product, is basically the same price as the petrol); conversion processes for desired products are, however, in many cases under development, and expanding and conversion costs should consequently drop. Biobased products are (a) traditionally distinct in nature from petroleum-based products, (b) a substitution for petroleum based products, or (c) novel applications in themselves.

Table 1.2 Cost comparison of selected raw and refined materials

Raw materials	Average world market price (2000-2003)
Petroleum	175 €/t
Coal	35 €/t
Ethylene	400 €/t
Corn	80 €/t
Straw	20 €/t
Sugar	180 €/t

Source: BACAS (2004).

In terms of the adaptability of biobased materials, the example of the possibility to use maize as an industrial crop (figure 1.4) demonstrates the possible range of non-food and non-feed uses from a single crop, already part of current manufacturing practice for some considerable time. This is not surprising, considering that 30% of organic chemicals were derived from plants as recently as 1930 (Somerville and Bonetta, 2001), and that in 2000 the US National Research Council set a goal that 25% of organic chemicals should be derived from biomass by 2020 (Perlack et al., 2005). So it is to be expected that at least a third of a product family such as organic chemicals should be biobased. As will be discussed further on, this same type of growth potential exists for other product families as well.

The intention of this study on the biobased economy is to examine the state-of-the-art knowledge about the biobased economy, and what development can be expected. The methodology for this task is presented in the next section, and the following sections give a presentation of results of the analysis of the tat data, their interpretation, and the provision of an additional perspective through reference to the literature.

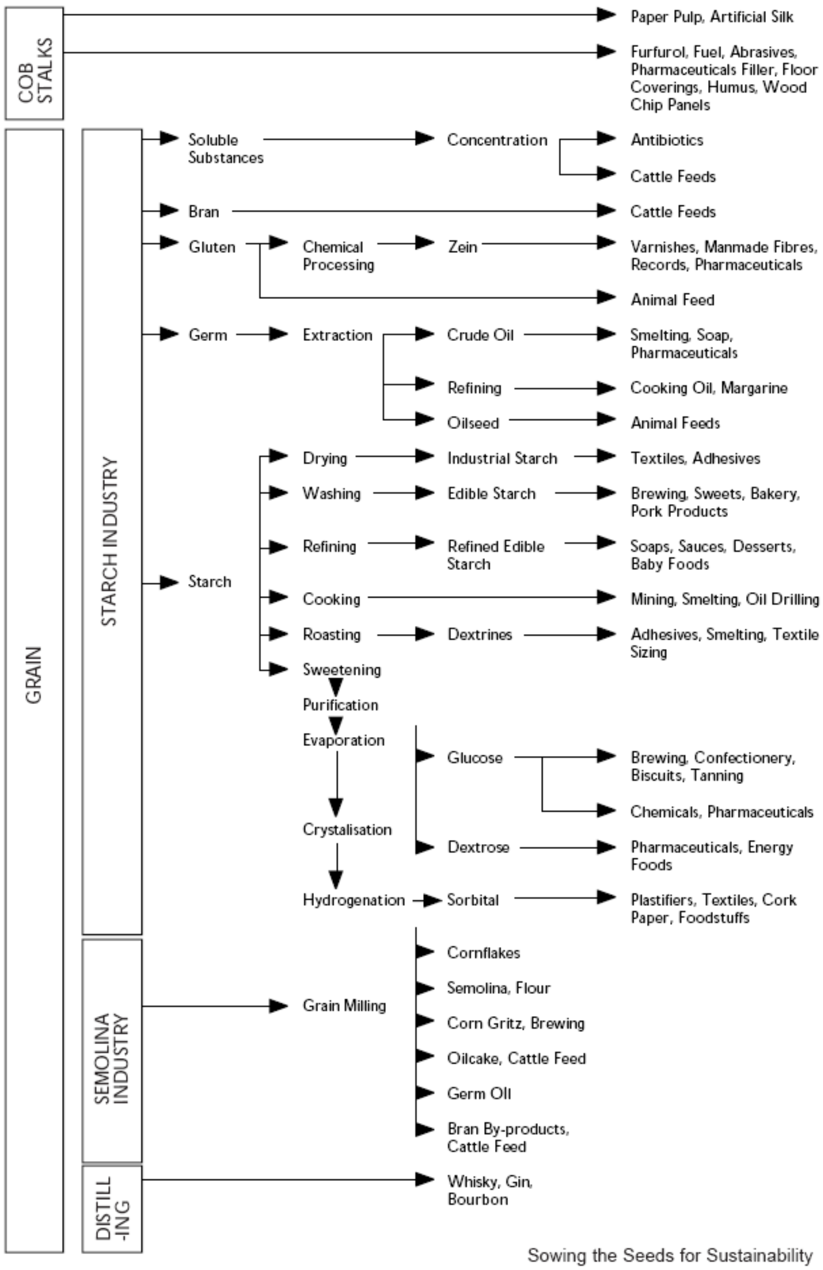

Figure 1.4 The industrialisation of maize a).

a)'Approximately 20% of the corn kernel is not utilised in the production of ethanol and other starch based products, such as sweeteners and high-fructose corn syrup. It is an excellent near-term biomass resource for bioproducts. The corn fiber produced as a byproduct of ethanol dry mills, DDG (dry distillers grain) is sold for animal feed. It is estimated that about half of the corn fiber produced is (or will be used) for animal feed while the remainder is (or could be) used for bioproducts.' (Perlack et al., 2005:31)

Source: Nowicki (2001, citing OECD 1979).

Exogenous factors having an influence on the biobased economy

It has already been highlighted that there are two aspects of the price for biobased products: the cost of the feedstock and the cost of the conversion process. According to Russo (2006), in a mature industrial production process the feedstocks represent 75% of the product cost and the conversion process only 25%. With regard to the biobased-economy, to the extent that substitution of petroleum as a feedstock is the issue, then the question is (a) what will be happening in the foreseeable future with the price of crude oil, and (b) what will be the knock-on effect with regard to the price of biobased materials that might serve as alternative feedstocks.

Figure 1.5 gives the most recent analysis available with regard to the ten-year perspective for oil prices. The average projection indicates that the price of oil will drop from the current high of USD74 per barrel to just over USD50. The lower range would bring the barrel down to about USD30, and the upper would keep the price at the level it is now. The price of oil determines the price of ethanol, because of the relative value of the two products in terms of energy, and thus the price of ethanol is in a constant relative position with regard to a refined petroleum product such as gasoline (figure 1.6). The price of ethanol is important for three reasons: (a) it is a final product in its own right within the biobased economy; (b) it is an intermediary product in the production process for other goods; and (c) the value of ethanol determines the value of cereals (such as maize corn), which in turn determines the value of other co-products, such as dried distillers grain (DDG), which is *itself* a feedstock in the production of biobased goods. Therefore the value of DDG is also important to take into consideration, as it is linked to the price of the feedstocks for ethanol (figure 1.7).

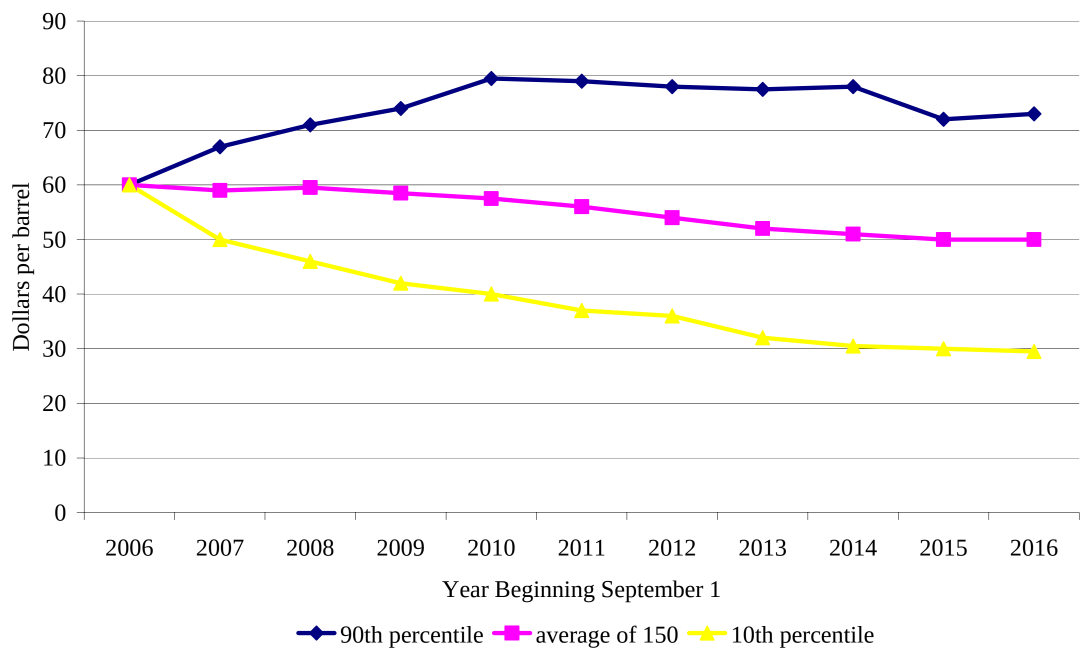

Figure 1.5 Petroleum prices-summary of 500 outcomes
Source: FAPRI (May 2007).

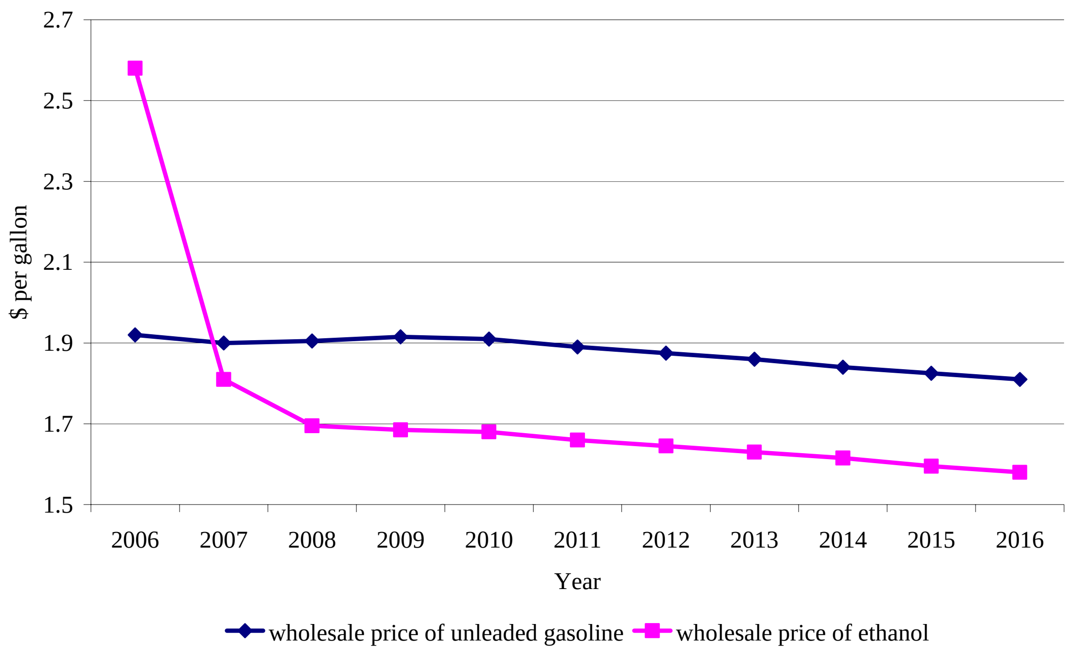

Figure 1.6 Projected ethanol and gasoline prices
Source: CARD (May 2007).

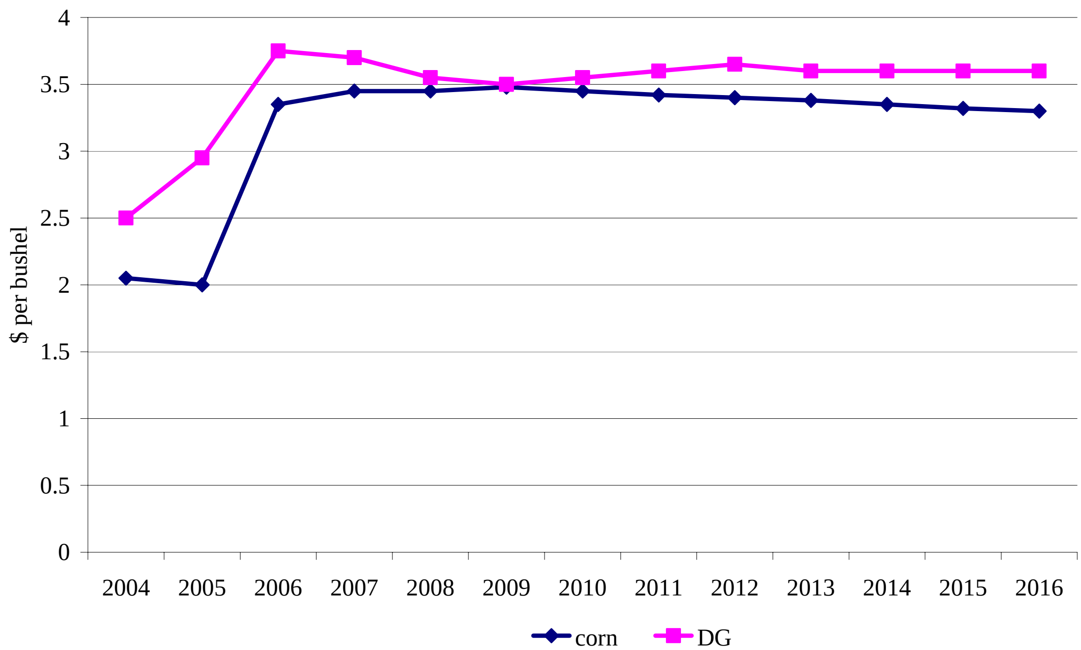

Figure 1.7 Relationship between maize and distillers grains prices
Source: CARD (May 2007).

