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Development of a biofuel database for the CAPRI modelling system

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1 Introduction

For an endogenous representation of 1st generation biofuel markets in the CAPRI modelling system¹, explicitly covering biofuel supply, biofuel feedstock demand, biofuel demand and bilateral biofuel trade and furthermore a simplified representation of 2nd generation biofuel processing, there are challenging requirements in terms of the ex-post biofuel database. These biofuel extensions, including also the biofuel database development, were mainly executed in the course of the IPTS project No. 151250-2008 A08-DE², which was carried out at the Institute for Food and Resource Economics (ILR) of Bonn University between October 2008 and June 2010.

The establishment of a sufficient ex-post biofuel data is an ambitious exercise. The main difficulty results from the fact that a notable biofuel market expansion has not started more than 5 years ago. Even if the European discussion to promote biofuels already started in the 1990s and first support measures in European Member States were implemented between 2001 and 2003, a significant increase in biofuel production, consumption and trade did not materialize before 2003, with a market boost in 2007 and 2008. Hence, official statistical sources like EUROSTAT have not collected production or consumption data for long ex-post time series. Furthermore, biodiesel, in contrast to ethanol, was not shown explicitly in most official trade statistics until 2008. Whereas ethanol (differentiated in “undenatured” and “denatured” ethanol) is explicitly classified in the official HS code scheme³, biodiesel was covered before 2008 in different aggregates of chemical products which does not allow for a precise allocation of biodiesel quantities.

The consequence of these difficulties is that a variety of official statistics and privately offered data sources have to be consulted to develop the required database. The main problem with such a compiled database is to achieve consistency as different data sources often vary in their variable definitions. In particular, this is true for ethanol that may be defined as “fuel-ethanol” or (all) “ethanol” on the production and consumption side and “undenatured” or “denatured” ethanol within trade statistics. It is not always evident which

¹ Common Agricultural Policy Regional Impacts Assessment model (CAPRI). More information available at: www.capri-model.org, 11.10.2010

² IPTS project No. 151250-2008 A08-DE: “Integrated Impact Assessment of an Increase in Biofuel Demand in Europe: The Economic and Technological Dimension”. More information available at: http://www.ilr1.uni-bonn.de/agpo/rsrch/projects/ipts_biofuel_e.htm, 11.10.2010

³ Harmonized Commodity Description and Coding System (HS)

definition is used by a particular data source and thus the compilation requires a lot of care to reduce such uncertainties.

As the CAPRI trend estimation procedure, which is an important component of the baseline construction, relies on a statistical analysis of ex-post time series, biofuel data should ideally be available for the full time horizon of the standard CAPRI database (COCO⁴). The COCO module includes statistical estimation procedures to fill gaps or to correct inconsistencies in the original statistical datasets. The time horizon covered in the COCO module (in its status of 2009) is 1985 to 2005. Thus, ex-post time series for biofuels should ideally cover the same time period or at least a certain section of this horizon. Subsequent biofuel data points beyond 2005 are also useful, e.g. for cross checking with results from the trend estimation procedure and for future database updates. Because production and consumption quantities of biofuels become notable in Europe not before 2002 and data for years later than 2005 are very incomplete, a realistic goal was to establish complete biofuel time series from 2002 to 2005 in COCO.

The specific data needs for the CAPRI biofuel representation result from the set of behavioural functions which should be implemented. As a complete market representation of 1st generation biofuels was desired, closed market balances for ethanol and biodiesel in European and non-European countries or country aggregates (which are covered in CAPRI⁵) are required for each of those ex-post years. In general the market balance consists of 4 positions: Domestic production, domestic consumption, imports and exports (all measured in 1000 metric tons). In addition ex post biofuel prices (differentiated in producer-, consumer-, import-, and export-prices) as well as some technical parameters are required to estimate price elasticities and parameter values within the calibration procedure for the different behavioural functions.

Furthermore feedstock demand resulting from biofuel production has to be identified, in line with the market balances for the agricultural products concerned in the CAPRI COCO module.

As CAPRI features bilateral trade only for the EU aggregates (EU10, EU15, EU27) and for non-European countries or country aggregates, bilateral trade statistics are not required for the individual European Member States. In this case only aggregated import or export positions have to be collected.

⁴ Complete and Consistent Data Base (COCO) of the CAPRI model. More information available in Britz and Witzke (2009).

⁵ The envisaged biofuel representation in CAPRI will distinguish European Member States and non-European countries or country aggregates in accordance with the standard CAPRI regional coverage as described in Britz and Witzke (2009).

Technically, product market balances for European countries, prices and processing parameters are defined in the CAPRI COCO module, whereas market balances for non-European countries or country aggregates are stored separately in the CAPRI world database, established in another module called GLOBAL. As this differentiation results only from technical aspects, it does not matter for methodological issues.

2 Market balances of ethanol and biodiesel

In the following the data sources used are described for each market balance position. The positions production (*MAPR*), import (*IMPT*) and export (*EXPT*) cover the aggregated ethanol quantities, including all fuel- or non-fuel and undenatured or denatured ethanol. By contrast total domestic consumption (*DOMM*) is split into fuel consumption (*HCOM*) and non-fuel consumption (*INDM*). In the case of biodiesel this differentiation is not required as biodiesel is only produced for fuel purposes and no additional demand beside fuel use exists. Thus, total biodiesel consumption is completely covered by *HCOM*, which is equal to *DOMM*. After identifying and collecting the required ex-post data, the initial data set is checked with respect to completeness and consistency within the COCO module, where several assumptions are made to fill in missing balance positions. The resulting final biofuel market balances (differentiated in biodiesel and ethanol) for European countries are displayed for 2005 in Table 8.5 in the ANNEX. The ex-post market balances for the EU aggregates (EU10, EU15) and non-European countries or country aggregates are shown for 2005 in Table 8.1 for ethanol and in Table 8.3 for biodiesel, both tables also placed in the ANNEX.

