Measuring Bio-Based raw materials use in the chemical industry

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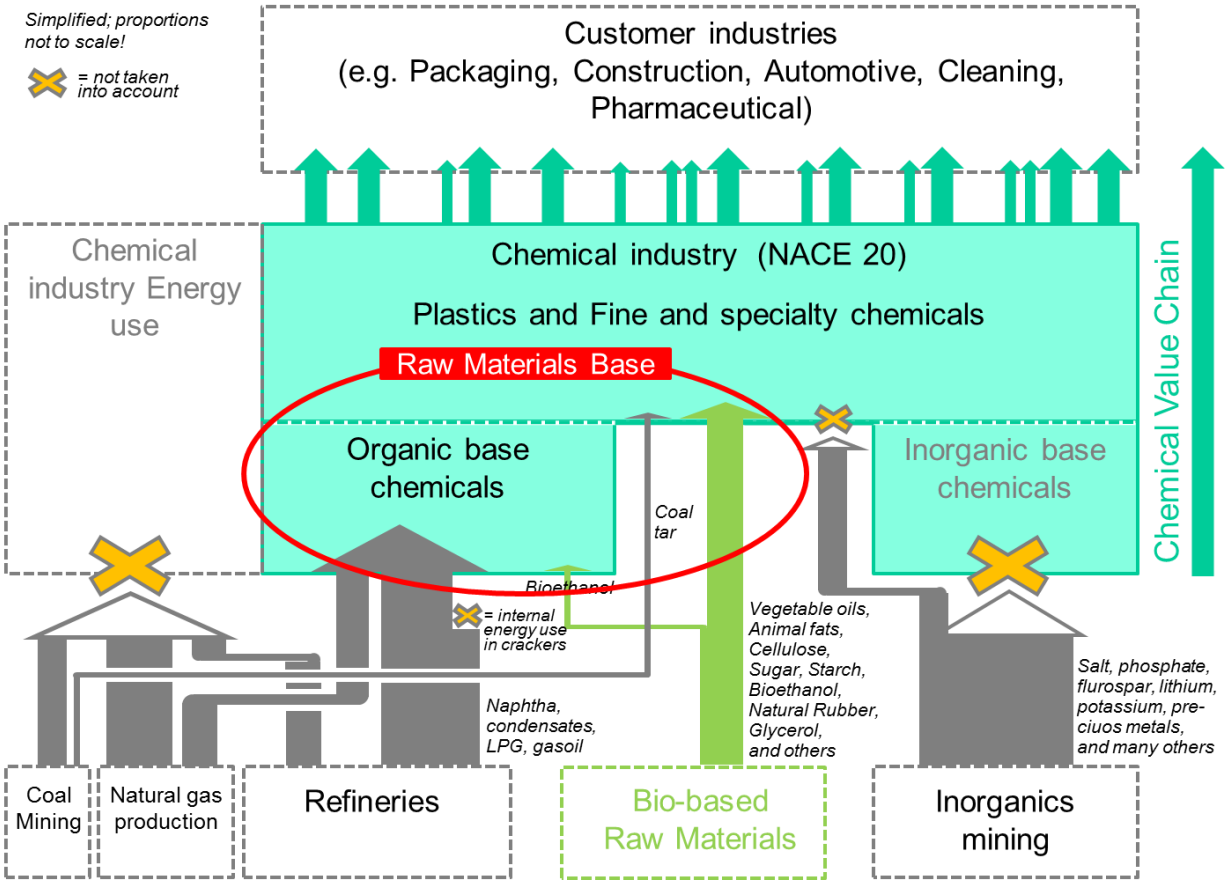
Raw materials must be measured

In the European Union as well as in a number of member states, research and political strategies for the development of a (more) bio-based economy have been adopted (1, 2). These strategies and the concept of the bio-based economy in general, offer a potential for the chemical industry both to produce chemical building blocks and products from renewable raw materials, but also to develop innovative new molecules with new functionality.