The price of the feedstocks will have repercussions all the way through the value chain, and thus the price of a biobased product is not necessarily lower when the price of crude oil goes up, for many values for products are ultimately tied to the value of petroleum. In some studies the calculations are made on the basis of energy equivalent (Platform Groene Grondstoffen, 2006). In others, the reference point is the general evolution of commodity markets in function of policy objectives, which themselves may be driving the incorporation rate of biofuels in the transportation fuel market, thus having a direct influence on the level of production of biofuels. The competitive position of biobased feedstocks compared to petroleum may, in this sense, be directly proportional to the amount of subsidy for a commodity, such as bioethanol or biodiesel. In this case, the repercussions are policy driven rather than market driven, as is demonstrated by Eururalis (see below).

When the value of feedstocks depends either on temporary peaks in market demand or on non-market demand (mandatory blending through regulation or incentives in the form of subsidies), there is a danger that the repercussions in the value chain will have an influence on operating costs of the industries that are producing the biobased materials. Figure 1.8 makes this point very clearly with the fall in the market value of ethanol and DDG in respect to the increasing operating costs (by the increase in price of the feedstock) for the production unit. In this case, if the investment in production capacity is not paid back very quickly, then the long-term return on investment may not only become uninteresting for an investor, but may even turn into a loss of part of the capital originally invested.

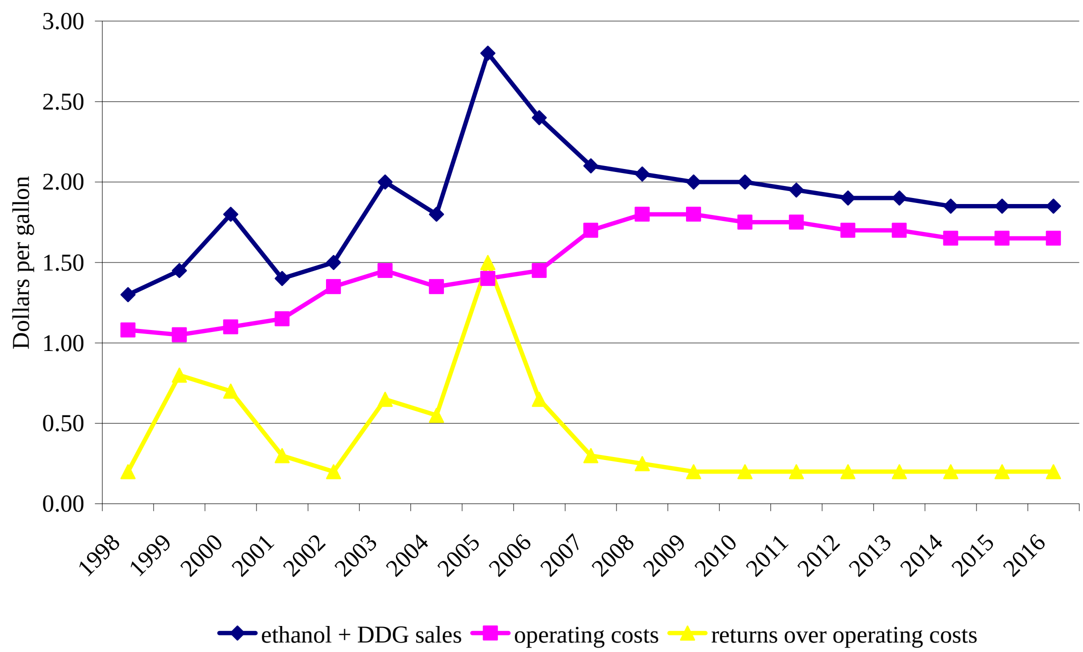

Figure 1.8 Ethanol dry mill costs and returns
Source: FAPRI (May 2007).

Bourgeon and Trégeur (2007), citing specific calculations, demonstrate the influence that the implementation of the Biofuels Directive, with a 5,75% incorporation rate, may have on rapeseed-related products. They give the example of an additional demand of 3 million tonnes for rapeseeds, a biodiesel feedstock: the value of co-products, such as rapeseed cake, and related products, such as other cereals and oils derived from other oils, will in some cases vary considerably (table 1.3). On one hand, a fall in the price of rapeseed cakes will be beneficial for the livestock industry; on the other hand, increase in the prices of vegetable oils will at first reduce the profit margins of the margarine industry, and eventually will result in higher prices for the consumer.

Table 1.3

Commodity	Price variation %
Rapeseed oil	19
Other oils	9.6/11
Rapeseed cakes	-5.5
Other cakes	-0.6/-3.5
Rapeseed grain	12
Other vegetable grains	3.3
Cereals (EU)	0
Cereals (World)	3

Source: Bourgeon and Trégeur (2007), citing Dronne and Gohin (2006).

Eururalis: relationship of biofuels with the global economy

Within the Eururalis project (Version II) the GTAP model has been extended to analyze world wide expansion in the production of biofuels. The following paragraphs shortly present the results of this analysis for the Global Economy (equivalent of A1 of SRES) scenario which assumes the WTO negotiations are successful, global trade fully liberalised and a further eastwards enlargement of the EU including Turkey. This scenario shows a strong technological change combined with high income growth for almost all regions

To analyze the impact of an enhanced use of biofuels as the consequence of the EU biofuels directive a reference scenario has been calculated up to 2020 which covers all reform steps of the CAP and possible outcomes of the WTO. The reference scenario assumes no mandatory blending for biofuel use. However it is important to notice that due to changes in relative prices (biofuel crops vs. fossil fuel) the use of biofuels also changes under the reference scenario even without a mandatory blending.

Sweden together with Germany and the Czech Republic are those countries with the highest share in the use of biofuels in transportation in the initial situation. Under the reference scenario with no mandatory blending, the use of biofuels increases endogenously (see figure 1.10).

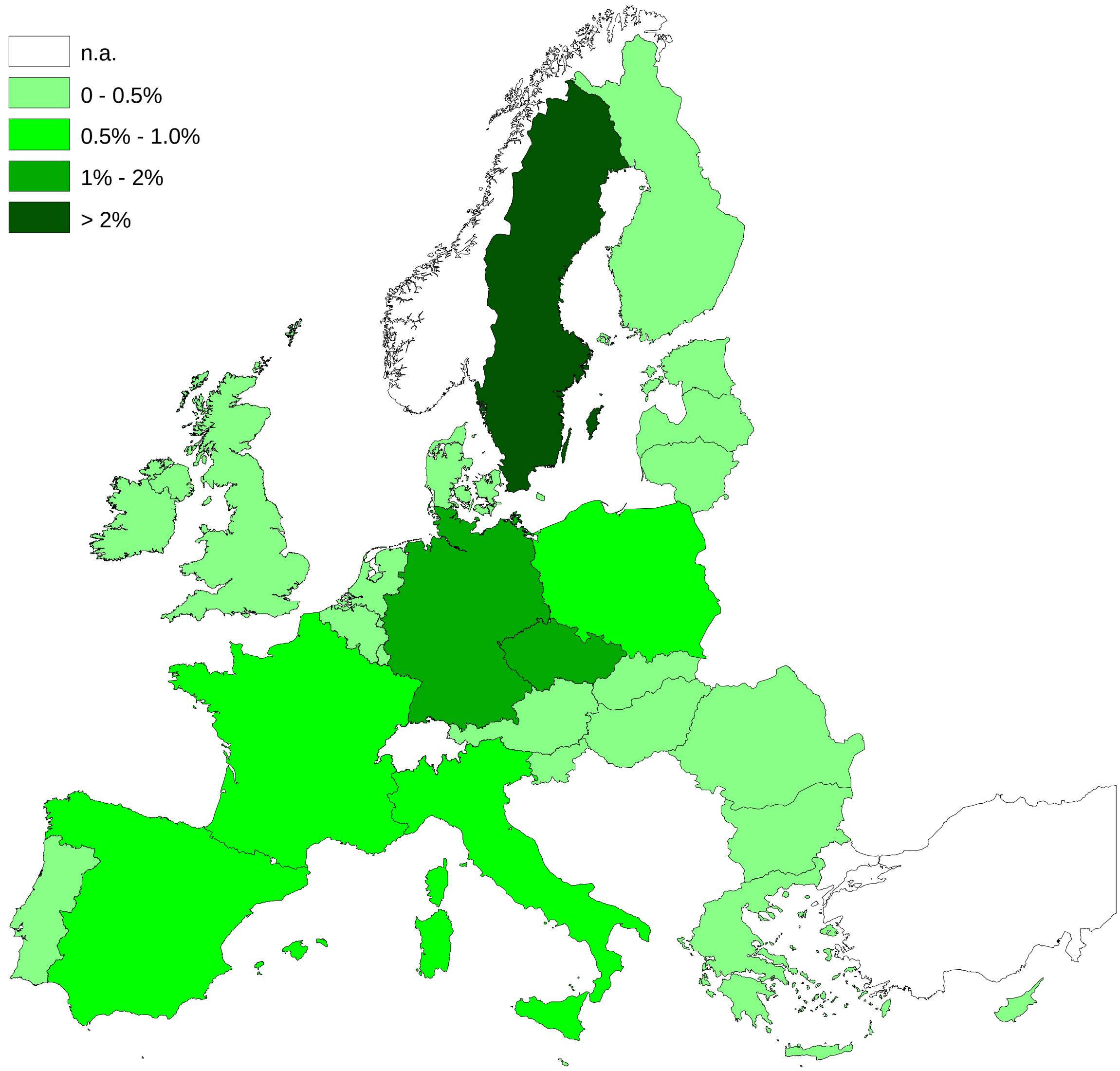

Figure 1.9 Initial Share of Biofuels in Transportation in the EU-25(2005)

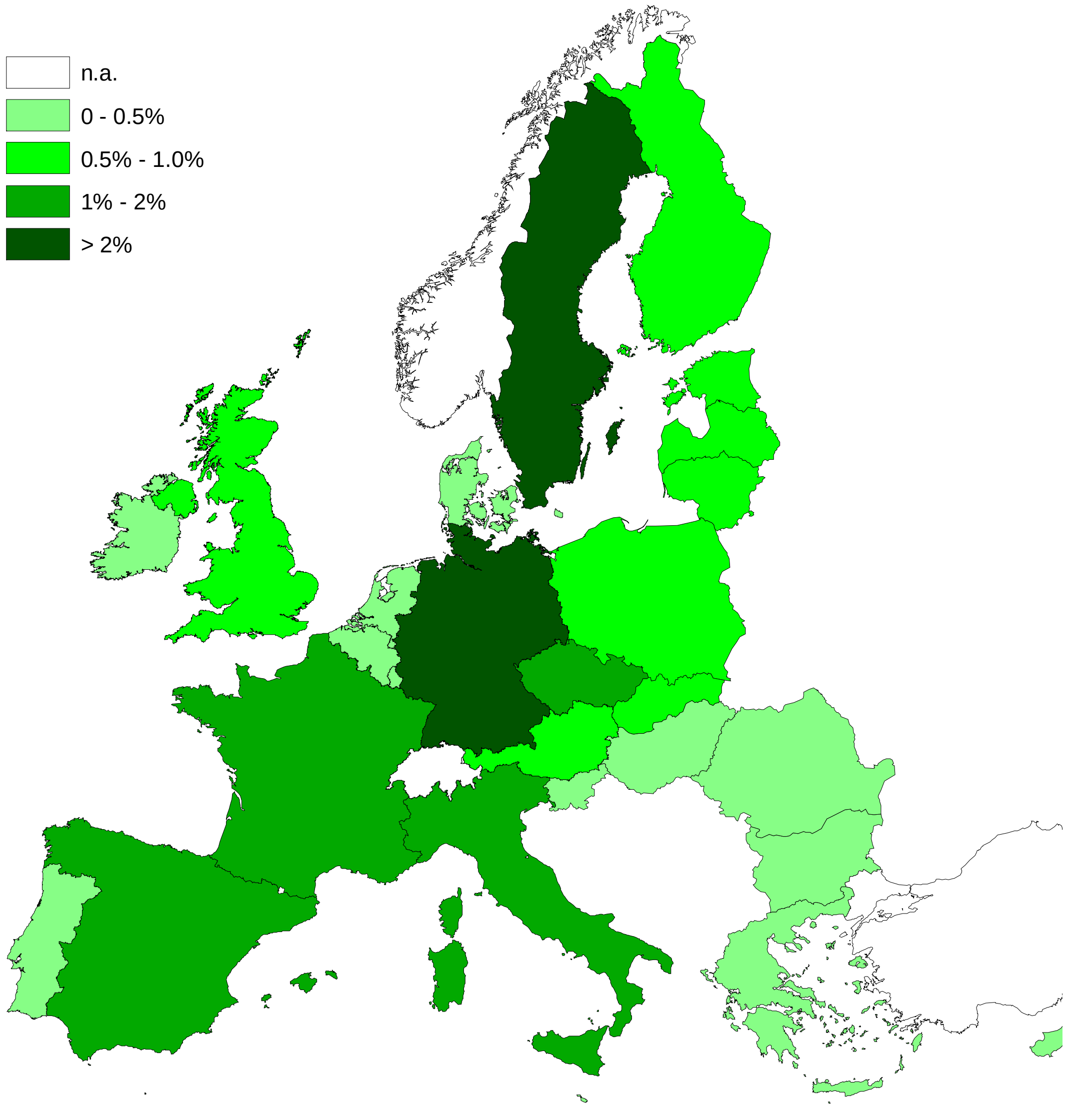

Figure 1.10 Share of Biofuels in Transportation in the EU-25, 2010-No mandatory blending

Even without an enforced use of biofuel crops through a mandatory blending, the share of biofuels in fuel consumption for transportation purposes increases.To present the impact of a mandatory blending, the following figures illustrate the change in agricultural production and land use. These results show the differences of the scenario with the mandatory blending in the EU relative to the reference scenario.