For ex-post biofuel production quantities in European and non-European countries the data sources listed in Table 2.1 are consulted. Whereas EBIO⁶, EBB⁷ and EUROSTAT⁸ are official public available data sources, F.O.Licht⁹ is a privately offered data source, specialised on international sugar and biofuel markets. Within the development of this database several volumes of 2008 and 2009 of the “F.O.Lichts World Ethanol & Biofuels Report” are used. Beside these data sources also data information from the PRIMES¹⁰ energy model and the

⁶ European Bioethanol Fuel Association: <http://www.ebio.org/> . Data extracted at 24.06.09

⁷ European Biodiesel Board: <http://www.ebb-eu.org/> . Data extracted at 24.06.09

⁸ <http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction> . Data extracted at 24.06.09

⁹ F.O.Lichts World Ethanol & Biofuels Report. Monthly magazine (selected volumes 2008-2009)

¹⁰ PRIMES energy system model. Baseline and ex-post data used in this analysis are extracted from a version of December 2009. More general information available at: <http://www.e3mlab.ntua.gr/>. 10.11.10

OECD - FAO AgLink-COSIMO¹¹ model are available within the IPTS project No. 151250-2008 A08-DE. In the case of ethanol EBIO and PRIMES production data covers only fuel-ethanol quantities, whereas F.O.Licht and EUROSTAT-PRODCOM differentiate between undenatured and denatured ethanol.

Table 2.1: Overview on data sources consulted for biofuel production

Source	Variables covered	Time period	Regional coverage
EBIO	Fuel ethanol production	2004 - 2008	Sel. EU MS
EBB	Biodiesel production	2003 - 2007	EU MS (EU 27)
EUROSTAT - PRODCOM	Sold volume: Biodiesel (code: 20595990)	2007 - 2008	Sel. EU MS
	Undenatured ethanol (code: 20147400)	1995 - 2008	Sel. EU MS
	Denatured ethanol (code: 201474500)	1995 - 2008	Sel. EU MS
PRIMES	Fuel ethanol production	2000 - 2007	Sel. EU MS
	Biodiesel production	2000 - 2007	EU MS (EU27)
AgLink- COSIMO	Ethanol production from agr. crops	2000 - 2008	EU27 + OECD Members
	Ethanol production from non-agr. inputs	2000 - 2008	EU27 + OECD Members
	Biodiesel production	2000 - 2008	EU27 + OECD Members
F.O.Licht	Undenatured ethanol production	2000 - 2008	Sel. EU MS + non-EU
	Denatured ethanol production	2000 - 2008	Sel. EU MS + non-EU
	Biodiesel production	2003 - 2008	Sel. EU MS + non-EU

Source: Own compilation

The AgLink-COSIMO database does not distinguish between these sub-products but introduced a new differentiation between ethanol produced from agricultural sources and ethanol produced from non-agricultural sources. To achieve consistency among the different sources for ethanol production, the collected data are cross-checked. From this it became obvious that the PRIMES production data (fuel-ethanol production) is largely consistent with the EBIO data. Furthermore, the AgLink aggregate for ethanol produced from agricultural

¹¹ OECD - FAO agricultural sector model AgLink-COSIMO. Baseline and ex-post data used in this analysis are extracted from a version of October 2009. More general information available at: http://www.oecd.org/about/0,3347,en_2649_33781_1_1_1_1_37401,00.html

and non-agricultural sources is consistent with the F.O.Licht aggregate for denatured and undenatured ethanol. These consistencies permit defining the production activity variable (*MAPR*) for ethanol to cover the whole ethanol production quantity (undenatured and denatured ethanol, regardless of its origin) in a certain country and year. The F.O.Licht production data for ethanol is taken as the basic dataset as it covers explicitly European as well as non-European countries. In the case of biodiesel the PRIMES model provides the basic data, whereas the F.O.Licht data is taken into consideration to amend non-European production. If production data from both, PRIMES and F.O.Licht are available for a respective region, the higher value is taken to define *MAPR*. We have avoided to consider only fuel-ethanol production, as a significant share of non-fuel ethanol is also produced from agricultural products. Thus, the differentiation between fuel- or non-fuel use and denatured or undenatured chemical status is not relevant for the production side. However, the differentiation of non-agricultural or agricultural ethanol is of course important, as it signals that not the whole ethanol production is based on agricultural sources. To consider this fact in the CAPRI database the AgLink data on non-agricultural ethanol are used to calculate the supply share of non-agricultural ethanol which is entered on code *NAGR*. As AgLink only features EU27 aggregated data, this share is applied for all EU countries.

For the definition of ex-post biofuel consumption the data sources listed in Table 2.2 are consulted. Information on consumption quantities of ethanol and biodiesel in European and non-European countries is more limited than information on biofuel production. In addition, demand information for ethanol can be given as fuel-ethanol consumption or total ethanol consumption, which covers as well non-fuel ethanol demand quantities, e.g. ethanol use for beverage. Furthermore, the regional mapping problems need to be overcome, as PRIMES covers only European Member States, AgLink covers only the EU27 aggregated and OECD member countries and only F.O.Licht includes detailed information for both, but only for selected ones. As a consequence the required consumption information is utterly incomplete. As it is necessary to split demand into fuel- and non-fuel ethanol demand there are more gaps resulting from this status of original data sources.

Table 2.2: Overview on data sources consulted for biofuel consumption data

Source	Variables covered	Time coverage	Regional coverage
EUROSTAT ¹²	Biofuel consumption: Ethanol Biodiesel	2005 - 2007 2005 - 2007	EU MS EU MS
PRIMES	Biofuel consumption Ethanol Biodiesel	2000, 2005 2000, 2005	EU MS EU MS
AgLink-COSIMO	Fuel ethanol consumption Non-fuel ethanol consumption Biodiesel consumption	2000 - 2008 2000 - 2008 2000 - 2008	EU27 + OECD Members EU27 + OECD Members EU27 + OECD Members
F.O.Licht	Fuel ethanol consumption Non-fuel ethanol consumption Biodiesel consumption	2000 - 2008 2000 - 2008 2003 - 2008	Sel. EU MS + non-EU Sel. EU MS + non-EU Sel. EU MS + non-EU

Source: Own compilation

Consumption data of European and non-European countries for ethanol and fuel-ethanol are taken from F.O.Licht, as this data source provides the most complete country and time coverage and is by and large consistent with the fuel-ethanol consumption quantities offered by PRIMES, EUROSTAT and AgLink. To fill in the remaining gaps on consumption data the following assumptions are used within the COCO procedure:

- If information on production and trade flows are available in a respective year and country the consumption of ethanol ($DOMM=HCOM+INDM$) is equal to the production of ethanol ($MAPR$) minus exports ($EXPT$) plus imports ($IMPT$).
- If no information on fuel-ethanol consumption ($HCOM$) is available but the aggregated ethanol consumption ($DOMM$) exist, the EU27 average share of non-fuel ethanol consumption (provided by AgLink) is used to calculate $INDM$ and consequently $HCOM$.