We must know the status of bio-based chemical raw materials use. This paper serves both as a baseline and as a framework to keep a gimlet eye on its progress.

Scope and methodology



All major renewable raw materials and all fossil raw materials have been quantified in a bottom-up approach combining publicly accessible statistics and best available estimates from various informed sources. This is the first time that a comprehensive overview on organic (=carbon containing) raw materials used as raw material in the European chemical industry[1] has been established. The primary raw materials base of the chemical industry has been chosen as the scope of this analysis.

This means that we count fossil-based and renewable-based raw materials as they first enter the chemical value chain rather than at each downstream conversion. While many of these raw materials are also used as energy source, only the proportion which ends up in materials use is taken into account here.

Limitations

While we are confident that both the methodology and data used are the best available at the time of writing and allow for a consistent picture of the raw materials base, we would also like to stress the limitations of this approach:

Defining the proper scope is not always unambiguous, especially when going into the details. Where different options exist, we take on the chemical industry perspective. These choices on scope and methodology influence the resulting data.

The fact that data of varying quality from different sources and estimates had to be used places limits the reliability of the resulting data, especially with regard to whether these will be maintained for future monitoring.

Consequently, the data set presented here is an important step towards a baseline for monitoring the future development of bio-based chemical production, but should not be seen as complete and as a definitive baseline. Changes in scope and methodology as well as changes in data sources and estimates could lead to structural changes in the data, limiting the validity of future monitoring. These uncertainties require careful interpretation of the resulting data, especially when analyzing future developments.

The way forward

For future monitoring, data sources will be regularly screened to ensure timeliness of data and to enable continuous improvement of data quality with new and better data sources. In this context, estimates would need to be replaced by systematic and regular surveys. Due to chemical industry's inherent complexity, new information might also require changes in the methodology to further improve the quality of database.

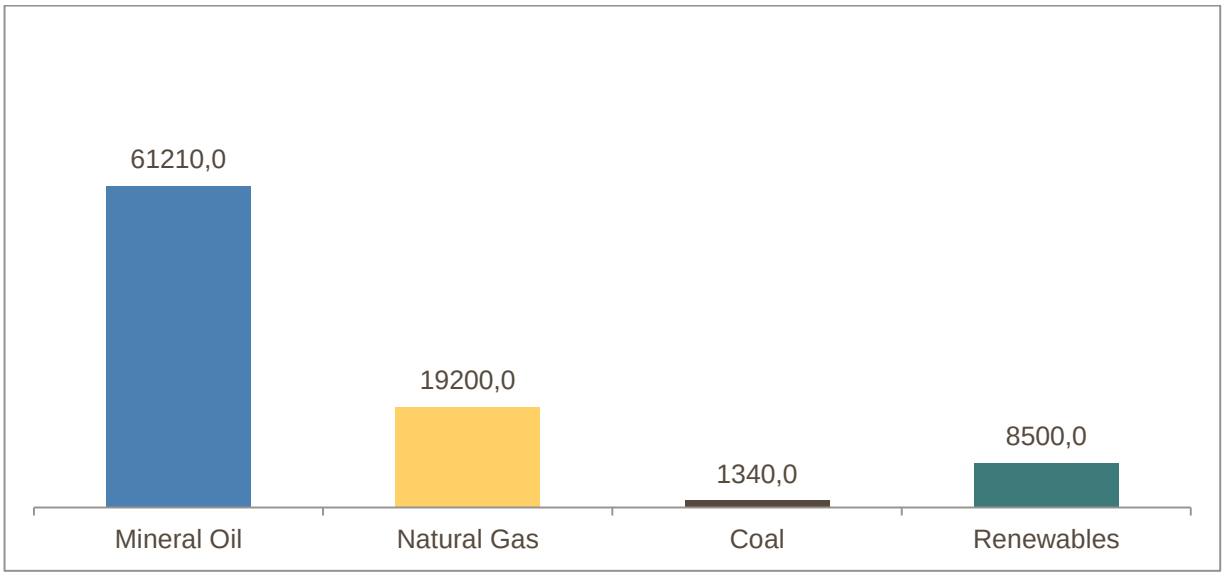
Results

Based on the above methodology, the total volume of organic raw materials used in in 2011 amounted to 90.3 million tonnes of which 8.6 million tonnes were renewable. The renewable share of the European chemical industry's raw material use thus amounts to 9% in 2011.

