German Biomass Sustainability Ordinance

Commentary Paper to the draft dated December 5th, 2007

Institut für Energetik und Umwelt
gemeinnützige GmbH

Institute for Energy and Environment

Commentary Paper for the Draft on the German Biomass Sustainability Ordinance (BioNachV) from December 5th, 2007

2008

Geschäftsführer / Managing Director:
Prof. Dr.-Ing. Martin Kaltschmitt
Handelsregister: Amtsgericht Leipzig HRB 8071
Sitz und Gerichtsstand Leipzig

Deutsche Kreditbank AG
(BLZ 120 30 000)
Kontonr.: 1364280

Stadt- und Kreissparkasse Leipzig
(BLZ 860 555 92)
Kontonr.: 1100564876

Zert.-Nr. 12100105

Principal: **UFOP**
(Union for the Promotion of Oilseeds and Protein Plants reg. Ass.)
Haus der Land- und Ernährungswirtschaft

Claire-Waldoffstr. 7

10117 Berlin

www.ufop.de

Agent: **Institut for Energy and Environment gGmbH (IE)**

Torgauer Straße 116

04347 Leipzig

☎: +49 (0) 341 / 24 34 – 112

✉: info@ie-leipzig.de

Dipl.-Ing. Stefan Majer

☎: 03 41 / 24 34 - 4 11

✉: Stefan.Majer@ie-leipzig.de

Dipl.-Ing. Gerd Schröder

☎: 03 41 / 24 34 - 4 27

✉: Gerd.Schroeder@ie-leipzig.de

Table of contents

1 Introduction

There are two requirements established in the draft of the "German Biomass Sustainability Ordinance" (BioNachV):

Bio-fuels may only be taken into account if they meet the needs according to § 37a paragraph clause 1 and 2 in connection with § 37a paragraph 3 of the Federal Immission Control Act (Germany), provided if it **can be proven that**:

1. They comply with the requirements mentioned in § 2 regarding the **sustainable cultivation of agricultural areas** and the requirements mentioned in § 3 for the **protection of natural habitats,**
2. The bio-fuels have a determined **greenhouse gas (GHG)–reduction potential** according to § 4 paragraph 1.

The requirements indicated under point 1 are considered to be fulfilled, if the biomass was generated according to the good technical practice in land, forest and fishing economy. There are partly comparable regulations valid for bio energy sources generated outside Europe.

The used bio-fuel must possess a determined greenhouse gas – reduction potential that has to be proven by the generator or user so that the obligations can be fulfilled according to the BimSchG (Federal Immission Control Act.) There is no specification in the draft of the BioNachV about the basis or method that has to be considered for the environmental assessment of this proof. It is possible to provide a proof of the greenhouse gas – reduction potential, for instance, through a so-called "LCA" (Life Cycle Assessment).

The concept of LCA as a method of ecological assessment will be explained in greater detail in the following chapter (Chapter 2), before we go further to the proper discussion of the draft with regard to BioNachV and the methods used to determine the greenhouse emissions. According to the agreement, the following considerations will focus on these topics: allocation methods for the consideration of co-products (Chapter 3), land use change according to IPCC (Intergovernmental Panel on Climate Change) (Chapter 4) and discussion of the table "default values" from annex 2 of the draft (Chapter 5). The requirement mentioned under point 1 with respect to the sustainable cultivation and conservation of natural habitats will not be treated within this discussion paper.

2 Basic principles of the ecological assessment

It is possible to supply a wide range of information on the “environmental demands” of a product or a service with the help of an LCA. Environmental demands can be interpreted in this context, both as environmental impacts caused by pollutant emissions, and as resource extraction. There are two objectives that can be roughly differentiated when applying an LCA:

- LCAs for the comparison of several products and
- LCAs for the ecological optimization of the life cycle of a product.

The methodology based on LCA can be viewed comprehensively in two respects. For one thing, the system boundaries in which the environmental impacts are determined is very large. It generally comprises the overall product life cycle, starting with the extraction of all raw materials (“from cradle”) through to the utilization of the product and the disposal of all intermediate or waste products (“to grave”). On the other hand, the impacts regarding the very different environmental impact categories can be investigated by means of this method. For example, in addition to the consumption of exhaustible energy sources and to the contribution to the anthropogenic greenhouse effect, the contribution to the acidification and to other impact categories can be investigated in LCAs.