Biodiesel consumption quantities for European countries are taken from the PRIMES model because the F.O.Licht data at hand was incomplete for the required ex-post time period. The biodiesel consumption data available from F.O.Licht is broadly consistent with the PRIMES dataset, where overlaps exist. Furthermore, the PRIMES data is useful as it contains ex-post data for 2000 and 2005 and thus allows for an interpolation of the intermediate years. Biodiesel consumption data for non-European countries is taken from F.O.Licht as PRIMES does not cover non-European countries.

¹² <http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database>

Ex post data on trade flows are partly covered by the EUROSTAT foreign trade division COMEXT, the AgLink-COSIMO database and F.O.Licht. The PRIMES model does not include ex-post trade quantities as they are calculated endogenously within the simulation runs (cp. Capros, 2005). CAPRI needs aggregated import and export quantities for European Member States and import and export quantities described in a bilateral way for the EU aggregates (EU15, EU27) and non-European countries. The data sources consulted for biofuel trade data are listed in Table 2.3.

Table 2.3: Overview on data sources consulted for biofuel trade data

Source	Variables covered	Time coverage	Regional coverage
EUROSTAT (COMEXT)	Imports, Exports(bilateral) Unden. Ethanol (HS 20147400)	2000 - 2008	EU agg. + EU MS
	Denat. Ethanol (HS 201474500)	2000 - 2008	EU agg. + EU MS
	Biodiesel (HS 3824 9091)	2008	EU agg. + EU MS
Aglink- COSIMO	Net-trade Ethanol (not differentiated)	2000 - 2008	EU27 + OECD Members
	Biodiesel	2005 - 2008	EU27 + OECD Members
F.O.Licht	Imports, Exports(bilateral) Unden. Ethanol	2003 - 2008	Sel. EU MS + non-EU
	Denat. Ethanol	2003 - 2008	Sel. EU MS + non-EU
	Biodiesel	2006 - 2008	Sel. EU MS + non-EU

Source: Own compilation

The AgLink model describes trade by a net-trade position, meaning that import and export flows are not given explicitly and an allocation of exported or imported quantities to individual trade partners does not take place. Therefore trade information provided by the AgLink model is mainly used for checking and comparisons. The trade division of EUROSTAT (COMEXT) provides European external trade in a bilateral way for the European aggregates and the individual Member States, usually in a high quality. However there are two problems from a CAPRI perspective. On the one hand COMEXT covers only products which are identified in the HS (or CN8) code scheme. This is perfect in the case of ethanol as undenatured as well as denatured ethanol is explicitly covered. However, as mentioned above, biodiesel which was not covered explicitly before 2008. Thus, only biodiesel trade quantities for 2008 can be taken explicitly from COMEXT. On the other hand COMEXT only reports from a European perspective, meaning that only trade flows are covered which includes the European Union or single Member States as reporters. Trade flows between non-European countries are not

covered. The only available source which covers European and non-European countries in such detail that allows for describing trade flows bilaterally is F.O.Licht. Furthermore, it includes some information about biodiesel trade. However, the data is only published for selected countries and in the case of biodiesel not before 2006. For this reason it has been decided to use the COMEXT data for ethanol and biodiesel to derive European foreign trade in a bilateral way and for aggregated import and export flows of single European Member States. In the case of ethanol the data at hand could be directly used. Only the aggregation of denatured and undenatured ethanol was required. In the case of biodiesel the available explicit data for 2008 (HS 3824 9091) is used to estimate the share of biodiesel in the former aggregates including biodiesel (HS 3824 9098 and HS 3824 9099). Therefore, the absolute value in 2008 is used to calculate the percentage share of biodiesel within the 2007 value of the aggregate HS 3824 9098. This share is assumed to be constant over time which permits a backward calculation of absolute quantities for biodiesel trade in the relevant time period 2002-2005. Data on ethanol trade between non-European countries is taken from F.O.Licht. In the case of biodiesel this data source is very limited and mainly restricted to production data (*MAPR*). Therefore, the AgLink data is taken into account which covers the main biodiesel production countries and provide consumption data (*DOMM*) as well. As in the ex-post period basically only the U.S. exported biodiesel and only the EU27 imported biodiesel the problem of the limited net-trade information provided by AgLink could be resolved assuming that all import quantities of biodiesel into the EU are exported from the USA. If no information on trade flows but production (*MAPR*) and consumption (*DOMM*) quantities are available for a respective country and year it is assumed that the difference between *MAPR* and *DOMM* is equal to an import flow (*IMPT*) if its value is negative and equal to an export flow (*EXPT*) if its value is positive. The resulting total import and export quantities of biodiesel and ethanol for European Member States and non-European countries are included within the market balances, are already displayed in Table 8.5, Table 8.1 and Table 8.3 in the ANNEX. Bilateral trade flows of ethanol and biodiesel between regions covered in the global market model of CAPRI (EU aggregates and non-European countries) are displayed for 2005 in Table 8.2 and Table 8.4 in the ANNEX.

3 Biofuel prices

For various purposes ex-post biofuel prices are required as well¹³. Furthermore, for the application of the Armington approach within the CAPRI market module (cp. Britz and Witzke, 2009) a differentiation in producer, consumer and import price is essential. These differentiated prices are currently not covered in any statistical database for biofuels, but they can be derived indirectly by given information on taxes, tariffs and subsidies from the world market price, which is available. Thus beside ex-post prices, information on consumer (excise) taxes, import tariffs and further subsidies are required. The AgLink-COSIMO database includes ex-post world market prices for ethanol and biodiesel. This price is taken as the starting point to calculate the differentiated prices in the respective countries. The import tariffs for ethanol and biodiesel are also taken from the AgLink-Cosimo database. As the consumer taxes for ethanol and biodiesel in most instances correspond to a reduced excise tax on fossil fuels the consumer taxes for gasoline and diesel are also taken into account. This tax information is taken from EurActiv¹⁴ where levels of diesel and petrol taxation in 2002 are published for European Member States. For the desired years (2002-2005) taxation levels are calculated in line with COM (2002)410¹⁵ which set minimum excise tax rates for non-commercial diesel and petrol since 2006. To identify the national excise tax exemptions and producer subsidies we screened the obligatory 'Member States reports on the implementation of Directive 2003/30/EC of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport' which are published by the Commission¹⁶. Three different types of tax regulations for biofuels are identified which are applied among the different Member States: an absolute tax for biofuels, an absolute reduction of the excise tax on fossil fuels and a relative reduction of the excise tax on fossil fuels. All differentiated in taxation for blended biofuels or pure biofuels. Based on this information the different ex-post prices for the period 2002-2005 are recalculated. As the envisaged biofuel demand functions of the endogenous biofuel market model will be functions of (among other variables) the relation between

¹³ For the baseline construction these price information is not essential as the supply, demand and trade quantities in the projection year are statistically estimated within the CAPRI trend estimation procedure. However, for the calibration of the behavioural market model they are required.