The consequences of the EU biofuel directive on land demand and agricultural production within the EU and outside Europe are illustrated in the following figure.

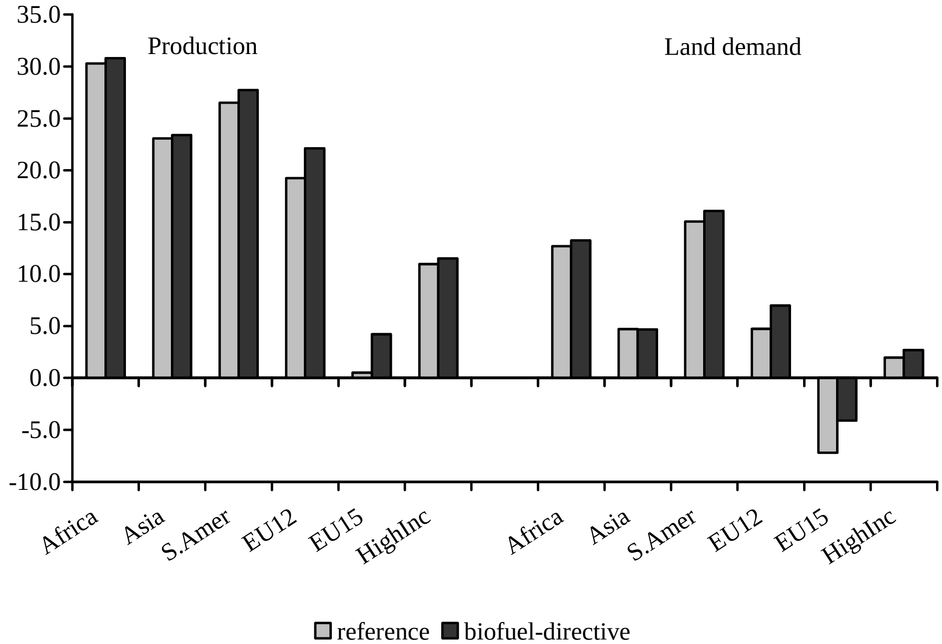

Figure 1.11 Impact of EU Biofuel Directive on Agricultural Land Demand and Production, 2010, change in percent relative to initial situation (2001)

The EU-biofuel directive has a strong impact on the agricultural production and land use not only in Europe (EU15 and EU12) but also to countries outside Europe. The agricultural production will increase especially in Central and South America due to the additional demand for biofuel crops in Europe.

The reference scenario indicates that the relative prices between fossil fuel and biofuel determine the profitability of biofuel use for production of transport fuels. However, to fulfil the blending targets of the EU-biofuel directive of the individual EU member states, subsidies have to granted to the petroleum producers. figure 1.12 illustrates the importance of these subsidies for selected EU member states. Countries which are already close to the 5.75% blending target show the lowest subsidy while others like France or the UK require high subsidies to meet the envisaged blending target by 2010. It becomes also clear that under higher crude oil prices this picture changes significantly. In figure 1.12 the resulting subsidies on bio-fuel crops as an intermediate input for the petroleum industry will become much smaller, if the crude oil price increase is stronger-as under the biofuel-directive scenario.

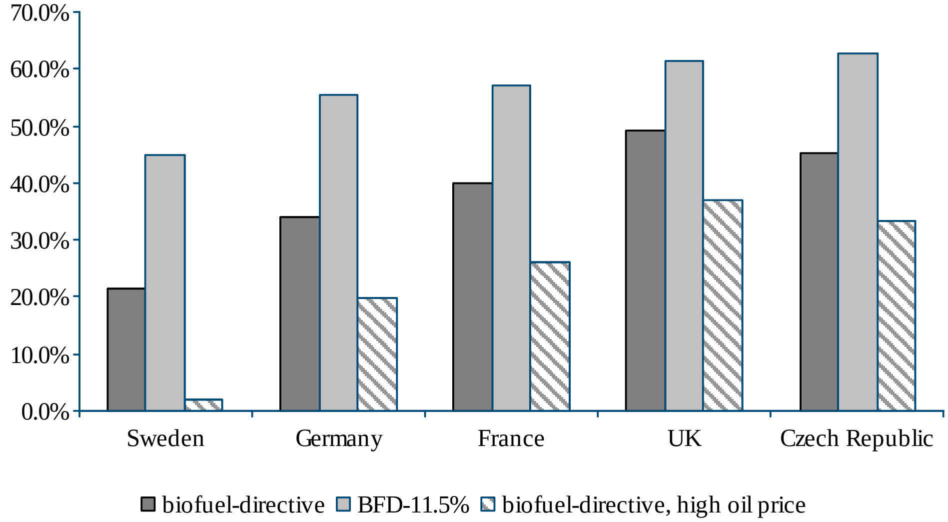

Figure 1.12 Subsidy levels for biofuel crops required to meet the BFD target, in % of global market value, 2010

2. Methodology

The methodology has two components, both focusing on potential biobased products and their markets. The first is data compilation and analysis; the focus here is on existing products. The second is an estimation of the potential use of biobased material; the focus here is both on existing product categories and on the range of novel products. From these two approaches it is possible to assess the potential market demand, market penetration and market value of biobased products.

In order to benefit from a comprehensive inventory of products, the tat statistical series for manufactured goods has been used as the data source. The data from tat are organised by product categories structurally related to market sectors, which facilitates the screening of some 4,000 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.

The decision to use tat data on manufactured goods is based on two premises: that the tat data set would provide the most exhaustive and consistent data available; and that, as an economic area, the EU-25 group of countries is representative of the global market potential for biobased goods, and giving at the same time an adequate perspective on the respective place of The Netherlands within this market.

tat 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: tat (1996).

The NACE classification is currently organised into 60 Divisions, 222 Groups and 503 Classes. The analysis for this study began with a preliminary identification of 936 potentially biobased products in 26 classes (avoiding all classes that are related to food or feed) within 8 divisions (leaving aside the number of the intermediate groups as sometimes the NACE root for a set of individual products has been given at the level of a group rather than at the level of a specific class within a group).

This first round of identification of potentially biobased products went through further screening 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, 780 products are retained for further analysis.

In order to organise the products into internally consistent groupings, two layers of sieving have been carried out. The first is by production process. Here, 6 types of production process have been identified (figure 2.1; described in Bos and van Rees, 2004). Of these 6, the last three are directly relevant for the manufactured products contained within the tat listing.

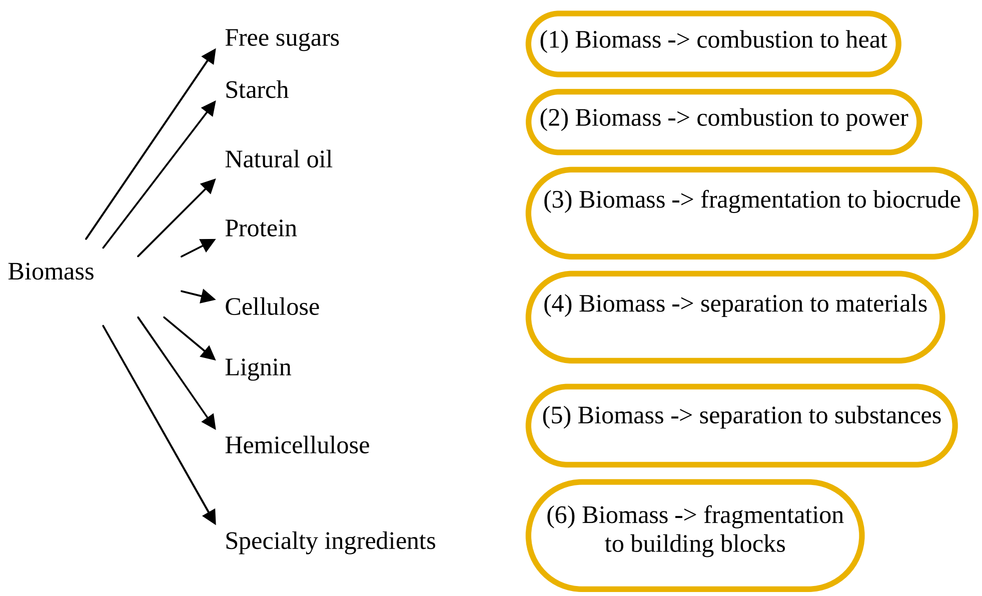

Figure 2.1 Resources and processes underlying a biobased economy

The products are also identified by 'families', which are logical clusters such as 'fabrics' and 'polymers', etcetera, that have a similarity in their use. The composite framework for the families of products are given in table 2.1, arranged according to the production process involved. It is readily apparent that some families are divided over all three types of production process related to manufactured goods, which is a reflection of the difficulty to establish a typology with mutually exclusive parameters. On the other hand, this situation is an indication of the complexity behind any analysis in the domain of the biobased economy beginning with the basic question of what exactly falls within the boundaries of the subject and how to delineate the subject matter. The literature search has not found a commonly recognised systematic treatment of the subject, which in itself is a conclusion that supports the type of systematisation undertaken within this study.

Separation to materials (type 4)	Separation to substances (type 5)	Fragmentation to building blocks (type 6)
Biomass	Biodiesel	Additives
Chemicals	Chemicals	Agrochemicals
Fabrics	Cosmetics	Base chemicals
Fibres	Glue	Bioethanol
Free sugars	Lubricants	Chemicals
Lignocellulose	Oils and fats	Cosmetics
Oils and fats	Paints and inks	Enzymes
Pharma and neutraceuticals	Pharma and neutraceuticals	Fabrics
Proteins	Polymers	Fibres
Pulp and paper	Pulp and paper	Paints and inks
Skins and leather	Solvents and detergents	Pharma and neutraceuticals
Starch		Polymers
Wood and ligneous materials		

Figure 2.2 Product families organised by production process (types 4, 5 and 6)

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 etcetera) 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 etcetera) and can these be obtained from a bio-based origin?

As an example, consider a process for the production of a chemical *X*. It starts with ethylene and has 4 subsequent steps: 2 are thermal conversions, 1 is an oxidation and 1 uses chlorine (5 factors). From this, the starting material can be replaced and 3 steps may be considered bio-derived (the step using chlorine can not be replaced), thus it is estimated that perhaps 4 factors could be bio-derived and so approximately 80% of the process could be bio-derived. Since no doubt there may be a catalyst used, etcetera, the percentage bio-derived will be a little lower, but since catalysts improve efficiency, are re-used, etcetera, they are currently not considered.

Where processes were not known this approach could not be adopted. Thus the weighting was done so that if halogens, salts and other inorganic species were present then the percentage substitution was low, otherwise the percentage was mid to low (depending on complexity of product the more complex the product is, it is assumed that there are more steps and more reagents required and so lower amounts of substitution are possible).

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

- a large percentage 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, etcetera, 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.

3. Results and interpretation

A first analysis is made for each family of product according to production process. This gives a basic understanding of the size and value of the biobased component of the market, the potential expansion of this biobased market, and (often to a lesser degree) the relative situation of The Netherlands within the current situation; from this, a conclusion can sometimes be drawn about the priority to be given within The Netherlands to each market segment. A synthesis is made for each type of production process. (The product data table is appended.)

3.1 Product production type 4: Biomass separation to materials

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 EU-25 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 EU-25. With an average value of 0.43 € per kg for a total market of 94 million , it is a mature product without much prospect for future development;

Fabrics 21 items:

- these are the traditional fabrics, made from cotton, carded wool, silk, flax, and hemp. The total EU-25 market is almost 9.5 billion . The data for NL is given as being confidential. Only certain companies with high value-added products remain in The Netherlands; but these have growth potential;

Fibres 29 items:

- the fibres included here are all of natural origin (cotton, silk, wool, etcetera). The EU-25 volume is slightly over 2.1 million tonnes per year, with a value of nearly 6 billion . Growth is possible here, especially with regard to potential substitution in products in type 6 that would have similar uses;

Free sugars 10 items:

- already a fully biobased market, the non-food and non-feed applications are on the order of 10% of total production. Not enough information is available to give an appreciation of the market share of The Netherlands. But sugar is a 'new' platform chemical for products in type 6; there is the presence of the sugar beet industry in The Netherlands, represented, *inter alia*, by Cosun and CSM (Purac);

Lignocellulose 1 item:

- this item refers to beet-pulp: bagasse and other sugar manufacturing waste, representing nearly 1 billion 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 2^{nd} generation bio-refineries;

Oils and fats 18 items:

- these 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. Where figures are given for volume and value, The Netherlands has a very strong market position, between 30-50% for individual items at the EU-25 level;

Pharma and neutraceuticals 13 items:

- this 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 . The exact figure is difficult to determine, considering that some of the data, such as for vitamin B12, is confidential. Specific data for The Netherlands is not given. It is possible to assume that there is potential for development because firms such as DSM, Organon and food companies have a current orientation towards the neutraceuticals market;

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 per year. The Netherlands assures about 20% of annual production by volume, and receives a corresponding part in value;

Pulp and paper 124 items:

- although not all individual product volumes and values are given, this very large industrial sector represents more than 135 billion in annual sales value, of which 70% is biobased, and an additional 20% could be. The figures given indicate that The Netherlands already is well placed in this market, with nearly 3% by volume and more than 5% by value, showing that it is present in the higher value-added segment of the market. It is possible, therefore, that The Netherlands could figure in a proportionally larger part of the potential biobased component substitution in this market, for a total EU-25 product value of some 27 billion ;

Skins and 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);

Starch 7 items:

- little more than 30% of the use of starch is for non-food, non-feed purposes, representing a slightly over 2 billion tonnes of annual production and 1 billion of market value. As not all the figures for The Netherlands are given, one can assume that the country holds a disproportionately large part of the EU market already, with about 20% of market share noted. Starch is a very important platform for the development of the bio-economy;

Wood and ligneous materials: 77 items:

- a large market sector in terms of quantity of products that are by nature biobased, the figures given do not allow an assessment of the market share of The Netherlands, neither in volume nor in value. The EU-25 market value is some 68 billion , of which over 80% is biobased and more than 95% could be. It could be worthwhile to more fully explore the potential of The Netherlands to figure in this market evolution, as it represents some 10 billion of product value at the EU-25 level. 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.