The LCA method is defined within the international norms DIN ISO 14040 and 14044 (2006) /1/, /2/. According to these international standards an LCA consists of four steps: the goal and the scope definition, ecological inventory or LCI[1] (life cycle inventory), impact assessment and interpretation. Each single step is represented in the Figure 2-1:

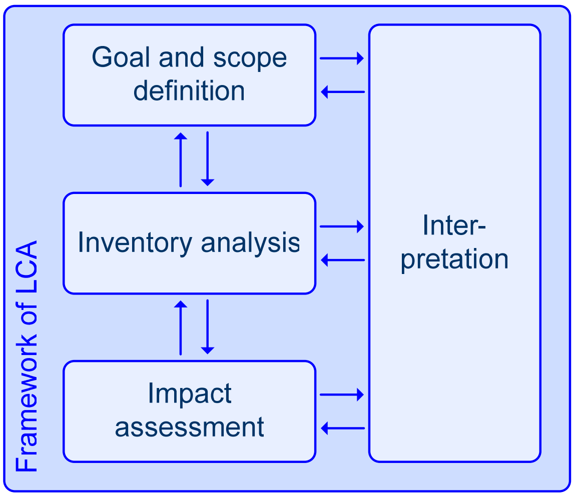


Figure 2-1 Life cycle assessment framework according to /1//2/

[1] Essential part of the LCA, that includes the composition and quantification of inputs and outputs of a given product along its life cycle.

In order to carry out a verification of a greenhouse reduction potential for a bio-fuel by using an LCA, it is necessary to define an comparison with equivalent, conventional fuels as reference and the analysis of the fuels in the overall life cycle, starting from the preparation (of preliminary products as well) on to the utilization and the possible disposal of waste and by-products, as **goal and scope definition**.

The comparison of the environmental impacts of the different bio-fuels should be drawn on the basis of a uniformly functioning unit. In this case, it is recommendable to use the amount of fuel with the energy content of a GJ as functional unit. In the draft of the BioNachV, expected environmental impacts should be considered based on land use changes (LUC) by cultivating biomass for fuel production in the face of the practice used so far. In most cases, this position has not been taken into account in former LCAs (compare /7/). However the consideration of this point seems to be important in the sense of the international consideration and integration of the bio-fuel production. A time span under consideration of 20 years is usually taken into account for environmental impacts based on land use changes in accordance with the IPCC calculation procedure (this topic will be tackled later and in more detail in section 4).

The **LCI** is generally performed in the form of a so-called “process chain analysis”. This rests on the connection of single processes based on physical quantities. There is an example of a process chain represented in the Figure 2-2.