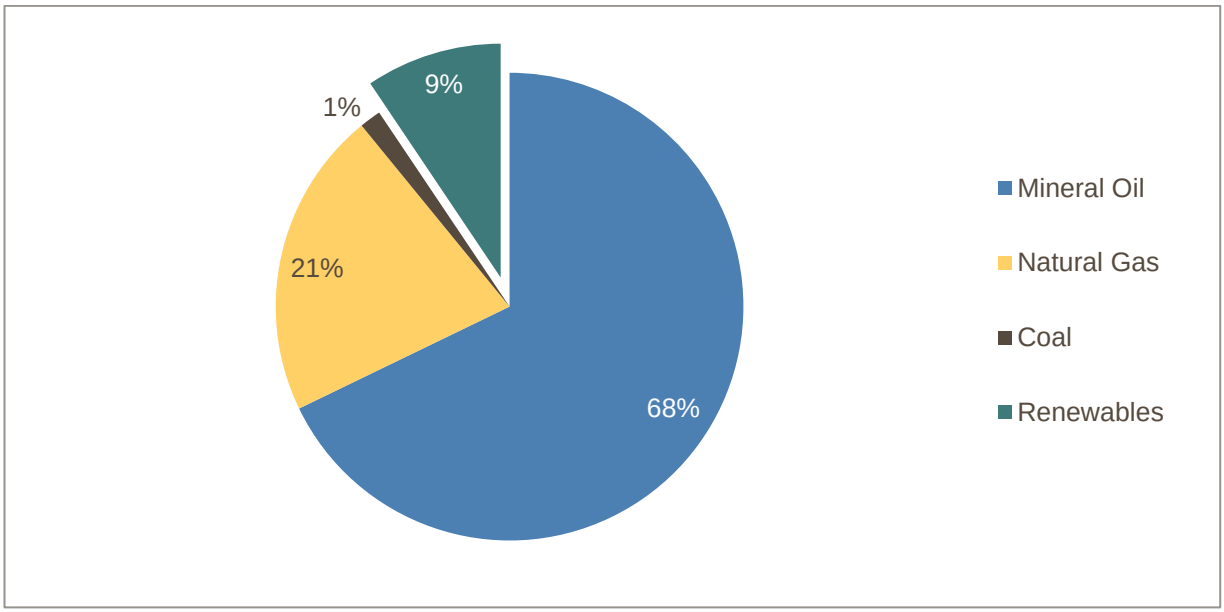
[1] Chemical Industry as defined by NACE 20 (EU statistical classification)

Organic raw material use in the EU chemical industry

Volume in 1.000 tonnes – material (feedstock) use only, EU chemical industry, 2011