¹⁴ <http://www.euractiv.com/en/taxation/fuel-taxation/article-117495>. Extracted at 20.07.2009

¹⁵ Proposal for a Council Directive amending Directive 92/81/EEC and Directive 92/82/EEC to introduce special tax arrangements for diesel fuel used for commercial purposes and to align the excise duties on petrol and diesel fuel (COM(2002)410).

¹⁶ http://ec.europa.eu/energy/renewables/biofuels/ms_reports_dir_2003_30_en.htm. Extracted at 20.07.2009

fossil fuel consumer prices and biofuel consumer prices, entries for fossil fuel prices are also required in the database. To ensure consistency between the biofuel and fossil fuel prices, the price information for fossil fuels is also taken from the AgLink-COSIMO database which provides EU market prices for diesel and petrol. For the re-calculation of consumer prices in individual European Member States the above mentioned taxation levels for fossil fuels are applied. Because there exists a significant difference between the physical energy contents and densities of biodiesel, ethanol, petrol and diesel a direct comparison of prices (in €/t) is not possible. For this reason the prices as well as the taxation levels are converted into Euro (€) per ton of oil equivalent (toe) as displayed in Table 3.1.

Table 3.1: Factors for the transformation of ton in toe

	ton	toe
Petrol	1	1.05
Diesel	1	1.01
Biodiesel	1	0.86
Ethanol	1	0.64

4 Biofuel feedstock demand

Official and publicly available statistic sources which explicitly cover detailed information on the single feedstock used for biofuel processing over all European Member States and non-European regions could not be identified so far. Private offered data sources like F.O.Licht, which offer estimates on feedstock shares in European and global biofuel production, have not been subscribed within this analysis. On the one hand, the available monetary budget was limited and, on the other hand, it was not definitely clear if the required data is really covered in sufficient detail. Instead publicly available data sources are screened to find indirect information on biofuel feedstock use. Furthermore, several industrial associations are contacted and data on feedstock demand has been requested. However, all these sources only include very sketchy information:

In general all sources agree on the most important feedstock which is used for biofuel processing in major global production regions. FAPRI (2010) stated the basic biofuel feedstock by region as displayed in Table 4.1.

Table 4.1: Most important feedstock used for biofuel processing by region

Region	Ethanol	Biodiesel
USA	maize	soya oil
Argentina	-	soya oil
Brazil	sugar cane	soya oil
Canada	corn, wheat	-
Europe	cereals, sugar beets	rape oil
Indonesia / Malaysia	-	palm oil

Source: FAPRI (2010)

As the U.S. is currently the greatest ethanol producer, followed by Brazil, it can be assumed that the predominant share of total world ethanol is produced based on corn and sugar cane. In the case of biodiesel where the EU27 and the U.S. are the biggest producers it is obvious that firstly rape and secondly soya oil are the most important feedstock. Balat and Balat (2010) also identify rapeseed and sunflower oils as the main biofuel feedstock in the EU, whereas “[...] palm oil predominately dominates in biodiesel production in tropical countries, and soy-bean oil is the major feedstock in the United States.” Furthermore, “[...] rapeseed oil has 59% of total global biodiesel raw material source, followed by soybean (25%), palm oil (10%), sunflower oil (5%) and other (1%). Rapeseed used for biodiesel is the EU’s dominant bio-fuel crop with a share of about 80% of the feedstock. [...] Soybean oil accounts for approximately 90% of biodiesel produced in the United States”, (Balat and Balat 2010). As Argentina and other South American countries are currently significantly increasing their biodiesel production capacities it is probable that in the short-term the most important biodiesel feedstock worldwide will become soya oil. The European Bioethanol Fuel Association (EBIO) stated feedstock shares, but only for the aggregated EU27 fuel-ethanol production in 2006, 2007 and 2008 as summarized in Table 4.2.

Table 4.2: Distribution of ethanol processing demand on different feedstock in EU27

Feedstock	2006 (in %)	2007 (in %)	2008 (in %)
Wheat	37	39	27
Rye	15	3	4
Molasses	16	24	27
Barley	7	12	3
Maize	2	13	26
Raw alcohol	23	9	8

Source: EBIO (<http://www.ebio.org/product.php>), extracted at for 2006-07 at 18.07.09 and for 2008 at 22.09.10

This information is used to differentiate the use of single cereals, as well as sugar (based on molasses) and industrial alcohol for ethanol processing on the