Table 3.1 Synthesis table for production type 4

Separation to materials	Number of items	% item values recorded	Total value for EU-25 a) (thousand €)	Actual biobased value b) (thousand €)	Potential bio-based value b) (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
Free sugars	10	80	15,606,826	1,560,683	1,560,683
Lignocellulose	1	100	544,890	27,244	27,244
Oils and fats	18	80	10,268,743		
Pharma and neutraceuticals	13	69	2,209,266	1,934,784	2,209,266
Proteins	2	50	348,283	104,485	104,485
Pulp and paper	124	78	136,642,951	95,650,066	122,978,656
Skins and leather	19	26	1,346,874	1,259,538	1,303,206
Starch	7	86	2,666,614	1,026,981	1,026,981
Wood and ligneous materials	77	79	68,104,970	55,510,555	65,586,087
Totals	323	78	253,211,353	172,417,515	210,268,544

a) For known figures; b) Based on expert judgement of the non-food, non-feed component.

Conclusions:

- basically, this product production type is a well-developed biobased resource user, representing 323 items;
- some improvement can be made in the percentage of biobased components, basically in the pulp and paper sector and, secondarily, in the wood and related items sector;
- The Netherlands is well integrated into the food-related sectors, such as free sugars, proteins and starch; for a higher value-added sector such as pharma and neutraceuticals, there is not enough information available;
- it is likely that The Netherlands could have a positive influence, because of its process-engineering experience, for increasing the share of the biobased composition in the pulp, paper and wood-related industries, with a potential market value of some 37 billion for the products concerned.

3.2 Product production type 5: Biomass separation to substances

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%. The Netherlands contributes 2% to the total EU-25 output, and it is to be assumed that this part can increase.

Chemicals 5 items:

- two of the items are glycerol based, a co-product of biodiesel production. The total volume involved for the 5 items is about 800,000 tonnes. EU-25 values are given for only 2 of the items, and the data for The Netherlands is indicated as confidential. All that can be stated is that the percentage of biobased components used within this product family can almost double; there is considerable potential to substitute for products - or product components -now in type 6.

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%, for a range of products that are largely biobased already. Two product-related values are given for The Netherlands, but these by themselves suggest that the market presence is limited, which is not necessarily the case. Here there is potential to substitute for products-or product components-now in type 6. The interest of a major firm such as Unilever is to be noted.

Glue 7 items:

- although the figures are not completely given, certain calculations can be made which show that, on the one hand, The Netherlands has almost the complete production of an item such as 'prepared glues and other prepared adhesives', on the other hand it has only 6% of the production of 'gelatin and its derivatives'. This would suggest that there is an industrial strategy towards being present in the higher end of the value-added spectrum. It is to be noted that the percentage of biobased components can increase from a level of 70 to 90% throughout this product family. Some items in the 'glue' family could also be applied within the type 6 production process.

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. Although few numbers are available for The Netherlands concerning the market part in either volume or value, the figures for two items suggest only a modest involvement in this market sector, at least as concerns the biobased part. This market sector is not small-3,5 billion tonnes worth more than 5 billion -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 and fats 3 items:

- these oils and fats are basically wood-related (ie, resin based). The known part of the market share for The Netherland is 25% by volume and 29% by value.

Paints and inks 21 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 90-100% in many cases. The share of The Netherlands in this market varies, and is currently about 25% for one item; there is good market presence for other items, so a change in processing to be more biobased would have sizable repercussions for Dutch producers.

Pharm and neutraceuticals 1 item:

- this item concerns prepared culture medium for development of micro-organisms. The part of The Netherlands seems to be negligible, within an EU-25 market of less than 200 million for less than ten thousand tonnes of annual production.

Polymers 9 items:

- these items are largely cellulose based products. The part of the market of The Netherlands is confidential-except for one item with 9% of market volume indicated-as are the EU-25 figures for the volumes of 2 items and the value for another 4 items. These products are already fully biobased, and the demand for them could expand.

Pulp and paper 10 items:

- although some EU-25 volume figures are missing (and all as regards The Netherlands), the value figures are totally absent with one exception. In this case, The Netherlands has less than 2%. Although this could indicate a generally negligible presence in a market involving some 26 million tonnes of output, the interest within The Netherlands should be substantial as these are high added value cellulosic products.

Solvents and detergents 16 items:

- although all figures are not available for market volume and value at the EU-25 level-and even less for The Netherlands-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 accruing to The Netherlands is 6% of a little more than 6 billion for EU-25 as a whole. The presence of Unilever indicates a high level of capacity in product process development that could be oriented to more biobased standards.

Table 3.2 Synthesis table for production type 5

Separation to substances	Number of items	% item values recorded	Total value for EU-25 a) (thousand €)	Actual biobased value b) (thousand €)	Potential bio-based value b) (thousand €)
Biodiesel	1	100	6,647,825	4,653,477	6,315,433
Chemicals	5	40	386.,07	281,436	366,801
Cosmetics	11	24	2,428,273	1,214,136	1,699,791
Glue	7	86	1,286,205	900,344	1,157,585
Lubricants	17	76	5,344,504	2,857,958	3,982,408
Oils and fats	3	67	407,932	406,251	406,251
Paints	21	86	17,721,451	3,738,348	15,473,848
Pharma and neutraceuticals	1	100	195,915	97,958	137,141
Polymers	9	56	4,236,910	2,118,455	2,118,455
Pulp and paper	10	10	3,023,858	2,872,665	2,872,665
Solvents and detergents	16	50	6,241,165	4,012,976	4,012,976
Totals	101	60	49,670,228	23,154,004	38,543,354

a) For known figures; b) Based on expert judgement of the non-food, non-feed component.

Conclusions:

- within the product range of this production process type, there is in general the possibility to further develop the part of biobased components by some 30%. The estimated increased biobased value for the products involved is 15 billion within EU-25;
- some of this expansion in the biobased composition of products might also penetrate into the product range now associated with production process type 6. Whether this would be through simple substitution or rather through the development of novel products remains to be determined;
- The Netherlands already has a disproportionately large part within some product families such as 'glue' and 'oils and fats', which seem to be (a) associated with agricultural competence and (b) for those particular products having a relatively higher value-added character;
- the market share of The Netherlands in products having a relatively higher value-added character may also be the case for 'polymers' and 'solvents and detergents', but not enough specific data for The Netherlands is available to draw a conclusion. With regard to these product families, although the biobased composition may not change, growth in overall demand is likely;

- although no conclusion can be drawn from the data with regard to the 'chemicals' product family, it would be surprising that The Netherlands is not already well represented in this market sector, even if the total output-in volume and in value-of this production process type is relatively small. For some products, an increase in the part of the biobased component can be as much as 20%;
- it is surprising that the relative share of The Netherlands in EU-25 biodiesel production is 2% considering the industrial knowledge and the port facilities available, this situation could change substantially (there is no necessary dependence on national production of the appropriate feedstocks).

3.3 Product production type 6: Biomass fragmentation to building blocks

Additives 41 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 1,3 billion tonnes, so more than a billion tonnes of biobased components could be involved, a gigantic substitution from the perspective of the actual 90 million tonnes. The one volume figure and the one value figure both reveal a 10% market share of The Netherlands for these two products, but a generalisation from this data would be unfounded. There is no basis for estimating the total EU-25 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. All the production data for The Netherlands is confidential, and no market values are given, even for EU-25.

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%. In terms of production, for the one item where the part of The Netherlands is given, this is equal to 23%. No values are given for this family.

Bioethanol 1 item:

the part of The Netherlands in the production of bioethanol in 2005 is an insignificant part within the EU-25 total production. As with biodiesel, the capacity to produce biofuels in The Netherlands is certainly very high.

Chemicals 131 items:

a large product family, in which the contribution of biobased components is already 80% for 10 items, but currently 0% for the rest. The capacity for a substitution by biobased 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 EU-25 volume of production is more than 140 billion tonnes, of which almost a 100 billion 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 EU-25 level: only for two items. The values, however, are given for eight, amounting to more than 10 billion in total. For the two items for which the values accrued by The Netherlands are given, these are 1,4 and 5,7% of the respective EU-25 values. The market value for the biobased components could double and be above 5 billion .

Enzymes 1 item:

The Netherlands produced 0,3% of the 2005 production of enzymes within EU-25, 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 for the EU-25 output.

Fabrics 17 items:

although currently most of the 6.9 billion tonnes of annual production is not biobased, the potential is for more than half (3.7 billion tonnes) to be so. The market value is about 12 billion , of which about a sixth is already for biobased components. The current position of The Netherlands in this market area is impossible to determine with the volume and value figures available.

Fibres 37 items:

this product family, representing some 3.8 billion 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 , of which 2.5 billion could be for biobased components.

Paints and inks 2 items:

the part of market volume for The Netherlands is 4% for one item and 9% for the other. These are both 30% biobased and could be 70%. A comparison of unit prices for the first item reveals that The Netherlands is a very competitive producer. The current EU-25 production level is just above one million tonnes.

Pharma and 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 actually revealed. The four figures available allowing to compare part of The Netherlands with EU-25 can not be considered as indicative. 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 billion tonnes. In the few cases where volume figures are given for both The Netherlands and EU-25, the market share of The Netherlands ranges from 2 to 38%, with two values at about 10%. This is circumstantial evidence that suggests a proportionately larger presence within this market area. Although only three items currently have biobased components, the potential for the others ranges between 20 and 80%. A big future market is expected.

Table 3.3 Synthesis table for production type 6

Fragmentation to building blocks	Number of items	% item values recorded	Total value for EU-25 a) (thousand €)	Actual biobased value b) (thousand €)	Potential bio-based value b) (thousand €)
Additives	41	39	6,702,867	99,997	6,026,698
Agrochemicals	4	0			
Base chemicals	2	0			
Bioethanol	1	100	354,746	283,797	354,746
Chemicals	131	7	2,039,661	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	17	88	8,307,865	1,921,229	5,114,547
Fibres	37	81	9,704,653	0	4,269,021
Paints and inks	2	50	558,556	167,567	390,989
Pharma and neutraceuticals	68	56	116,342,729	28,375,266	58,695,086
Polymers	43	0			
Totals	356	33	155,235,368	34,451,552	81,640,191

a) For known figures; b) Based on expert judgement of the non-food, non-feed component.

Conclusions:

- the apparent low level of information in fact only applies with regard to the values for certain unit groupings within three product families (see table 3.3), and with regard to volume in a single unit grouping within one product family. Thus it is possible to focus any future research very easily; and the current conclusions have enough support from the remaining information to retain their validity;
- most of the product families are currently in the situation of having enormous potential to substitute biobased components in their production process;
- if this were to occur, the value of the biobased production could effectively more than double, on the order of 40 billion (as a minimum);
- it is probable that products from production process type 5 will replace quite a number of products in type 6, either through substitution (a price-dependent shift) or through the development of novel products (a technology-dependent shift);
- it is probable that The Netherlands is well placed to both invest in such process-related substitution and to capture a relatively large portion of the ensuing benefits. This is especially the case if the process-related substitution also brings savings in

unit price, through a simplification of the production process (reducing the number of steps; see Scott, Peter and Sanders, 2007);
- it is to be expected that the market share of The Netherlands for bioethanol would increase.

3.4 Overview of biobased production potential

Conclusions:
- there is a theoretical potential for a substantial number of industrial products, which are not directly part of the food and feed market sectors, to underpin a biobased economy (see table 3.4);
- the estimated value at present of the part of biobased components in these industrial products is on the order of 245 billion , compared to 460 billion for food (not including beverages) and feed, as recorded for the annual output of EU-25 manufacturing goods in 2005;
- the largest group of product families (production type 6) is by nature closely related to the knowledge base used in the chemical industry; this is an area in which The Netherlands is highly competent;
- almost all of the product families are already well represented in the economy of The Netherlands;
- although the figures presented are indicative of the real situation with regard to the biobased economy, the lack of data-especially at the national level-means that more precise information has to be collected for the product families;
- it should be kept in mind that with regard to individual products themselves, although substitution of biobased components is in many cases possible-and may prove economically advantageous-these products may eventually be replaced by the development of novel products; this would be a logical consequence of further research into biobased materials

Table 3.4 Overview of biobased production values

	Number of items	% item values recorded	Total value for EU-25 a) (thousand €)	Actual biobased value b) (thousand €)	Potential bio-based value b) (thousand €)
Production type 4*:* Biomass separated to materials	323	78	250,585,486	187,714,799	211,567,228
Production type 5: Biomass separated to substances	101	60	47,920,145	23,154,004	38,543,354
Production type 6: Biomass fragmented to building blocks	356	33	155,235,368	34,451,552	81,640,191
Totals	780	55	453,741,000	245,320,355	331,750,773

a) For known figures; b) Based on expert judgement of the non-food, non-feed component.

Table 3.5 Synthesis of values for EU-25, by product family and by product type.