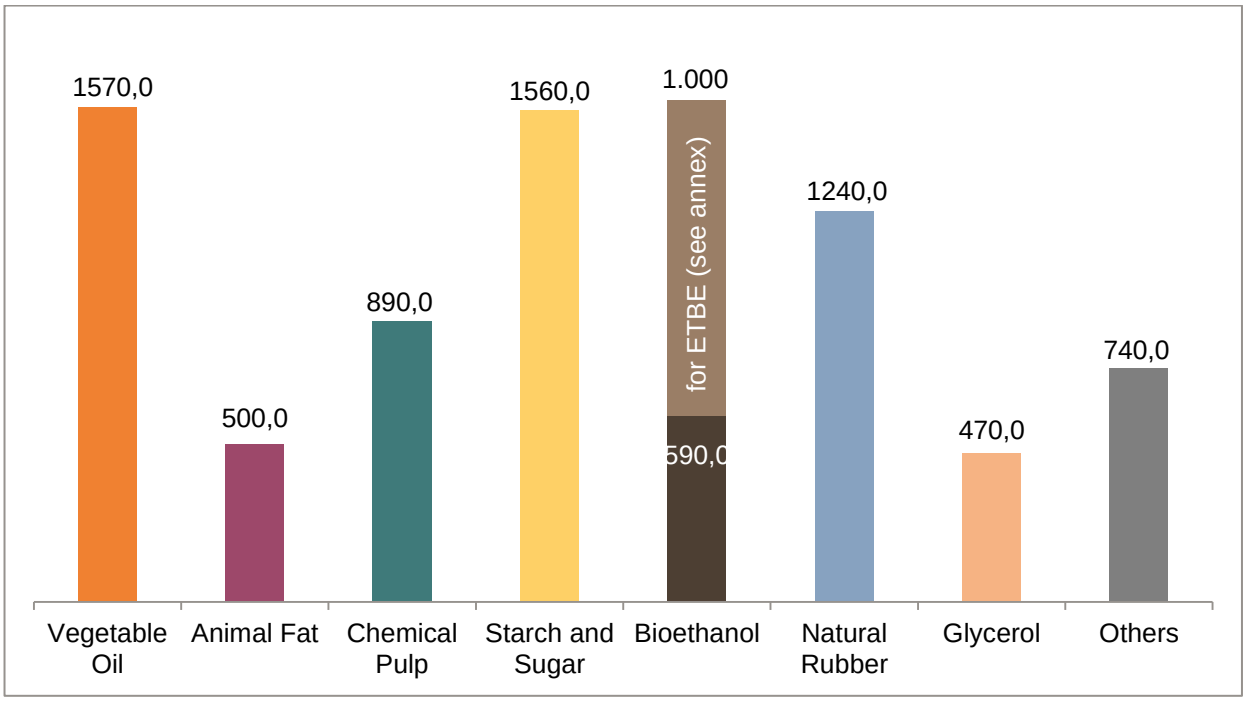
Shares in total organic raw materials – material (feedstock) use only, EU chemical industry, 2011



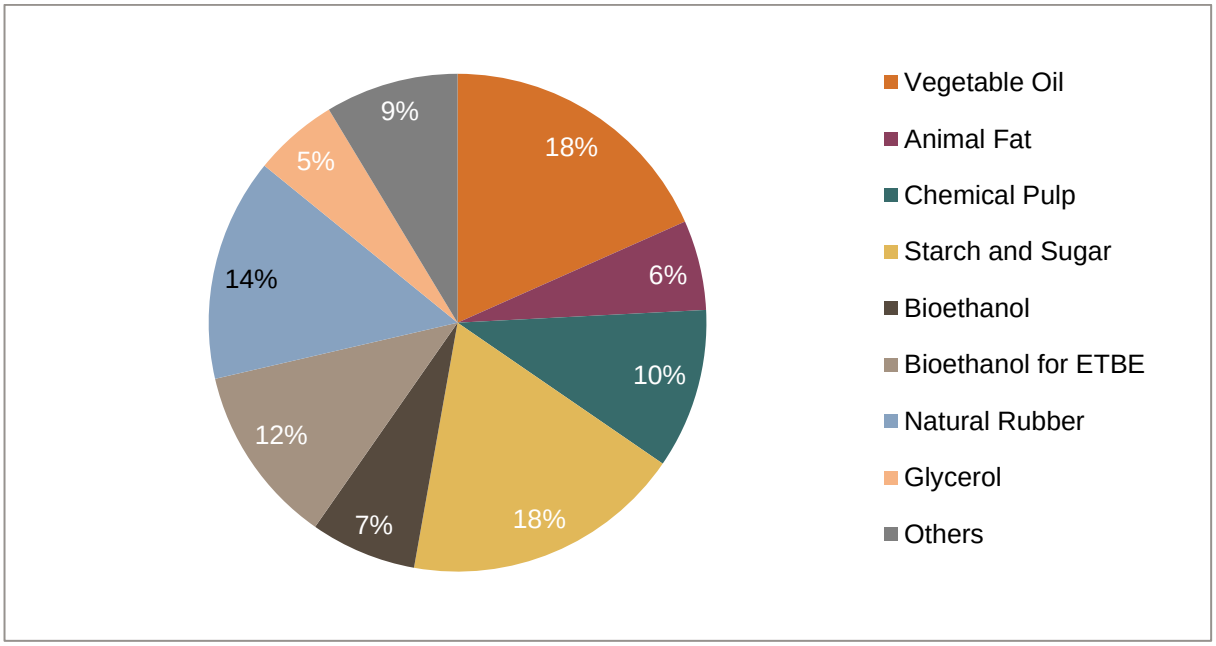
Detailed breakdown of renewable raw materials