European level. As one can observe the importance of sugar (molasses) and maize relative to wheat has increased over the past years. Given the ongoing European sugar market reform it can be expected that the share of molasses, and thereby sugar beets, in ethanol processing will further increase. An indication for this trend gives the 2008 business report of the German ethanol company CropEnergies, a subsidiary company of Südzucker, one of Germany's major sugar producers. Here it is mentioned that in financial year 2007/2008 the ethanol facility in Zeitz, Germany (annual ethanol production output of 220 thousand tons) significantly increased the feedstock share of sugar beets (nearly 40%) in relation to the foregoing years. In this way demand for cereals could be decreased (CropEnergies 2008). This trend is also observed by AFC (2008). Here it is mentioned that the share of cereals in total German ethanol production was 88%, for sugar beets 7.5%, respectively in 2007. Already in 2008 the share of cereals decreased to a level of 61%, whereas the share of sugar beets increased to a level of 36%. This aggregate information for Europe can only be used as a starting point, as the CAPRI database requires more detailed information (production shares or absolute quantities, ideally for all used feedstock and each European country). The same holds for feedstock demand information available from the AgLink-COSIMO or FAO database which only cover the EU as an aggregate as well as product aggregates like cereals or vegetable oils. Referring to this specific data requirement, some indications are provided by the British Renewable Fuel Agency (RFA 2010). In the framework of a national reporting for the British Renewable Transport Fuel Obligation they show the biofuel quantities consumed in the UK in year 2008/2009 by feedstock used and region of origin, based on industry information. An overview of this compilation is given by Figure 4.1. Regardless of the respective absolute quantities in million litres, this compilation indicates the most relevant feedstock used in important European and non-European regions. It can be seen that in the case of biodiesel, Germany predominately processes rape oil. Waste oil (e.g. used cooking oil - UCO), or other feedstock like tallow have only a marginal production share in European countries. The same is true for France and other European countries, but on a lower absolute level. The only exemption is the UK and Ireland which predominately use residues like used cooking oil or tallow. However, the absolute quantities are moderate. The information and assumptions for non-European countries from above are confirmed by the British RFA. The U.S., Argentina and Brazil basically use soya oil and Indonesia / Malaysia basically use palm oil for biodiesel production. The information on ethanol feedstock included in this source is limited as the fuel-ethanol quantities consumed in the UK are marginal relatively to biodiesel. However, it becomes obvious, that ethanol produced in the UK is predominately based on sugar beets and the Brazilian ethanol imports, as expected, are predominately rely on sugar cane.

for biodiesel waste oil is a non-negligible feedstock¹⁷. However, until 2010 these quantities might be small if not marginal relative to total European biodiesel production. The Austrian Biomass Association¹⁸ indicates that in addition to the ethanol feedstock stated by EBIO also table wine is used for ethanol production, in particular in Spain and Sweden.

So far the available statistical information, even including selected national publications, is too thin to provide underpinnings for an EU wide database. As a consequence an indirect approach has been chosen to establish this database. In several European countries and for some feedstock a positive correlation can be observed between the increase in ethanol and biodiesel production since 2002 and the evolution of industrial use (*INDM*) of agricultural crops (mainly cereals and oilseeds) as collected by EUROSTAT on the ZPA1 domain. This relation is more significant in the case of ethanol than biodiesel and not obvious for all European countries. However, lacking other statistical information it is assumed that, as a first approximation, the increase in industrial use of agricultural crops entirely results from the increase in demand for agricultural crops on the part of the biofuel processing industry. As this information is available for every European Member State and for each agricultural product within the time period 2002-2005, it is sufficient to estimate feedstock demand allocations for every EU Member State. Apart from some bounds and security mechanisms this required first to calculate the increase in the *INDM* quantities of possible biofuel feedstock before and after the biofuel boom. The share of these increases (for wheat, barley etc.) in the aggregate increase of *INDM* of potential feedstock is used to initialise the feedstock shares. This approach could be applied for all feedstock, but some pre-calculations had to be made in the case of palm oil because ZPA1 does not cover this product. Therefore palm oil market balance positions are taken from FAO data and are rendered consistent with EUROSTAT-COMEXT data on import and export quantities of crude palm oil (HS 151110) for European Member States.

In order to get a consistent dataset where the production of biofuels (*MAPR*) is equal to the sum of the inputs multiplied with the respective conversion coefficient, and to ensure closed market balances, a simple Highest Posterior Density estimator is applied, which includes the following constraints:

¹⁷ In spite of scetchy evidence that waste oil is non-negligible in some MS, it has been ignored so far is the database establishment. An option for a future update is to check the plausibility of aggregate information in PRIMES on waste oil and to include a derive estimate in the NAGR position in CAPRI.

¹⁸ Österreichischer Biomasse-Verband (<http://www.biomasseverband.at/biomasse?cid=4>), 18.07.09

- The sum of industrial use (*INDM*) and human consumption (*HCOM*) as found in ZPA1 should not deviate strongly from the corrected estimates for industrial use (*INDM*) and human consumption (*HCOM*) plus the newly introduced position “use for biofuel production” (*BIOF*).
- The production of biofuels (*MAPR*) must be equal to the sum of the processing input (*BIOF*) for the different products times their conversion coefficients.
- The *BIOF* shares should be as close as possible to the initially calculated shares above.

The calculated ex-post quantities of agricultural products used for biodiesel and ethanol production in European Member States are shown for 2005 in Table 8.6 in the ANNEX.

5 Technological parameters

Conversion coefficients for 1st generation biofuels are collected from different sources. The PRIMES database includes conversion coefficients but only for the feedstock aggregates which are covered in the PRIMES - Biomass module¹⁹ (vegetable oils, sugar crops, starchy crops and corn). As CAPRI needs coefficients for individual agricultural crops or products these parameter values are used as a starting point and additional sources have been used.

Table 5.1: Conversion coefficients for 1st generation biofuel production

Conversion coefficients (t/t)		Ethanol	Byproducts
Grains	Wheat	0.274	0.266 DDGS
	Barley	0.247	0.266 DDGS
	Oats	0.247	0.266 DDGS
	Rye	0.247	0.266 DDGS
	Corn (dry milling)	0.335	0.292 DDGS
Other	Table Wine	0.100	
Sugar crops	Sugar	0.517	- -
	Sugar beets	0.079	0.004 Vinasses*
		Biodiesel	Byproducts
Vegetable oils	Rape oil	0.922	0.100 Glycerine
	Soy oil	0.922	0.100 Glycerine
	Sunflower oil	0.922	0.100 Glycerine
	Palm oil	0.922	0.100 Glycerine

* considered as molasses (1t vinasses=0,1 t molasses equivalent) depending on the reduced sugar content
Source: Own compilation base on AgLink and PRIMES information and Szulczyk (2007)

¹⁹ Capros, et al. (2008)

The AgLink-COSIMO model (version October 2009) includes a set of conversion coefficients which are in line with the CAPRI product definition. These values have been cross-checked against other publications (i.a. Szulczyk 2007) to establish a set of validated conversion coefficients. Because the parameter values differ only in a small range the average values have been calculated and adopted for the CAPRI data base. Table 5.1 displays the set of conversion coefficients finally used for 1st generation biofuels and corresponding by-products.