	# items	# values	% values	Total value of products	Actual bbm value	% t_v	Potential bbm value	% t_v
Biomass	1	0	0	N/A	-	-	-	-
Chemicals	1	1	100	94,320	94,320	100	94,320	100
Fabrics	21	21	100	9,469,465	9,340,708	99	15,377,616	100
Fibres	29	29	100	5,908,151	5,908,151	100	5,908,151	100
Free sugars	10	8	80	15,606,826	1,560,683	10	1,560,683	10
Lignocellulose	1	1	100	544,890	27,244	5	27,244	5
Oils and fats	18	14	78	7,642,876	1,298,684	17	1,298,684	17
Pharma and neutraceuticals	13	9	69	2,209,266	15,933,384	88	2,209,266	100
Proteins	2	1	50	348,283	104,485	30	104,485	30
Pulp and paper	124	96	77	136,642,951	95,650,065	70	122,978,656	90
Skins and leather	19	5	26	1,346,874	1,259,539	94	1,303,206	97
Starch	7	6	86	2,666,614	1,026,981	39	1,026,981	39
Wood and ligneous materials	77	61	79	68,104,970	55,510,555	82	65,586,087	96
Totals type 4	323	252	78	250,585,486	187,714,799	69	211,567,228	84
Biodiesel	1	1	100	6,647,825	4,653,477	70	6,315,433	95
Chemicals	5	2	40	386,107	281,436	73	366,801	95
Cosmetics	11	4	36	2,428,273	1,214,136	50	1,699,791	70
Glue	7	6	86	1,286,205	900,344	70	1,157,585	90
Lubricants	17	13	76	5,344,504	2,857,958	53	3,982,408	75
Oils and fats	3	2	67	407,932	406,251	100	406,251	100
Paints and inks	21	18	86	17,721,451	3,738,348	21	15,473,848	87
Pharma and neutraceuticals	1	1	100	195,915	97,958	50	137,141	70
Polymers	9	5	56	4,236,910	2,118,455	50	2,118,455	50
Pulp and paper	10	1	10	3,023,858	2,872,665	95	2,872,665	95
Solvents and detergents	16	8	50	6,241,165	4,012,976	64	4,012,976	64
Totals type 5	101	61	60	47,920,145	23,154,004	48	38,543,354	80

Table 3.5 Synthesis of values for EU-25, by product family and by product type (continue)

	# items	# values	% values	Total value of products	Actual bbm value	% t_v	Potential bbm value	% t_v
Additives	41	16	39	6,702,867	99,997	1	6,026,698	90
Base chemicals	2	0	0	N/A	-	-	-	-
Bioethanol	1	1	100	354,746	283,797	80	354,746	100
Chemicals	131	9	7	2,039,661	229,196	11	710,110	35
Cosmetics	9	8	89	10,290,596	2,627,543	26	5,145,298	50
Enzymes	1	1	100	933,696	746,957	80	933,696	100
Fabrics	17	15	88	8,307,865	1,921,229	23	5,114,547	62
Fibres	37	30	81	9,704,653	0	0	4,269,021	44
Paints and inks	2	1	50	558,556	167,567	30	390,989	70
Pharma and neutraceuticals	68	38	56	116,342,729	28,375,266	24	58,695,086	50
Polymers	43	0	0	N/A	-	-	-	-
Totals type 6	356	119	33	155,235,369	34,451,552	22	81,640,191	53
Grand totals	780	432	55%	453,741,000	245,320,355	51	331,750,773	73

bbm = biobased material

N/A = data not available

- = no calculation possible

% t_v = percentage of total value

Table 3.6 Synthesis of type 4 Volumes and Values for EU-25 extrapolated to 100%.

	# items	# data	% data	Total	Extrapolated tot	Actual b-b	Extrapolated act	Potential b-b	Extrapolated pot
Biomass									
- volume (000s kg)	1	1	100	2,713,679	2.713.679	2,713,679	2,713,679	2.713.679	2,713,679
- value (000s)	1	0	0						
Chemicals									
- volume (000s kg)	1	1	100	221,808	221.808	221,808	221,808	221.808	221,808
- value (000s €)	1	1	100	94,320	94.320	94,320	94,320	94.320	94,320
Fabrics									
- volume (000s m²)	21	20	95	4,342,794	4.559.934	4,304,895	4,520,140	4.342.794	4,559,934
- value (000s €)	21	21	100	9,469,465	9.469.465	9,340,708	9,340,708	9.469.465	9,469,465
Fibres									
- volume (000s kg)	29	27	93	2,104,957	2.260.880	2,104,957	2,260,880	2.104.957	2,260,880
- value (000s €)	29	29	100	5,908,151	5.908.151	5,908,151	5,908,151	5.908.151	5,908,151
Free sugars									
- volume (000s kg)	10	9	90	31,455,202	34.950.224	3,17,244	3,532,493	3.179.244	3,532,493
- value (000s €)	10	8	80	15,606,826	19.508.533	1,560,683	1,950,854	1.560.683	1,950,854
Lignocellulose									
- volume (000s kg)	1	1	100	9,586,641	9.586.641	479,332	479,332	479.332	479,332
- value (000s €)	1	1	100	544,890	544.890	27,244	27,244	27.244	27,244
Olis and fats									
- volume (000s kg)	18	14	78	12,098,051	15.554.637	2,171,735	2,792,231	2.171.735	2,792,231
- value (000s €)	18	14	78	7,642,876	9.826.555	1,298,684	1,669,737	1.298.684	1,669,737
Pharma and neutraceuticals									
- volume (000s g)	1	1	100	9,148	9.148	9,148	9,148	9.148	9,148
- value (000s €)	1	1	100	379,384	379.384	379,384	379,384	379.384	379,384
- volume (unit?)	12	0	0						
- value (000s €)	12	8	67	1,829,882	2.744.823	15,554,000	23,331,000	1.829.882	2,744,823

Table 3.6 Synthesis of type 4 Volumes and Values for EU-25 extrapolated to 100% (continue)

	# items	# data	% data	Total	Extrapolated tot	Actual b-b	Extrapolated act	Potential b-b	Extrapolated pot
Proteins									
- volume (000s kg)	2	1	50	472,686	945,372	141,806	283,612	90,089	180,178
- value (000s €)	2	1	50	348,283	696,566	104,485	208,970	104,485	208,970
Pulp and paper									
- volume (000s g)	105	86	82	131,820,836	160,944,044	92,274,585	112,660,831	118,638,752	144,849,639
- value (000s €)	105	86	82	113,245,386	138,264,715	79,271,770	96,785,301	101,920,847	124,438,243
- volume (000s kg 90% std)	4	2	50	10,185,898	20,371,796	7,130,129	14,260,258	9,167,308	18,334,616
- value (000s €)	4	0	0						
- volume (000s m²)	1	1	100	756	756	529	529	680	680
- value (000s €)	1	1	100	14,412	14,412	10,088	10,088	12,971	12,971
- volume (000s p/st)	8	5	63	4,397,889	7,036,622	3,078,522	4,925,635	3,958,100	6,332,960
- value (000s €)	8	6	75	22,292,909	29,723,879	15,605,036	20,806,715	20,063,618	26,751,491
- volume (unit?)	6	0	0						
- value (000s €)	6	3	50	1,090,244	2,180,488	763,171	1,526,342	981,220	1,962,440
Skins and leather									
- volume (000s kg)	7	3	43	1,329,785	3,102,832	1,329,785	3,102,832	1,329,785	3,102,832
- value (000s €)	7	0	0						
- volume (000s m²)	7	5	71	195,276	273,386	177,288	248,203	186,282	260,795
- value (000s €)	7	1	14	847,074	5,929,518	847,074	5,929,518	847,074	5,929,518
- volume (000s p/st)	1	1	100	58,003	58,003	58,003	58,003	58,003	58,003
- value (000s €)	1	1	100	136,909	136,909	136,909	136,909	136,909	136,909
- volume (unit?)	4	0	0						
- value (000s €)	4	3	75	362,891	483,855	275,556	367,408	319,223	425,631
Starch									
- volume (000s kg)	7	5	71	5,889,691	8,245,567	2,135,697	2,989,976	2,135,697	2,989,976
- value (000s €)	7	6	86	2,666,614	3,111,050	1,026,981	1,198,145	1,026,981	1,198,145

Table 3.6 Synthesis of type 4 Volumes and Values for EU-25 extrapolated to 100% (continue)

	# items	# data	% data	Total	Extrapolated tot	Actual b-b	Extrapolated act	Potential b-b	Extrapolated pot
Wood and ligneous materials									
- volume (000s kg)	29	21	72	48,433,137	66,883,856	48,432,561	66,883,060	48,433,022	66,883,697
- value (000s €)	29	20	69	11,028,775	15,991,724	11,027,326	15,989,623	11,028,485	15,991,303
- volume (000s m)	1	1	100	418,959	418,959	418,959	418,959	418,959	418,959
- value (000s €)	1	1	100	731,486	731,486	731,486	731,486	731,486	731,486
- volume (000s m^2)	12	10	83	2,023,706	2,428,447	1,087,446	1,304,935	1,836,454	2,203,745
- value (000s €)	12	10	83	7,388,003	8,865,604	4.,999,278	5,999,134	6,910,258	8,292,310
- volume (000s m^3)	27	25	93	131,022	141,504	91,652	98,984	123,148	133,000
- value (000s €)	27	24	89	21,355,780	24,025,253	14,930,148	16,796,417	20,070,653	22,579,485
- volume (000s p/st)	4	4	100	840,396	840,396	783,352	783,352	828,987	828,987
- value (000s €)	4	3	75	17,069,797	22,759,729	13,437,966	17,917,288	16,343,431	21,791,241
- volume (unit?)	4	0	0						
- value (000s €)	4	3	75	10,531,130	14,041,507	10,384,351	13,845,801	10,501,774	14,002,365
Totals type 4									
- value (000s €)	323	252	78	250,585,487	315,432,814	187,714,799	240,950,540	211,567,228	266,696,485
Totals type 4 (extrapolated)									
- value (000s €)	323	252	78	250,585,487	321,186,954	187,714,799	240,602,699	211,567,228	271,175,455

Legend: g = gram; kg = kilogram; kg 90% std = kilogram of substance 90% dry; m = metre; m² = square metre; m³ = cubic metre; p/st = number of items; unit? = no unit given.

Note for tables 3.6, 3.7 and 3.8: The extrapolation to 100% undertaken can only serve as a means to establish the order of magnitude for potential values, which need to be verified by further research. This method of analysis also indicates the likely importance of the missing values.

Guide for reading tables 3.6, 3.7 and 3.8: All numbers in yellow cells are the result of extrapolation to 100%. When the numbers related to values are added-which is not done with regard to volumes-then their totals (for each production type) are treated as 'normal' numbers (therefore presented in white cells). For the sake of comparison, the totals for the *non*-extrapolated values are also extrapolated to 100% in function of the percentage of the number of values given within each production type as a whole; the results, in the last line of the tables, are also in yellow cells.

Table 3.7 Synthesis of type 5 Volumes and Values for EU-25 extrapolated to 100%

	# items	# data	% data	total	Extrapolated tot	Actual b-b	Extrapolated act	Potential b-b	Extrapolated pot
Biodiesel									
- volume (000s kg)	1	1	100	13,955,847	13,955,847	9,769,093	9,769,093	13,258,055	13,258,055
- value (000s €)	1	1	100	6,647,825	6,647,825	4,653,477	4,653,477	6,315,433	6,315,433
Chemicals									
- volume (000s kg)	5	4	80	157,762	197,203	47,328	59,160	157,762	197,203
- value (000s €)	5	2	40	386,107	965,268	281,436	703,590	366,801	917,003
Cosmetics									
- volume (000s kg)	5	2	40	165,173	412,933	148,655	371,638	156,914	392,285
- value (000s €)	5	0	0						
- volume (unit?)	6	0	0						
- value (000s €)	6	4	67	2,428,273	3,642,410	1,214,136	1,821,204	1,699,791	2,549,687
Glue									
- volume (000s kg)	7	6	86	339,159	395,686	237,411	276,980	305,243	356,117
- value (000s €)	7	6	86	1,286,205	1,500,573	900,344	1,050,401	1,157,585	1,350,516
Lubricants									
- volume (000s kg)	17	12	71	3,550,183	5,029,426	1,835,452	2,600,224	2,595,440	3,676,873
- value (000s €)	17	13	76	5,344,504	6,988,967	2,857,958	3,737,330	3,982,408	5,207,764
Oils and fats									
- volume (000s kg)	3	2	67	407,716	611,574	403,878	605,817	403,878	605,817
- value (000s €)	3	2	67	407,932	611,898	406,251	609,377	406,251	609,377
Paints and inks									
- volume (000s kg)	21	19	90	10,111,040	11,175,360	2,153,473	2,380,154	8,858,273	9,790,723
- value (000s €)	21	18	86	17,721,451	20,675,026	3,738,348	4,361,406	15,473,848	18,052,823
Pharma and neutraceuticals									
- volume (000s kg)	1	0	0						
- value (000s €)	1	1	100	195,915	195,915	97,958	97,958	137,141	137,141

Table 3.7 Synthesis of type 5 Volumes and Values for EU-25 extrapolated to 100% (continue)

	# items	# data	% data	Total	Extrapolated tot	Actual b-b	Extrapolated act	Potential b-b	Extrapolated pot
Polymers									
- volume (000s kg)	6	4	67	739,095	1,108,643	654,933	982,400	654,933	982,400
- value (000s €)	6	2	33	1,255,436	3,766,308	627,718	1,883,154	627,718	1,883,154
- volume (000s m²)	3	3	100	1,076,109	1,076,109	538,054	538,054	538,054	538,054
- value (000s €)	3	3	100	2,981,474	2,981,474	1,490,737	1,490,737	1,490,737	1,490,737
Pulp and paper									
- volume (000s kg 90% std)	9	6	67	26,005,106	39,007,659	24,704,851	37,057,277	24,704,851	37,057,277
- value (000s €)	9	0	0						
- volume (000s kg)	1	1	100	29,329	29,329	27,863	27,863	27,863	27,863
- value (000s €)	1	1	100	3,023,858	3,023,858	2,872,665	2,872,665	2,872,665	2,872,665
Solvents and detergents									
- volume (000s kg)	13	12	92	14,071,932	15,244,593	9,184,161	9,949,508	9,184,161	9,949,508
- value (000s €)	13	7	54	5,300,951	9,844,623	3,354,826	6,230,391	3,354,826	6,230,391
- volume (000s p/st)	1	1	100	1,030,257	1,030,257	721,180	721,180	721,180	721,180
- value (000s €)	1	1	100	940,214	940,214	658,150	658,150	658,150	658,150
- volume (unit?)	2	0	0						
- value (000s €)	2	0	0						
Totals type 5									
- value (000s €)	101	61	60	47,920,145	61,784,358	23,154,004	30,169,840	38,543,354	48,274,839
Totals type 5 (extrapolated)									
- value (000s €)	101	61	60	47,920,145	79,343,191	23,154,004	38,336,957	38,543,354	63,817,684

Legend: kg = kilogram; kg 90% std = kilogram of substance 90% dry; m² = square metre; p/st = number of items; unit? = no unit given.