A total of 8.6 million tonnes per year of renewable raw materials is used in European chemical production. Vegetable oils and animal fats, carbohydrates (sugar and starch), and bioethanol account for almost 2/3 of the quantities. Other important materials are natural rubber, chemical pulp, and glycerol. Others include a variety of vegetable waxes, natural resins, tanning agents, proteins, and medicinal plants.

Renewables volume in 1.000 tonnes, EU chemical industry, 2011



Renewables shares in total renewables, EU chemical industry, 2011



Annex: Methodology, assumptions and limitations of the method used

Quantification approach

Raw materials

In the chemical industry, a complete and accurate quantification of production volumes is not possible, as products will be counted several times along the long and complex value chains. Instead, the analysis focuses on raw materials, as any given "raw material" can only be used once as input for a production process.

The multitude of conversion steps in chemical production requires a proper definition, where renewable and non-renewable raw materials have to be counted at comparable stages in the value chain. The first conversion process within the boundaries of chemical industry seems to be best. However, such an approach may give an incomplete picture, when intermediates are imported, as these will not be recorded. In the quantification carried out here, imported intermediates (fatty acids, for example) will not be included, thus only showing the production base in Europe. Today, net import quantities of intermediates are estimated to be small both for fossil and renewable intermediates. Their development will be monitored and should they become relevant in future, case by case examples to illustrate their effects will be used to complement the quantification of raw materials use in Europe.

Organic and inorganic raw materials

1) A limitiation of this study is that it does not represent the whole chemical industry as it includes only organic (=carbon containing) raw materials This is a practical limitation as no data are currently available on the inorganic raw materials use in the chemical industry in publicly accessible statistics or other information sources.

2.)The multitude and variety of different materials could presents methodological problems – beyond obvious materials like salt or precious metals, inorganic raw materials include hydrogen and nitrogen, for example, which are already products of the chemical industry. As they are separated from the raw material air, air would have to be counted as raw material for the chemical industry, following the methodology presented here.

3.) Once sufficient data on inorganic raw materials use are available, an extension of the analysis will be considered. Renewables are, however, unlikely to supplement or substitute inorganic raw materials like salt, precious metals, etc. This means that a 100% bio based chemical industry is not, even conceptually, an attainable target.

Calculation base

Options for reporting the renewable content are:
- value of raw materials
- total weight
- carbon content

Value was eliminated because of its variability. Carbon content is arguably the most

accurate basis to compare different organic raw materials, however, this concept is difficult to communicate to wider stakeholders. Therefore, proportion of total weight was chosen as a clear unambiguous measure.