Conversion coefficients for 2nd generation technologies are taken from the PRIMES model and are also compared with other literature sources. Whereas the aggregates “Agricultural residues” (*ARES*) and “New energy crops” (*NECR*) can be used for the production of Fischer-Tropsch diesel, Pyrolysis diesel, HTU diesel and Lignocellulosic ethanol, “Livestock residues” (*LRES*)²⁰ can only be used within the production of HTU diesel. As the processing of the considered agricultural residues and new energy crops to biofuels rely on the same ingredient (ligno- or herbaceous cellulosis) which has nearly the same energy content per ton dry mass in both product groups, the conversion coefficients are assumed to be equal. Table 5.2 displays the coefficients adopted for 2nd generation biofuel processing.

Table 5.2: Conversion coefficients for 2nd generation biofuel production

Conversion coefficients (t/t)	FT Diesel	FT By-product (tailgas)	Prolysis Diesel	HTU Diesel	LC Ethanol	LC By-product (lignin)
Agricultural residues*	0,700	0,250	0,236	0,278	0,147	0,120
Livestock residues**				0,278		
New energy crops***	0,700	0,250	0,236	0,278	0,147	0,120

* Grain straw and sugar beet leaves ** Cadavers, Manure *** Poplar, Willow, Miscanthus

Source: Own compilation base on AgLink and PRIMES information and Szulczyk (2007)

6 Information on alternative feedstock

Data on alternative biomass feedstock is required to introduce 2nd generation biofuel production in the model. Therefore, two alternative feedstock types are distinguished: agricultural residues (*ARES*), covering straw from cereals and oil seeds as well as leaves from sugar beets, and new energy crops (*NECR*) covering

²⁰ Finally, livestock residues (*LRES*) have not be implemented as alternative biofuel feedstock in the CAPRI biofuel module, as further necessary information on technological parameters could not be identified in a sufficient manner. However, the conversion coefficients for livestock residues (*LRES*) as shown in Table 5.2 have been stored to prepare for a future implementation of this feedstock group.

fast growing woody or herbaceous species like poplars or willows as well as gramineous species like miscanthus or switchgrass. While agricultural residues are by-products of crop or livestock production, meaning that no additional input factors like agricultural land or fertiliser are required for production (neglecting collection costs), new energy crops are produced on agricultural land as energy feedstock and thus compete with other agricultural production activities within the production decision of a farm. Some considerations are made concerning the integration of these energy crops in the model. As production data and information on production costs and input requirements are very limited in the literature they have not been integrated as an explicit production activity in the regional supply models of CAPRI. Instead they are handled exogenously, allowing to impose a given share of these crops in future agricultural supply. Thereby, the land requirement is estimated via assumed yields and leads to a decrease of available land for other agricultural production activities. Coefficients for the production of agricultural residues (*ARES*) are taken from the PRIMES model, where the evaluation and estimation of alternative biomass potentials has been done in an earlier PRIMES project, relying on Fischer et al. (2007). The applied coefficients are displayed in Table 6.1.

Table 6.1: Production coefficients for *ARES* which can be used for 2nd gen. biofuel production

	Av. production coeff.	Usability share	Water content	Av. production coeff. for usable biomass
Product	ratio	%	%	ratio
Wheat	1.23	50%	15%	0.52
Barley	1.70	50%	15%	0.72
Maize	1.50	50%	15%	0.64
Rye	2.00	50%	15%	0.85
Oats	2.00	50%	15%	0.85
Sugar Beets	0.55	50%	75%	0.07
Sunflower seed	2.63	50%	40%	0.79
Rapeseed	2.75	50%	40%	0.83

Source: Own calculation based on Fischer et al. (2007)

Table 6.2 displays the primary yield information (also derived from Fischer et al. 2007) for the estimation of land requirements of new energy crops (*NECR*) and the average yields for selected European Member States which are used in the CAPRI biofuel module. The different yield classes (depending on soil type) are adopted from the PRIMES model. Because the CAPRI model does not make such a distinction the average yields (over all yield classes) are applied. As the yields of herbaceous and woody energy crops differ only moderately a further simplification is achieved using an average aggregated yield covering both

herbaceous as well as woody crops. This allows to handle woody and herbaceous crops as one product in the model: New energy crops (*NECR*).

Table 6.2: Average yields of new energy crops

		Yields in t d.w./ha				Average yield	Average aggregated yield
		Class 1	Class 2	Class 3	Class 4		
Germany	Herbaceous	16.60	12.90	9.00	5.20	10.93	9.83
	Woody	13.40	10.40	7.10	4.00	8.73	
France	Herbaceous	18.50	14.40	9.90	5.90	12.18	10.69
	Woody	15.40	10.80	7.10	3.50	9.20	
Italy	Herbaceous	19.50	14.70	10.20	6.30	12.68	10.90
	Woody	15.10	10.80	7.10	3.50	9.13	
Great Britain	Herbaceous	14.00	11.60	8.40	4.50	9.63	9.00
	Woody	13.20	10.00	6.70	3.60	8.38	
Sweden	Herbaceous	10.90	9.60	6.90	4.10	7.88	7.27
	Woody		9.80	6.70	3.50	6.67	
Poland	Herbaceous	17.10	13.30	9.40	5.40	11.30	10.05
	Woody	13.30	10.60	7.20	4.10	8.80	
Bulgaria	Herbaceous	19.20	14.60	10.10	5.60	12.38	10.40
	Woody	13.80	9.60	6.80	3.50	8.43	

Source: Own calculation based on Fischer et al. (2007)

7 References

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8 ANNEX

Table 8.1: Ethanol market balance for EU15, EU10 and non-European countries (2005)