Note for tables 3.6, 3.7 and 3.8: The extrapolation to 100% undertaken can only serve as a means to establish the order of magnitude for potential values, which need to be verified by further research. This method of analysis also indicates the likely importance of the missing values.

Guide for reading tables 3.6, 3.7 and 3.8: All numbers in yellow cells are the result of extrapolation to 100%. When the numbers related to values are added-which is not done with regard to volumes-then their totals (for each production type) are treated as 'normal' numbers (therefore presented in white cells). For the sake of comparison, the totals for the *non*-extrapolated values are also extrapolated to 100% in function of the percentage of the number of values given within each production type as a whole; the results, in the last line of the tables, are also in yellow cells.

Table 3.8 Synthesis of type 6 Volumes and Values for EU-25 extrapolated to 100%.

	# items	# data	% data	Total	Extrapolated tot	Actual b-b	Extrapolated act	Potential b-b	Extrapolated pot
Additives									
- volume (000s kg)	41	33	80	13,129,641	16,312,584	90.260	112,141	11,813,260	14,677,081
- value (000s)	41	16	39	6,702,867	17,176,097	99.997	256,242	6,026,698	15,443,414
Agrochemicals									
- volume (000s kg)	4	4	100	6,060,578	6,060,578	411.204	411,204	1,099,572	1,099,572
- value (000s €)	4	0	0						
Base chemicals									
- volume (000s kg)	1	1	100	11,251,338	11,251,338	0	0	11,251,338	11,251,338
- value (000s €)	1	0	0						
- volume (000s m³)	1	1	100	6,003,306	6,003,306	0	0	6,003,306	6,003,306
- value (000s €)	1	0	0						
Bioethanol									
- volume (000s kg)	1	1	100	950,000	950,000	760.000	760,000	950,000	950,000
- value (000s €)	1	1	100	354,746	354,746	283.797	283,797	354,746	354,746
Chemicals									
- volume (000s kg)	128	111	87	127,409,813	146,923,028	2.179.032	2,512,758	88,048,658	101,533,588
- value (000s €)	128	9	7	2,039,661	29,008,512	229.196	3,259,676	710,110	10,099,342
- volume (000s kg N)	3	3	100	13,563,041	13,563,041	0	0	10,841,577	10,841,577
- value (000s €)	3	0	0						
Cosmetics									
- volume (000s l)	9	2	22	98,349	442,571	49.174	221,283	49,174	221,283
- value (000s €)	9	8	89	10,290,596	11,576,921	2.627.543	2,955,986	5,145,298	5.788.460
Enzymes									
- volume (000s kg)	1	1	100	158,912	158,912	127.129	127,129	158,912	158,912
- value (000s €)	1	1	100	933,696	933,696	746.957	746,957	933,696	933,696
Fabrics									
- volume (000s m²)	17	14	82	5,708,152	6,931,327	566.576	687,985	3,137,364	3.809,656
- value (000s €)	17	15	88	8,307,865	9,415,580	1,921,229	2,177,393	5,114,547	5,796,487

Table 3.8 Synthesis of type 6 Volumes and Values for EU-25 extrapolated to 100%. (continue)

	# items	# data	% data	Total	Extrapolated tot	Actual b-b	Extrapolated act	Potential b-b	Extrapolated pot
Fibres									
- volume (000s kg)	37	32	86	4,902,415	5,668,417	0	0	2,300,162	2,659,562
- value (000s €)	37	30	81	9,704,653	11,969,072	0	0	4,269,021	5,265,126
Paints and inks									
- volume (000s kg)	2	2	100	1,274,099	1,274,099	382,230	382,230	891,869	891,869
- value (000s €)	2	1	50	558,556	1,117,112	167,567	335,134	390,989	781,978
Pharma and neutraceuticals									
- volume (000s g)	5	3	60	238,845	398,075	0	0	119,422	199,037
- value (000s €)	5	5	100	574,559	574,559	28,120	28,120	287,279	287,279
- volume (000s kg)	24	20	83	1,302,609	1,563,131	125,623	150,748	382,160	458,592
- value (000s €)	24	1	4	471,825	11,323,800	0	0	235,912	5,661,888
- volume (unit?)	39	0	0						
- value (000s €)	39	32	82	115,296,345	140,517,42(	28,347,146	34,548,084	58,171,894	70,896,996
Polymers									
- volume (000s kg)	43	37	86	70,375,672	81,787,943	365,878	425,210	1,312,558	1,525,405
- value (000s €)	43	0	0						
Totals type 6									
- value (000s €)	356	119	33	155,235,369	233,967,51:	34,451,552	44,591,390	81,640,190	121,309,411
Totals type 6 (extrapolated)									
- value (000s €)	356	119	33	155,235,369	464,401,60{	34,451,552	103,065,147	81,640,190	271,175,455

Legend: g = gram; kg = kilogram; kg N = kg nitrogen; l = litres; m² = square metre; m³ = cubic metre; unit? = no unit given.

Note for tables 3.6, 3.7 and 3.8: The extrapolation to 100% undertaken can only serve as a means to establish the order of magnitude for potential values, which need to be verified by further research. This method of analysis also indicates the likely importance of the missing values.

Guide for reading tables 3.6, 3.7 and 3.8: All numbers in yellow cells are the result of extrapolation to 100%. When the numbers related to values are added-which is not done with regard to volumes-then their totals (for each production type) are treated as 'normal' numbers (therefore presented in white cells). For the sake of comparison, the totals for the <u>non</u>-extrapolated values are also extrapolated to 100% in function of the percentage of the number of values given within each production type as a whole; the results, in the last line of the tables, are also in yellow cells.

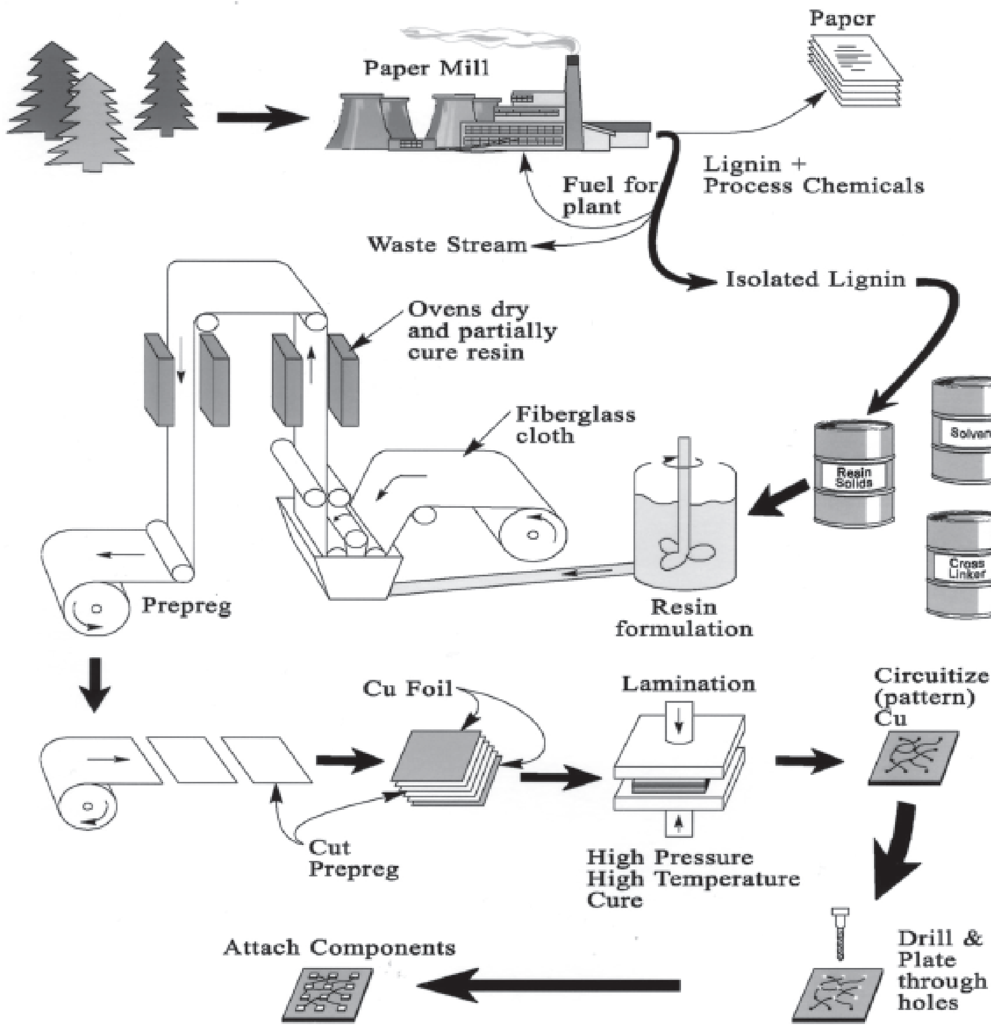

Figure 3.1 Use of a biobased material, lignin, in the electronics industry
Schematic representation of the process flow for production of printed wiring boards using lignin as a raw material. A comparison of the lignin-based resin and current resins via life-cycle assessment indicated up to 40% lower energy consumption for the biobased resin, as well as a financial advantage. The use of lignin in this way transforms a low-use residual material into a product for which there is a high-volume demand.
Source: Kosbar et al., 2001.

4. Additional perspectives

The methodological approach used to the produce data, and its analysis, covered in the preceding section makes two assumptions that would not necessarily hold up in the real development of the biobased economy. The first concerns the value of the share of the biobased components in the products. The interest in substitution of biobased components would primarily be the price factor, or at least the anticipation of a price advantage, and perhaps only secondarily the environmental considerations. This means that the resulting product would cost *less* to produce than currently, and would therefore have a *lower* value in the market. The second assumption is that biobased feedstocks are readily available, and at a lesser cost than petroleum-based feedstocks. Two points: (a) already the value of sugar is the same as crude oil (see table 1), and (b) the recent surge in demand for biofuels has already had a substantial impact on the commodity markets for cereals and oilseeds. If the biobased feedstock can not be a competitive substitute, then its use will only be possible because of mandatory incorporation into the production chain. This begs the issue of the availability of supplies in any case. But it also ignores the fact of scarcity: one day, and perhaps sooner than anticipated, there will simply be no more crude oil available. This is one of the reasons for conserving petroleum uses for those applications that can not be replaced by biobased components.

Accepting that there are certain limits to the results presented in section 4, but that these limits are recognised (and can be dealt with through a more targeted research), the purpose of this section is to present a perspective from the literature concerning both (a) the biobased feedstocks and (b) the production of biobased products as an industrial objective. In other words, the industrial objectives underpinning a biobased economy depend upon the possibility that the biological feedstocks can be adapted to a variety of uses, and that there is a use for the types of products that can be biobased. Both supply and demand has to enter into the equation.

The potential uses of renewable resources for industrial applications is one of the long-term European Union research objectives. Examples of major initiatives are the EPOBIO project under FP6[1] and Bio4EU[2]. But there are also several stakeholder groups promoting the use of biological resources: ERRMA (European Renewable Raw Materials Association)[3]; SusChem (European Technology Platform for Sustainable Chemistry)[4]; European Bioplastics[5]; and the Bioeconomy[6] web site.

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1 http://www.Europabio.org/
2 http://bio4eu.jrc.es/
3 http://www.errma.com/
4 http://www.suschem.org/
5 http://www.European-bioplastics.org/
6 http://www.bio-economy.net/centre3Europ.html

Of particular interest is BioMatNet[1], which is the activity of the EPOBIO project that makes available the results from RTD projects supported by the European Commission in the area of 'Biological Materials for Non-Food Products (Renewable Bioproducts)'. It includes final results from the Fifth Framework Programme (FP5), FAIR Programme (FP4) and previous programmes, as well as ongoing research from the Fifth and Sixth Framework Programmes (FP5 and FP6).

4.1 The adaptability of the biological resource base

The potential uses for specific arable crops can be extended from food and feed to industrial applications, and can even be specifically 'designed' for specific applications through bio-molecular engineering.

Examples of possible uses for sugar beet

Extended and novel uses for sugar beet
The use of the entire beet for industrial production of biofuels and other bioproducts would bypass the problems associated with sugar for human food production. It has also been suggested by the industry that even if co-products were present, aneasily accessible sugar fraction (perhaps only 20-30% of total) could be recovered at low cost and the sugar-rich residue (70-80% of total) used for fermentation Alternatively, the ratio between sugar and ethanol may be optimised according to the actual commodity prices. In this scenario, processing technology for co-products would have to be designed tailor-made for the particular chemical or polymer. (p 34)

Production of chemicals and biopolymers in beet A report being prepared by Platform Groene Grondstoffen (green raw materials); (http://www.senternovem.nl/energietransitie/groene_grondstoffen/index.asp) investigates the prospects of biomass production in the Netherlands for energy and platform chemicals. It concludes that amongst the various crops considered, sugar beet is especially promising due to its high biomass yield. While the CAP-reform has significantly reduced the profitability of sugar beet (in the Netherlands from €1,350 to €550 per hectare), new co-products such as amino acids or organic acids overproduced by GM-technology could restore profitability to the farmer to levels similar as before the CAP-reform. These new co-products (e.g. lysine or itaconic acid) would allow delivery of beet ethanol for prices between €0.28 and €0.35 L-1, and lysine for prices between €1,000 and € 530 t-1. (p 56).