Mineral oil derivatives

In the base chemicals production in petrochemical sites, part of the feedstock is used as internal energy source for the cracking process. This can either be counted as energy source or raw material. Part of the feedstock also goes back to the refinery, thus not being used either as energy source or raw material for chemical production. Mineral oil derivatives have been calculated both on a “gross” basis (based on total raw material input) and a “net” basis (based on summing up the products) here. As the particularities are not relevant to the other raw materials, a “net” perspective for mineral oil derivatives may more suitable:

Data and sources

Volume in 1,000 t	**EU 28 "gross"**	**EU 28 " net"**	**Data sources**
Mineral Oil	84,380	61,210	*APPE (Association of Petrochemicals Producers in Europe)*
Natural Gas	19,200	19,200	*Eurostat*
Coal	1,340	1,340	*Eurostat*
Renewables total	8,560	8,560	-
Vegetable Oil	1,570	1,570	*FEDIOL (European Vegetable Oil and Proteinmeal Industry Federation)*
Animal Fat	500	500	*APAG (European Oleochemicals and Allied Products Group)*
Chemical Pulp	890	890	*FAOSTAT, CIRFS (European man-made fiber industry organization)*
Starch and Sugar	1,560	1,560	*Ecosys/FNR (German renewable raw materials agency) and estimates*
Bioethanol (industrial use)	590	590	*European Commission*
Bioethanol (for ETBE)	1,000	1,000	*EFOA (European Fuel Oxygenates Association)*
Natural Rubber	1,240	1,240	*IRSG (International Rubber Study Group)*
Glycerol	470	470	*Eurostat and estimates*
Others[2]	740	740	*Eurostat and estimates*
Total organic	***113,480***	***90,310***	

[2] *Vegetable waxes, natural resins, tanning agents, proteins, medicinal plants*

Fossil raw materials as feedstock for chemical production

Mineral oil derivatives

Data source is APPE[3]. Data used are 2011, data for 2012 are available.

Gross volume (84.4 million tonnes) has been calculated with cracker feedstocks as basis, adding non cracker products (assuming conversion factors of 1:1). Non cracker products counted are propylene ex refinery, benzene (ex reformate, on purpose & coal), toluene and o-/p-xylene.

Net volume (61.2 mio. t) has been calculated based on the total production volume of olefins and aromatics on first conversion stage.

To account for feedstocks not covered, especially heavy heating/fuel oil for the production of synthesis gas, non energy use of heating & other gasoil in industry from Eurostat[4] has been added to both calculations.

Also in both cases, results have been divided by 0.9 to account for missing data in the APPE statistics, which cover only sites located in EU 15, not EU 28. Data is especially missing from the Czech Republic and from Poland.

Natural Gas

19.2 mio. t. Data source is Eurostat[5]. Data used are 2011, data for 2012 not yet available.

Coal

1.3 mio. t. Data source is Eurostat[6]. Data used are 2011, data for 2012 not yet available.

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[3] *Association of Petrochemicals Producers in Europe: Basic hydrocarbons and derivatives market evaluation 2012. May 2013, 24th edition*

[4] *Supply, transformation, consumption - oil - annual data [nrg_102a]; last update 26.06.13, extracted on 26.09.13; PRODUCT: Heating and other Gasoil, INDIC_NRG: Non-energy use in Industry sector (assuming all non-energy use takes place in chemical industry).*
http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

[5] *Supply, transformation, consumption - gas - annual data [nrg_103a]; last update 26.06.13, extracted on 08.09.13; PRODUCT: Natural gas, INDIC_NRG: Non-energy use in Industry sector (assuming all non-energy use takes place in chemical industry).*

[6] *Supply, transformation, consumption - solid fuels - annual data [nrg_101a]; last update 26.06.13, extracted on 26.09.13; PRODUCTS: Hard coal and derivatives, lignite and Derivatives, coke oven coal (deducted), INDIC_NRG: Non-energy use in Industry, Transformation & Energy Sectors (assuming all non-energy use takes place in chemical industry).*

Renewable raw materials as feedstock for chemical production

A total use of 8.6 million tonnes is estimated. Official Eurostat statistics do not exist for the chemical feedstock use of most of these materials. While some federation statistics exist, only estimates are available in many cases. While this (no regular data collection) limits especially the capability to monitor developments over time, the following estimates are seen as plausible and fairly reflect the current status of renewable raw material use in the European chemical industry.