1000 tons		2005					
		IMPT	EXPT	DOMM	INDM	HCOM	MAPR
Norway	BIOE	9.1	6.9	2.2	2.2	0.0	0.0
Turkey	BIOE	2.3	0.1	16.9	0.0	16.9	14.7
EU15	BIOE	772.9	7.4	2,546.9	1,713.4	833.5	1,781.5
EU10	BIOE	1.6	40.0	221.1	173.6	47.5	259.5
Bulgaria, Romania	BIOE	1.4	0.0	1.4	1.4	0.0	0.0
Western Balkan	BIOE	1.6	1.6	0.0	0.0	0.0	0.0
Rest of Europe	BIOE	21.0	0.0	29.7	0.0	29.7	8.8
Russia, Belarus, Ukraine	BIOE	8.8	66.1	728.0	0.0	728.0	785.3
USA	BIOE	729.9	206.6	11,707.5	1,216.3	10,491.3	11,184.3
Canada	BIOE	124.0	22.1	361.8	0.0	361.8	259.9
Mexico	BIOE	115.8	0.8	141.9	0.0	141.9	26.9
Argentina	BIOE	1.3	42.5	90.0	0.0	90.0	131.1
Brazil	BIOE	0.9	2,047.3	9,536.6	0.0	9,536.6	11,583.0
Chile	BIOE	26.3	0.0	26.3	0.0	26.3	0.0
Bolivia	BIOE	0.9	38.7	8.8	0.0	8.8	46.6
Rest of South America	BIOE	115.6	177.5	168.2	0.0	168.2	230.0
India	BIOE	230.2	3.2	1,121.4	0.0	1,121.4	894.4
China	BIOE	24.7	81.3	2,707.0	1,544.5	1,162.5	2,763.6
Japan	BIOE	392.2	0.2	480.6	0.0	480.6	88.6
Australia, New Zealand	BIOE	9.7	36.6	84.0	71.2	12.9	110.8
LDC countries	BIOE	7.8	0.2	18.8	0.0	18.8	11.2
ACP countries	BIOE	230.2	230.4	325.3	0.0	325.3	325.5
Rest of world	BIOE	326.4	145.2	812.0	130.9	681.0	630.7

Source: CAPRI model (05.10.2010)

Table 8.2: Global bilateral trade flows of ethanol (2005)

1000 tons			2005								
			Exporter								
Importer		Total imports	EU10	RBU	USA	ARG	BRA	RSA	CHN	ACP	ROW
Norway	BIOE	9.1	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0	0.0
Turkey	BIOE	2.3	0.0	1.0	0.1	0.0	1.0	0.0	0.2	0.0	0.0
EU15	BIOE	772.9	38.5	60.9	117.0	0.3	407.2	4.3	0.0	1.9	134.1
EU10	BIOE	1.6	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Rest of Europe	BIOE	21.0	0.0	0.8	0.1	0.0	0.0	16.6	0.0	2.6	0.0
Russia, Belarus, Ukraine	BIOE	8.8	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0	0.0
USA	BIOE	729.9	0.0	0.0	0.0	39.5	229.6	156.4	25.5	220.7	1.7
Canada	BIOE	124.0	0.0	0.0	36.0	0.0	87.3	0.0	0.0	0.1	0.0
Mexico	BIOE	115.8	0.0	0.0	1.5	0.3	112.5	0.0	1.1	0.0	0.0
Brazil	BIOE	0.9	0.0	0.0	0.1	0.0	0.0	0.0	0.5	0.3	0.0
Chile	BIOE	26.3	0.0	0.0	0.0	2.4	0.2	0.0	0.0	0.0	0.0
Rest of South America	BIOE	115.6	0.0	0.0	0.0	0.1	86.2	0.0	13.9	0.0	0.6
India	BIOE	230.2	0.0	0.0	8.4	0.0	219.1	0.0	2.2	0.0	0.4
China	BIOE	24.7	0.0	0.0	0.0	0.0	24.4	0.0	0.0	0.1	0.0
Japan	BIOE	392.2	0.0	0.0	0.1	0.0	373.7	0.0	9.7	0.0	7.7
Australia, New Zealand	BIOE	9.7	0.0	0.0	0.2	0.0	9.0	0.0	0.0	0.0	0.6
LDC countries	BIOE	7.8	0.0	0.0	0.1	0.0	4.4	0.0	0.2	2.1	0.0
ACP countries	BIOE	230.2	0.0	0.0	0.4	0.0	214.8	0.1	9.9	0.0	0.0
Rest of world	BIOE	326.4	0.0	1.7	24.1	0.0	277.0	0.0	18.1	2.6	0.0
		Total exports	40.0	66.1	206.6	42.5	2047.3	177.5	81.3	230.4	145.2

Source: CAPRI model (05.10.2010)

Table 8.3: Biodiesel market balance for EU15, EU10 and non-European countries (2005)

1000 tons		2005			
		IMPT	EXPT	DOMM	MAPR
EU15	BIOD	59.4	65.4	2,903.3	2,909.4
EU10	BIOD	10.8	288.2	56.5	333.9
Bulgaria, Romania	BIOD	0.4	12.1	2.1	13.9
USA	BIOD	28.1	106.3	101.1	179.3
Canada	BIOD	0.7	0.0	2.1	1.4
Rest of South America	BIOD	0.7	0.0	18.2	17.5
Rest of world	BIOD	372.0	0.0	372.0	0.0

Source: CAPRI model (05.10.2010)

Table 8.4: Global bilateral trade flows of biodiesel in 2005

1000 tons			2005			
			Exporter			
Importer		Total imports	EU15	EU10	BUR	USA
EU15	BIOD	59.4	0.0	4.2	0.0	55.1
EU10	BIOD	10.8	10.8	0.0	0.0	0.0
Bulgaria, Romania	BIOD	0.4	0.4	0.0	0.0	0.0
USA	BIOD	28.1	28.1	0.0	0.0	0.0
Canada	BIOD	0.7	0.7	0.0	0.0	0.0
Rest of South America	BIOD	0.7	0.7	0.0	0.0	0.0
Rest of world	BIOD	372.0	24.7	284.0	12.1	51.2
		Total exports	65.4	288.2	12.1	106.3

Source: CAPRI model (05.10.2010)

Table 8.5: Biofuel market balance for European countries in 1000tons (2005)