Source: Jan B. van Beilen et al. (2007): Industrial Crop Platforms for the Production of Chemicals and Biopolymers

[1] http://www.biomatnet.org/home.html

4.2 Industrial objectives for biobased products

As described in figure 13 and table 4[1], there are three routes in which plants are adapted for use by industry for the preparation of biobased products. Although the production processes are different, they all have in common the 'principles of green chemistry', which entail: (1) renewables as chemical feedstocks, (2) substitution of hazardous chemicals, and (3) reduced consumption of chemicals and energy (Sjöström, 2006:130). Positioning products in the market with respect to these principles of green chemistry is, therefore, the first aspect, and is *process*-related.

A second aspect of the industrial objectives for biobased products is *technology*-related, and specifically is the development of the role of biotechnology, which is 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use' (Sjöström, 2006:134). An informal classification of the biotechnology industry in Europe is on the basis of colours:

- white biotechnology is the industrial use of biological processes (enzymes or organisms) to produce different products[2];
- red biotechnology is related to the biomedicine and/or healthcare sectors, for instance, pharma, gene therapy or genetic testing;
- green biotechnology is applied to agricultural processes, such as GM-seeds.

The third aspect of the industrial focus on biobased products is *feedstock*-related, namely reducing dependency upon petrochemicals, which are responsible for 90% of current organic chemical manufacturing. The price factor is the stimulus, as the volatility in crude oil prices can increase the unit price of products several fold; an example is phenol, which already tripled in price as early as 2004 (Clark, 2006: 17).

The box on the following page-with text coming from the manufacturer itself -is an example of how the industrial objectives for biobased products can be fulfilled in all three aspects, related to process, technology and feedstock. It also demonstrates that environmental protection (notably related to climate change) and sustainable economy arguments are considered as strong selling points. On the pages thereafter, a second box is a news report of the application of bioethanol to the production of polyethylene, the most important of the polymers used in the production of plastics, and a third box demonstrates the application of novel bioplastics to industrial-scale agriculture.

[1] Pages 22 and 23, respectively.

[2] In The Netherlands alone, a large part of the €49 billion annual turnover of the life sciences companies is related to white biotechnology, with an investment of € 950 million in research and the employment of 255,000 persons (Ministry of Economic Affairs, 2003).

Sanoh selected Arkema's Rilsan® PA11 for innovative partially zero emission vehicle (PZEV) multilayer fuel line

Sanoh Industrial Co., Ltd. (Sanoh), the leading Japanese Automotive components manufacturer, has established a new production technology for multi-layer fuel lines and commercializes this environmentally friendly solution for automotive multi-layer fuel lines.

This innovative new multilayer technology exhibits very high barrier properties leading to a significant reduction of the permeation of hydrocarbons, even when the gasoline contains ethanol. Compared to existing multilayer combining *polyamide 12* and *ETFE*, the permeation level is significantly lower as well as the cost.

Thanks to the combination of Arkema's *biobased Rilsan*® *PA11* with fuel barrier *PPS*, these new fuel lines including both conductive and non conductive types, comply with stringent Japanese Automotive standards.

Rilsan® *PA11* was chosen for its unique chemical resistance (sour gasoline resistance), cold impact resistance, as well as its pressure resistance and durability at high temperature. Global warming and other environmental concerns drive advances in the automotive industry to minimize the environmental impact of today's cars. Governmental regulations such as Californian Legislation or EURO 5 set restrictive limits for fuel and tailpipe emissions and are tightening towards zero emission levels. In order to comply with this stringent legislation, the fuel system is equipped with barrier materials to minimize the diffusion of the fuel through the fuel system. The combination of *Rilsan*® *PA11* with fuel barrier material *PPS* leads to a completely new multilayer construct opening its use in partial zero emission vehicles. In addition, the use of renewable source materials and fuels, such as biobased *Rilsan*® *PA11* and *biofuels*, can significantly reduce greenhouse gas emissions and dependence on fossil fuels. Recently, *Rilsan*® *PA11* Biodiesel grade won a European 2006 Bioplastic Award for its impressive compatibility with Biofuels and other aggressive fuels.

Arkema commercializes its patented multilayer fuel line technology under the brandname Rilperm® and offers a wide range of cost-effective multilayer structures to meet specific application and regional needs.

Arkema is committed to sustainable development by developing and marketing products for today's generations, and not at the expense of tomorrow's generations. The use of renewable source materials and fuels such as *biodiesel* and flexfuel combined with the use of biobased *Rilsan*® *PA11* can significantly reduce greenhouse gas emissions.

With global brands like *Rilsan*®, *Pebax*®, and Kynar® unique products like *Rilsan*® biobased *PA11*, and leading capacities in *Rilsan*® *PA11* and 12, Arkema's Technical Polymers business unit provides its customers with global coverage and superior regional service from production facilities and research sites in Europe, Asia, and the USA.

A global chemical player, Arkema consists of 3 coherent and related business segments: Vinyl Products, Industrial Chemicals, and Performance Products. Present in over 40 countries with 17,000 employees, Arkema achieved sales of 5.7 billion in 2006. With its 6 research centers in France, the United States and Japan, and internationally recognized brands, Arkema holds leadership positions in its principal markets.

Source: Arkema (Omnexus newsletter, July 10, 2007).

FO Licht's World Ethanol and Biofuels Report

Brazilian chemical company Braskem SA said it has produced the world's first polyethylene plastic made entirely of renewable raw materials in a bid to develop 'green' plastic for commercial markets. The petrochemical company, South America's largest, said it developed the plastic from ethanol made from sugarcane, reports Forbes.

US-listed shares of Braskem jumped more than 4% on the news, nearing their 52-week high of USD18.73, reached in early May. Chief Executive Jose Carlos Grubisich said the plastic is the same as existing petroleum-based products and could potentially be used in a wide range of household goods.

'We are handing millions of consumers in Brazil and around the world a modern product for modern needs,' he said at a press conference in Brazil that was broadcast over the Internet.

Polyethylene is a common plastic used in a wide variety of consumer products, including plastic bags, carpet, drink bottles and food jars. Like traditional polyethylene, the ethanol-based plastic would be recyclable, Grubisich said.

Braskem has contacted Brazilian and international companies about possibly integrating the 'green' plastic into their product lines, Grubisich said. He declined to name the companies, citing confidentiality agreements. 'We're talking about global brands that are in North America, Europe and Asia,' he said in an interview with The Associated Press. Some only want to purchase the finished product, while others have expressed interest in investing in the production process, he said.

Beta Analytic, a Miami-based laboratory that specializes in carbon testing, certified that the new plastic contains 100 percent renewable raw material, Braskem said in a statement. A Beta Analytic spokesman said the lab does not comment on any work performed without written authorization from its clients.

Braskem is not alone in the emerging plant-based plastics business. Chemical giant DuPont Co. and agri-processor Tate and Lyle PLC earlier this month opened a USD100 mln facility to produce propanediol made from corn. The companies say the product, a clear liquid used in non-toxic antifreeze, can replace petroleum-based ingredients in certain types of plastic.

Braskem said its 'green' plastic, which the company says is unique because it is made entirely from renewable raw materials, is the result of a USD5 mln research and development project. Industrial scale production of the 'green' polyethylene is expected to begin at the end of 2009, with annual production capacity currently estimated at up to 200,000 tonnes.

Brazil leads the world in ethanol production. Because of the country's relatively cheap ethanol prices, Grubisich said he believes Braskem's 'green' plastic will be competitive with petroleum-based polyethylene given existing market conditions.

He added that certain industries might be willing to pay a premium of 15 to 20% for the product. 'You have many market segments where this green technology creates more value interest than others,' he said.

American Depositary Receipts of Braskem rose 74 cents, or 4.3%, to USD17.95 in afternoon trading. In the past year the stock has risen from a low of USD8.75 to peak at USD18.73 last month.

Date: 22 June 2007.

'EUROPEAN INVENTOR OF THE YEAR 2007'

Catia Bastioli, *CEO of Novamont*, has been awarded the prestigious international prize of '*European Inventor of the Year 2007*' by the Commissioner of the European Union, Günter Verheugen, and by the President of the European Patents Office (EPO), Alain Pompidou.

The 'European Inventor of the Year' award is a joint initiative by the EU Commission and the European Patent Office and aims to recognise those who, with their inventions and innovations, have made a substantial long-term contribution to technological progress in Europe and elsewhere, thus reinforcing the economic wellbeing of Europe itself.

Catia Bastioli and her team of colleagues (Vittorio Bellotti, Luciano Del Giudice, Roberto Lombi) were awarded the prestigious international title in the *Small and Medium Enterprise/Research Category* for a series of patents filed between 1992-2001, which allowed the production of the first bioplastics from renewable agricultural sources with a stable market presence. In view of its low environmental impact and economic sustainability, this innovation provided a starting point for redrawing relevant sectors of end use applications. These materials use vegetable components such as starches and preserve their chemical structure, generated during chlorophyll photosynthesis, through a process of starch complexation with complexing agents. Such complexing process allows to create supramolecular structures which in turn generate a broad range of in-use properties and are still biodegradable in a variety of environments.

The patents receiving the awards are an integral part of the Novamont patent portfolio based on *Mater-Bi®*, the family of biodegradable and compostable products developed by the company. Mater-Bi® guarantees resistance and durability comparable with traditional plastics, but 'biodegrades in composting' in a matter of weeks, unlike traditional plastics which take hundreds of years. Mater-Bi is today used in a range of sectors: from mulching in agriculture to shopping bags and waste bags for separated collection, from catering and hygiene products through to Goodyear low rolling resistance tyres manufactured using Biotred technology.

SPAIN: MATER-BI MULCHING FILMS USED ON EXTENDED COTTON CROPS

Mulching film is normally used on vegetable crops. The 'cotton' case study in Spain shows that it can also be used on a industrial crop. As the traditional polyethylene films do not transpire, they produce a copious amount of condensate between the soil and the film. This phenomenon results in considerable damage to the crop. In the initial phases of the plant's growth, this phenomenon is the cause of many burns to the young leaves. Furthermore, for PE films to remain a long time on the field, they need holes to be punched in them, which means an increase in labour costs, greater compacting of the soil and a risk of damaging the crop.

Then PE films have to be removed when the crop has been harvested, a job that is difficult (because the film has been damaged and breaks easily), requires labour, another pass of the machinery over the land, and a serious danger of polluting the cotton with fragments of PE, which reduces its commercial value. In addition to the problems mentioned above, there is the cost of disposing of the mulching film, which varies from zone to zone. in relation to traditional PE films, the Mater-Bi film has excellent structural advantages:

- *permeability*: to water vapour, thereby preventing the formation of condensate;
- *breaking capacity* of the film after 3/4 weeks under the pressure of the growing plant. As a result, it is no longer necessary to perforate the film on the field;
- *biodegradability*: the films biodegrade in a few months, and therefore do not have to be removed after the crop has been harvested. The phenomenon of 'white pollution' does not exist.

Source: www.novamont.com (accessed 17 August 2007).

5. Conclusions and orientations

The perspective concerning the biobased economy provided by the study is limited in scope, and is indeed intended only to be an overview. The decision to base the study on statistical information at the product level-with regard to volume and value of production-leaves aside another strategy that would have been to analyse the energy equation for producing goods. In this study, the framework is market value of finished products. The framework could have been the energy requirement for these products, in which biobased and petro-chemical based production chains are compared, and values can be expressed in GJ, which can be translated to monetary terms.[1] This type of analysis, however, is in an early period of development, and would not have provided a comprehensive overview that this study has attempted to do. As stated in the introduction, tat data for individual products has been examined, and the information concerning volume and value of production in EU-25 and The Netherlands has been compiled (figure 5.1 presents an overview of the results by value, in .)

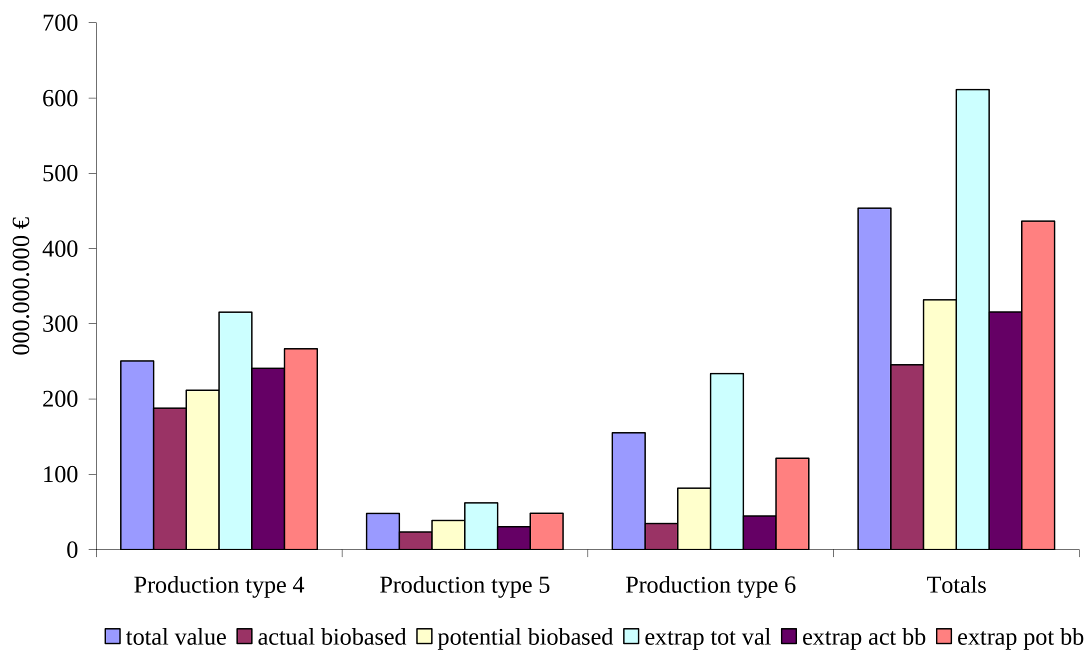

Figure 5.1 Product values (observed total; estimated actual and potential biobased; total extrapolated to 100%; extrapolated actual and potential biobased) by production types 4, 5 and 6

[1] One giga joule (GJ) is equivalent to 6 barrels of oil.