Vegetable Oils

1.6 million tonnes estimated by FEDIOL[7] for 2011, data for 2012 not yet available.

Animal Fats

500 kilotonnes were used in 2011, data for 2012 (500 kilotonnes) are available. Data source is APAG statistics[8].

Chemical Pulp

890 kilotonnes in total, 560 kilotonnes thereof for viscose production and 330 kilotonnes for cellulose derivatives . Data sources are FAOSTAT (total)[9] and CIRFS statistics (viscose)[10]. FAOSTAT provides data on EU production, import and export of dissolving wood pulp, enabling a calculation of the total amount used. CIRFS data are available for cellulosic fibres (viscose) production. As the conversion factor between chemical fibres and their feedstock cellulose/chemical pulp is assumed to be 1:1, raw material quantities are assumed to be equal to product quantities. The delta between use for viscose production and total use is assumed to be used for cellulose derivatives.

Starch and Sugar

Use of sugar and starch for fermentation of chemicals in the EU amounts to 1.3 million tonnes, not counting fermentation of yeast and bioethanol. They have been excluded, as they are mainly used in the feed and food sector (yeast) and the fuel sector (bioethanol). Also, both bioethanol and yeast are typically not considered to be produced in chemical companies, although such a definition is discretionary, of course. Data origin is a sector study by Ecosys for FNR[11]. Data are given is 2009, quantities

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[7] *European Vegetable Oil and Proteinmeal Industry Federation, www.fediol.be Publications > Statistics > Annual > 2011 > Split of end-use (consumption) of all EU-27 vegetable oils in 2010 vs 2011, accessed on 27.09.2013*

[8] *European Oleochemicals and Allied Products Group, personal communication by Cédric Delveaux, 23.09.2013*

[9] *Food and Agriculture Organization of the United Nations (FAO) statistics: http://faostat3.fao.org → search → "dissolving wood pulp"*

[10] *European man-made fiber industry organization, http://www.cirfs.org/KeyStatistics/CellulosicsinEurope.aspx*

[11] *Study available at http://www.fnr-server.de/ftp/pdf/berichte/22003310.pdf (in German).*

are estimated to have been stable until 2011. Use of starch and sugar in processes other than fermentation has been estimated to be 20 % of fermentation use, following an estimate by FNR for Germany, adding 260 kilotonnes[12].

Bioethanol

As the manufacture of bioethanol is considered to take place outside the chemical industry, bioethanol is treated as the raw material here. In consequence, calculation base is the weight of ethanol (and not its carbohydrate-equivalents, meaning the quantities of sugar and starch used for its production).

- industrial use

The European Commission publishes an annual ethanol balance, providing data on the industrial use of bioethanol, which was 590 kilotonnes tonnes in 2011[13]. This figure should be seen as upper limit, as it is not clear whether and to what extent the "industrial use" covers applications outside the chemical industry (use as solvent in other industry sectors, for example).

- for ETBE

In addition, bioethanol use for production of ETBE (Ethyl tert-butyl ether)has been taken into account. 1 million tonnes of bioethanol has been used to produce 2.2 million tonnes of ETBE in 2011. Data source is EFOA[14]. ETBE derived from bioethanol is a blending component for fuels. About half of all bio-ethanol blended into gasoline in the EU is currently in the form of ETBE. ETBE is manufactured by the chemical industry and for statistical purposes classified as a chemical product, justifying its inclusion. ETBE's use as fuel component, however, is not the "material use" intended to be quantified here, but a use as energy/fuel. This could be a argument for not considering ethanol use for ETBE as chemical industry raw material.

Natural Rubber

1.2 million tonnes natural rubber consumption in 2011, data for 2012 available. Data source is IRSG statistics[15].