1000 tons		2005					
		IMPT	EXPT	INDM	HCOM	MAPR	DOMM
BL	BIOE	146.0	55.7	89.3	0.9	0.0	90.3
	BIOD	0.0	0.0	0.0	0.8	1.0	0.8
DK	BIOE	29.2	11.0	34.1	0.4	16.3	34.5
	BIOD	0.0	61.0	0.0	10.2	71.1	10.2
DE	BIOE	456.2	109.2	359.4	247.0	259.4	606.4
	BIOD	3.9	0.0	0.0	1,639.6	1,635.6	1,639.6
EL	BIOE	1.8	0.1	1.6	0.0	0.0	1.7
	BIOD	0.0	2.6	0.0	0.5	3.0	0.5
ES	BIOE	41.0	26.4	138.8	169.2	293.4	308.0
	BIOD	163.2	89.5	0.0	145.2	71.5	145.2
FR	BIOE	155.0	267.9	494.1	111.4	718.4	605.5
	BIOD	0.3	106.3	0.0	376.1	482.2	376.1
IR	BIOE	8.7	0.4	8.3	0.1	0.0	8.4
	BIOD	1.0	5.1	0.0	0.8	4.9	0.8
IT	BIOE	128.7	73.1	179.2	1.8	125.4	181.0
	BIOD	12.2	225.5	0.0	174.7	388.1	174.7
NL	BIOE	265.5	192.6	78.3	0.8	6.3	79.2
	BIOD	0.0	0.0	0.0	0.0	0.0	0.0
AT	BIOE	48.7	3.0	50.7	0.5	5.4	51.1
	BIOD	1.1	42.3	0.0	42.1	83.3	42.1
PT	BIOE	11.0	0.1	10.8	0.1	0.0	10.9
	BIOD	0.0	0.9	0.0	0.2	1.0	0.2
SE	BIOE	140.0	36.6	11.1	216.6	124.2	227.7
	BIOD	6.6	0.0	0.0	7.6	1.0	7.6
FI	BIOE	26.7	0.0	26.4	0.3	0.0	26.7
	BIOD	0.0	0.0	0.0	0.0	0.0	0.0
UK	BIOE	241.3	161.5	243.0	64.8	227.9	307.8
	BIOD	0.0	24.8	0.0	25.2	50.0	25.2
CY	BIOE	0.0	0.0	0.0	0.0	0.0	0.0
	BIOD	0.2	1.0	0.0	0.2	1.0	0.2
CZ	BIOE	4.0	5.7	2.6	0.1	4.4	2.8
	BIOD	0.0	121.1	0.0	9.3	130.3	9.3
EE	BIOE	2.3	0.8	1.4	0.0	0.0	1.4
	BIOD	0.0	6.0	0.0	1.1	7.0	1.1
HU	BIOE	2.9	15.7	32.9	0.4	46.0	33.2
	BIOD	0.0	0.0	0.0	0.0	0.0	0.0
LT	BIOE	3.7	5.0	5.0	0.1	6.3	5.0
	BIOD	0.0	4.4	0.0	2.5	6.9	2.5
LV	BIOE	2.7	5.2	7.1	0.1	9.7	7.2
	BIOD	2.9	5.3	0.0	2.5	4.9	2.5
MT	BIOE	0.0	0.0	0.0	0.0	0.0	0.0
	BIOD	0.0	1.7	0.0	0.3	2.0	0.3
PL	BIOE	3.7	37.6	111.6	43.0	188.6	154.6
	BIOD	15.0	101.2	0.0	11.9	98.0	11.9
SI	BIOE	5.0	0.0	5.0	0.1	0.0	5.0
	BIOD	0.0	6.8	0.0	1.2	8.0	1.2
SK	BIOE	6.7	1.1	5.6	0.1	0.0	5.6
	BIOD	0.0	65.6	0.0	10.9	76.4	10.9
BG	BIOE	2.3	0.9	1.3	0.0	0.0	1.4
	BIOD	0.0	0.0	0.0	0.0	0.0	0.0
RO	BIOE	0.0	0.0	0.0	0.0	0.0	0.0
	BIOD	0.0	0.0	0.0	0.0	0.0	0.0
EU27	BIOE	1,733.1	1,009.5	1,897.6	857.6	2,031.6	2,755.2
	BIOD	206.3	870.8	0.0	2,462.7	3,127.3	2,462.7
EU15	BIOE	1,699.8	937.5	1,725.1	813.9	1,776.7	2,539.0
	BIOD	188.3	557.9	0.0	2,423.0	2,792.7	2,423.0

Source: CAPRI model (05.10.2010)

Table 8.6: Feedstock demand for 1st gen. biofuel production in the EU (2005)

1000t		2005											
		SWHE	RYEM	BARL	OATS	MAIZ	OCER	TWIN	SUGA	RAPO	SUNO	SOYO	PLMO
BL	BIOF	0	0	0	0	0	0	0	0	1	0	0	0
DK	BIOF	3	0	39	0	0	0	0	6	51	0	0	18
DE	BIOF	219	133	0	59	120	57	0	0	1,208	0	0	301
EL	BIOF	0	0	0	0	0	0	0	0	0	0	0	4
ES	BIOF	60	0	129	45	155	0	140	112	0	53	0	15
FR	BIOF	370	0	0	0	403	0	0	435	337	28	0	90
IR	BIOF	0	0	0	0	0	0	0	0	0	0	0	4
IT	BIOF	115	0	0	0	138	0	0	0	245	41	0	72
NL	BIOF	10	0	3	0	1	0	0	0	0	0	0	0
AT	BIOF	0	0	9	0	5	0	0	0	52	0	21	0
PT	BIOF	0	0	0	0	0	0	0	0	0	1	0	0
SE	BIOF	272	0	0	0	0	0	0	0	1	0	0	0
FI	BIOF	0	0	0	0	0	0	0	0	0	0	0	0
UK	BIOF	511	0	0	0	0	0	0	0	31	0	0	20
CY	BIOF	0	0	0	0	0	0	0	0	0	0	0	0
CZ	BIOF	7	0	0	0	3	2	0	0	78	0	33	5
EE	BIOF	0	0	0	0	0	0	0	0	3	0	2	0
HU	BIOF	22	0	92	0	0	0	0	13	0	0	0	0
LT	BIOF	0	0	10	0	0	7	0	0	0	0	0	6
LV	BIOF	6	0	11	0	4	5	0	0	5	0	0	1
MT	BIOF	0	0	0	0	0	0	0	0	0	0	0	2
PL	BIOF	0	0	309	0	294	0	0	0	65	8	6	18
SI	BIOF	0	0	0	0	0	0	0	0	2	3	2	1
SK	BIOF	0	0	0	0	0	0	0	0	0	14	12	3
BG	BIOF	0	0	0	0	0	0	0	0	0	0	0	0
RO	BIOF	0	0	0	0	0	0	0	0	0	0	0	0
EU27	BIOF	1,596	133	601	104	1,120	71	140	566	2,079	149	77	560
EU15	BIOF	1,562	133	180	104	821	57	140	553	1,926	123	22	524

Source: CAPRI model (05.10.2010)