The study has encountered problems of data availability for certain products, and lack of data is essentially for reasons of industrial security, in which strategic market data is maintained as confidential. This fact applies particularly to certain sectors, most notably the fine chemical industry, or for speciality products (with high added-value) such as cosmetics and pharma/neutraceuticals. But even with regard to these products, in some cases the data availability is high for volume but not for value, and in some cases it is the contrary. In other instances, where for a particular product family the volumes of the individual products are expressed in different units (kg, l, m^2, m^3, etc), in some cases the data is complete for one type of unit but not for another. The more the analysis is made in detail of product grouping (production type, product family, units of volume), the better the quality of the results. In spite of notable gaps in data for two product families within one production type (number 6), the level of data is quite high, and allows for conclusions that are well founded in the data.

In section 4, on results and interpretation, conclusions have already been advanced for each production type, and for a collective overview. Considering the information in this study as a whole, some further conclusions are possible, which in turn leads to some considerations for possible further research orientations.

There are reasons to engage in developing the biobased economy in The Netherlands.

- A large potential market already exists for biobased materials.
- There is considerable potential for biobased substitution.
- High value-added products are involved.

The cost of intermediary products for biobased materials will become competitive to petroleum.

- NL has a reservoir of expertise:
    - coming from petroleum based chemical engineering;
    - transforming biobased resources into materials;
    - growing biobased resources (feedstocks).
- NL has the infrastructure to import a variety of feedstocks, and to export biobased production.

There are also information requirements about biobased materials (BBM) that remain to be addressed more fully than has been possible in this overview, in order to fully confirm the conclusions advanced above; these concern:

- updating the biobased product database (first for 2005, and then for 2006, when revised or new information from tat becomes available);
- refining growth potentials of different BBM sectors;
- discerning BBM influence on CO_2 reduction;
- determining economic added value for NL economy;
- estimating BBM impact on NL employment market;
- deriving added-value for NL agri-business complex;
- verifying BBM demands on NL arable land supply.

The final point to reiterate from the introductory section of this study is that the economics of biobased materials depends on the costs of the conversion process, which turns the feedstocks into products for the market. For fine chemicals, a normal ratio between feedstock and conversion costs might be 1:4; for bulk chemicals it might be just the opposite, 4:1. These ratios, however, apply for mature industrial processes; otherwise, as now occurs for some uses of biobased materials, a possible imbalance between costs for feedstocks and their conversion process is only justified for specialized uses or for niche markets when demand is not based on minimum price.

This leads to the reflection that the principle of the bio-refinery is the most sure technological strategy to bring feedstock and conversion costs into an acceptable relationship. This is true both in economic terms and also in energetic terms, that is whether the unit of value is € or GJ. The subject of the advantages of bio-refineries is separate to the topic addressed in this study, but the two subjects are inter-related, as illustrated by figure 5.2.

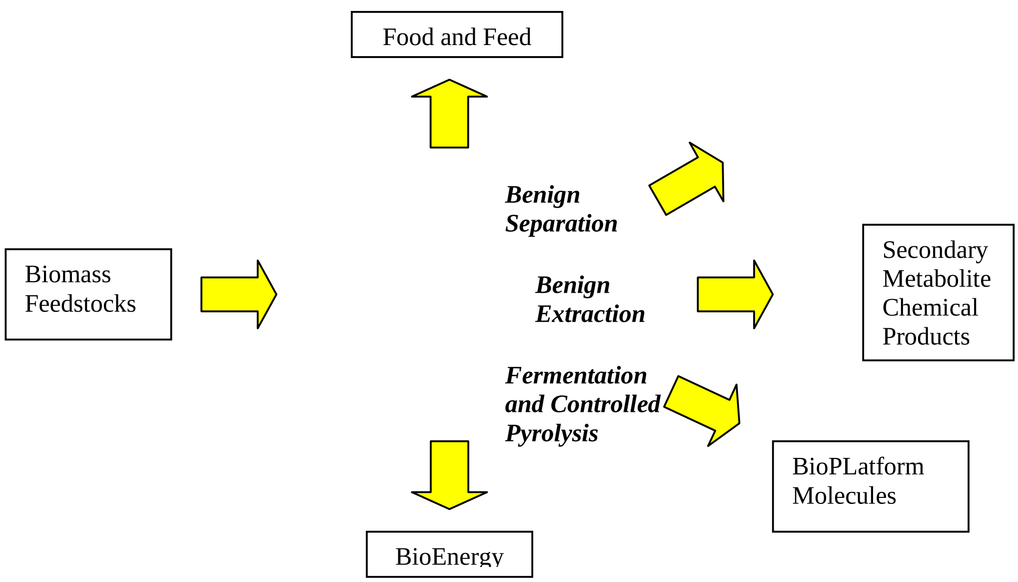

Figure 5.2 The integrated biorefinery as the center-point for the biobased economy
Source: Clark (2006)

The concept of the biorefinery introduces the importance of co-production within a biobased economy. A study such as that of Platform Groen Grondstoffen (2007) on the 'Potential of Co-production of Energy, Fuels and Chemicals from Biobased Renewable Resources' demonstrates the interest of co-production in terms of energy flows and savings.

The present study on the biobased economy is also 'state-of-the-art' in terms of the approach undertaken. Unlike other studies that are using energy as the accounting reference, it seeks to use a monetary approach, coupled with reference to specific units by volume. In this regard, in its use of tat data the method adopted is original, consistent in application, comprehensive in scope and coherent in its structure, in the sense that the boundaries of the subject treated is clearly defined by the choice of referring to individual products as the base for aggregation and consequent analysis of the resulting groups. This method seeks to understand the part of biobased production in the actual economy, and the potential expansion within the existing range of products in the market. It does not reflect the expansion of the market, due to the development of economy activity. Nor does it estimate the introduction of novel products into the market, which could be biobased. But it is perhaps a reasonable assumption that most of the innovation with new products and industrial applications will be oriented towards a biobased platform; there are two reasons for this: the increasing expense of the basic feedstock in the petro-chemical platform relative to biobased alternatives, and the environmental and energetic advantages of using biobased feedstocks.

Finally, there is no reason to believe that the development of the biobased economy will have an unfavourable effect on the agricultural land market. Although commodity prices in the agricultural sector may increase at first because of bulk demand of grains for biofuels, the second generation production systems foreseen will shift production systems to using the whole plant. Agriculture has a relative position in the gross value added of the economy as a whole that will become consolidated within a biobased economy, but which will not increase significantly. For the biobased economy is not new, but novel. The origins of economic history are rooted in a biobased economy. The present novelty is in the application of science to biobased materials permitting transformations of these in ways that were never previously imaginable.

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Appendix 1. Extract of Evaluation Table with tat PRODCOM Data

Publication date of data: 11-6-2007

Statistics on the production of selected manufactured goods
Volume - Value - Unit Value (ANNUAL 2005)

All Values and Volumes are expressed in Thousands
All confidential data and all national estimated data are surpressed
(:C) = Confidential, (CE) = Confidential Estimated, (:E) = Estimated

PRODCOM Code	Production Type	Unit	flag EU-25	Biobased material production process	Biobased material generic description	% non-food and non-feed application	% currently of biobased source	% biobased technically possible	Volume EU-25	Volume actually bio-based	Volume possibly bio-based	The Netherlands	NL: % EU 25	Unit	flag EU-25	Value EU-25	Value actually bio-based	Value possibly bio-based	The Netherlands	NL: % EU 25	Median Price per Volume Unit	EU-25 Unit val	EU-25 Ratio	NL Unit val	NL Ratio
15622110	S	kg	:E	4	free sugars	10	100	100	3,889,815	388,981	388,981	707,159	18.2	EUR		1,560,380	156,038	156,038	215,953	13.8	0.40	0.40	1.00	0.31	1.31
						Glucose and glucose syrup (excluding with added flavouring or colouring matter)																			
15421110	S	kg		4	oils and fats	10	100	100	1,341,289	134,129	134,129	435,420	32.5	EUR		713,984	71,398	71,398	218,797	30.6	0.56	0.53	1.06	0.50	1.12
						Refined soya-bean oil and its fractions (excluding chemically modified)																			
15622250	S	kg	:E	4	proteins	30	100	100	472,686	141,806	141,806	90,089	19.1	EUR		348,283	104,485	104,485	59,797	17.2	0.65	0.74	1.14	0.66	1.03
						Wheat gluten (excluding wheat gluten prepared for use as a glue or as a glazing or dressing for the textile industry)																			
21121450	S	kg		4	pulp and paper	100	70	90	1,451,816	1,016,272	1,306,635	37,253	2.6	EUR		1,039,027	727,319	935,124	48,556	4.7	0.79	0.72	1.10	1.30	1.65
						Graphic paper; paperboard : mechanical fibres ? 10%; weight > 150 g/m²																			
21123069	S	kg		4	pulp and paper	100	70	90	3,876,846	2,713,792	3,489,161	552,799	14.3	EUR		1,672,984	1,171,089	1,505,686	253,729	15.2	0.43	0.43	1.00	0.46	1.06
						Other uncoated paper and paperboard; in rolls or sheets; weight ? 225 g/m² (excluding products of HS 4802; fluting paper; testliner; sulphite wrapping paper; filter or felt paper and paperboard)																			
15622213	S	kg	:E	4	starch	30	100	100	1,563,602	469,081	469,081	275,926	17.6	EUR		643,172	192,952	192,952	89,502	13.9	0.41	0.41	1.00	0.32	1.27
						Maize (corn) starch																			
15622270	S	kg	:E	4	starch	50	100	100	1,843,948	921,974	921,974	687,776	37.3	EUR		1,134,985	567,492	567,492	433,905	38.2	0.62	0.62	1.00	0.63	1.02
						Dextrins and other modified starches (including ester/etherified; soluble starch; pregelatinised/swelling starch; dialdehyde starch; starch treated with formaldehyde/epichlorohydrin)																			
20301219	S	m²	:E	4	wood and ligneous materials	100	100	100	114,667	114,667	114,667	541	0.5	EUR	:E	1,918,845	1,918,845	1,918,845	15,251	0.8	17.33	16.73	1.04	28.19	1.63
						Parquet panels of wood (excluding those for mosaic floors)																			
20201350	S	m³	:E	4	wood and ligneous materials	100	50	90	2,137	1,068	1,923	282		EUR		325,315	162,657	292,783	49,836	15.3	372.85	152.24	2.45	176.82	2.11

						Particle board and similar board of ligneous materials (excluding wood)																			
24664895	S	kg		5	biodiesel	100	70	95	13,955,847	9,769,093	13,258,055	309,970	2.2	EUR		6,647,825	4,653,477	6,315,433	462,540	7.0	1.12	0.48	2.35	1.49	1.33
						Biofuels (diesel substitute); other chemical products; n.e.c.																			
24663179	S	kg		5	lubricants	100	50	70	500,062	250,031	350,044	42,717	8.5	EUR		783,537	391,768	548,476	70,325	9.0	1.61	1.57	1.03	1.65	1.02
						Lubricating preparations excluding preparations containing < 70 % of oils obtained from petroleum/bituminous minerals; preparations for treating textile materials; leather; hides and furskins																			
24147150	S	kg		5	oils and fats	100	100	100	369,329	369,329	369,329	95,191	25.8	EUR		391,121	391,121	391,121	113,672	29.1	1.11	1.06	1.05	1.19	1.07
						Rosin and resin acids; and derivatives; rosin spirit and oils; run gums																			
24301229	S	kg		5	paints and inks	100	60	100	618,292	370,975	618,292	44,584	7.2	EUR		2,097,004	1,258,202	2,097,004	221,621	10.6	3.29	3.39	1.03	4.97	1.51
						Paints and varnishes; based on polyesters dispersed/dissolved in a non-aqueous medium including enamels and lacquers excluding weight of the solvent >50% of the weight of the solution																			
24301290	S	kg		5	paints and inks	100	10	90	1,351,215	135,121	1,216,093	69,105	5.1	EUR		4,614,860	461,486	4,153,374	262,948	5.7	3.35	3.42	1.02	3.81	1.14
						Other paints and varnishes based on synthetic polymers n.e.c.																			
15515400	S	kg	:E	6	chemicals	100	100	100	422,849	422,849	422,849	152,132	36.0	EUR	:E	229,196	229,196	229,196	70,936	30.9	0.54	0.54	1.01	0.47	1.15
						Lactose and lactose syrup (including chemically pure lactose)																			
17203210	S	m^2	:E	6	fabrics	100	0	50	767,788	0	383,894	22,027	2.9	EUR		1,134,720	0	567,360	66,944	5.9	2.09	1.48	1.42	3.04	1.45
						Woven fabrics of synthetic staple fibres; containing 85 % or more by weight of synthetic staple fibres																			
24415263	S	g		6	pharma and neutraceuticals	100	0	50	159,882	0	79,941	0		EUR		146,841	0	73,421	0		0.85	0.92	1.08		
						Cortisone; hydrocortisone; prednisone (dehydrocortisone) and prednisolone (dehydrohydrocortisone)																			