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[12] *Fachagentur Nachwachsende Rohstoffe (German renewable raw materials agency), personal communication by Dietmar Peters, 30.10.2013*

[13] *EU-27 ethyl alcohol balance for 2011: http://ec.europa.eu/agriculture/markets/wine/facts/balance2011_en.pdf. Data are given in hectolitres of pure alcohol (HPA) and have been converted to tonnes using a conversion factor of 12.7 HPA/t (Source: EFOA).*

[14] *European Fuel Oxygenates Association, personal communication by Graeme Wallace, 29.10.2013*

[15] *International Rubber Study Group, http://www.rubberstudy.com/documents/WebSiteData_2.0.pdf, accessed on 24.11.2013*

Limitations

Scope and methodology

Defining the proper scope is not always unambiguous, especially when going into the details. Where different options exist, we take on the chemical industry perspective. For example, in the case of bioethanol, we do not consider the primary raw materials (sugar and starch) in our calculation, as bioethanol is usually not produced by chemical companies. From their perspective, bioethanol is the raw material, which we therefore include. Another example for a discretionary choice is the use of bioethanol for ETBE , which we included as raw material for the chemical industry. On the other hand, as a bio-fuels component, ETBE can an also be attributed to the bio-fuels sector. These choices on scope and methodology influence the resulting data.

Different data sources and estimates vs. collection of primary data

The above data should be seen as plausible estimates. They give a first analysis of raw material use by the European chemical industry and the significance of bio-based production as part of the emerging bio-economy. While Eurostat and APPE data are regularly collected based on a standardized methodology, this is not the case for most estimates. The fact that estimates from different external sources had to be used places limits on the reliability of the resulting data, especially with regard to whether these will be maintained for future monitoring.. In order to improve the data, estimates would need to be replaced by systematic regular surveys at association and company level and proper aggregation of data.
Changes in scope and methodology as well as changes in data sources and estimates might lead to structural changes in the data, limiting the validity of future monitoring.
Conseqeuntly, the data set presented here is an important step towards a baseline for monitoring the future development of bio-based chemical production, but should not be seen as complete and as a definitive baseline.

Benchmarking and comparability with company data

The “shape” of companies – meaning which parts of the value chain they cover both vertically and horizontally, as well as their size and position in the value chain – determines to a great extent what their “raw materials” entering and “products” exiting the company are. Organizational changes (mergers, spin-offs) can affect the balance of raw materials and the resulting fossil/renewable shares, even though the actual physical production in total does not change. The methodology developed here concentrates on one specific level of raw materials across the industry, which are counted regardless of company structures. This represents a fundamental methodological difference limiting comparability of results.

Next Steps

Continous improvement

For future monitoring, data sources will be regularly screened to ensure timeliness of data and to enable contiuous improvement of data quality with new and better data sources. Due to chemical industry's inherent complexity, new information might also require changes in the methodology to further improve the quality of the estimate.

EU Bioeconomy Observatory

The European Commission (DG JRC) is currently establishing a Bioeconomy Observatory to map progress and measure the impact of the development of the European Union's bioeconomy. The observatory will gather data to follow the evolution of markets, to map EU, national and regional bioeconomy policies, research and innovation capacities, and the scale of related public and private investments. The methodology developed and data gathered here will constitute a key contribution to the bioeconomy observatory, showing the renewable raw materials use in the European chemical industry.

EU member states and international dimension

A quantification following the same methodology has been done for Germany, for example Therefore, the approach presented here may serve as template for other European member states and even chemical regions outside Europe. Possible application will be discussed with national federations, taking into account existing approaches and methodologies. New data sources and methodological improvements might also come up from the discussion at national level.

Sources

1. Innovation for sustainable growth: A Bioeconomy for Europe. European Commission, February 2012

http://ec.europa.eu/research/bioeconomy/pdf/201202_innovating_sustainable_growth_en.pdf

2. Cefic Views on the bioeconomy. Cefic, June 2012

http://www.cefic.org/Documents/PolicyCentre/Industrial%20Policy/Cefic_Views_on_the%20_Bioeconomy.pdf

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