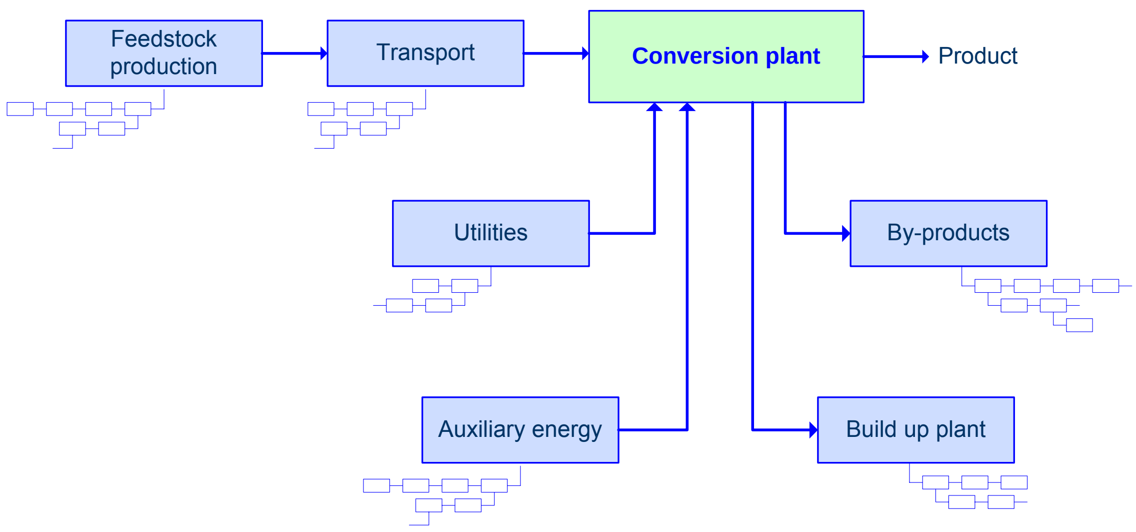


Figure 2-2 Schematic presentation of a process chain

The advantages of an LCI using a process chain analysis lie in the possibility of representing the life cycle in greater detail and, therefore, to exactly determine the cumulated demands made on the environment. The way the co-products or by-products that occur as a result of creating the actual product are dealt with always represents a critical point from the perspective of an LCA. Outside of the possibility of assigning the generated emissions or environmental impacts to main and by-product with the help of an allocation, co-products and by-products can also be adequately considered by means of a system enhancement or a credit/substitution system /1/, /2/.

Both methods are summarized and compared with one another in Table 2-1:

Table 2-1 Confrontation between allocation and substitution / enhancement of system boundaries

	Allocation	Substitution / enhancement of system boundaries
Specification	High value products along the entire production chain are responsible for environmental impacts	Co-products of the production chain make alternative production in society obsolete
Principle	Allocation of Co-products as environmental impact	Verification of causalities; co-products substitute other products
Approach	Sub-division of environmental impacts onto one or more products	Credits, that are subtracted from entire system

A clear regulation was laid down in the draft of the BioNachV for the treatment with co-products and their consideration in form as an allocation (see Chapter 3).

The information derived from the LCI is aggregated in the step related to the **impact assessment**, then compacted and evaluated with regard to the possible environmental impacts. In this context, single environmental impacts are attributed to certain impact categories and their influence on the respective category is determined with help of defined category indicators.

In Table 2-2 some impact categories that can be observed in an LCA, are represented next to the possible conversion factors of single category indicators.

Table 2-2 Possible environmental impacts of products or services

Environmental impact	Characteristics
Natural resources: Cumulated (primary) energy demand	Cumulated use of energy resources with focus on fossil energy carriers (e. g. coal, natural gas, oil, uranium)
Global Climate Change	Global warming and change of the atmosphere through anthropogenic green house gas (GHG) emissions; basically: CO_2 (equal to 1 CO_2-eq) and other gaseous emissions: CH_4 (21 CO_2-eq), N_2O (310 CO_2-eq)
Acidification	Change of the natural equilibrium of acidity in soil and ground water due to gaseous emissions of acidifying substances like SO_2 and equivalents; e.g. NO_x (0,7 SO_2eq), NH_3 (1,88 SO_2eq), HCl (0,88 SO_2eq)
Eutrophication	Release of nutrients to soil and ground water due to PO_4^{3-} and equivalents NO_x (0,13 PO_4^{3-}eq), NH_3 (0,35 PO_4^{3-}eq)
Smog, Photo-oxidant formation	Photochemical ozone or other photo-oxidant creation in the atmosphere due to sunlight and the presence of NO_x or other catalyst (e.g. CFC)
Stratospheric Ozone Depletion	Depletion of the stratospheric ozone layer due to substances like e.g. CFC, N_2O
Human Toxicity	Human toxic impact of small particles (PM10) in the air; direct or indirect effects through e.g. NO_x, CFC, NH_3, SO_2

Only the impact category "Global Warming Effect" is investigated within the framework of the draft of the BioNachV by taking into account the greenhouse gas emissions from the production of a bio-fuel compared with equivalent fossil fuels.

In the last step of the LCA, namely the **interpretation**, the results obtained in the previous steps are evaluated with regard to the set goal and scope of the LCA. A further aspect of the interpretation is to carry out sensitivity analyses. Also with that, how large of an effect the changes to the boundary conditions have; what the balancing is based on; and the total results of the balancing. This way, the partial processes that have a strong influence on the final result (in this case, e.g., land use change) as well as assumptions for the calculation methodology (e.g. allocation methods) should be taken into account. In the last step of the interpretation, namely the conclusions, the results of the previous steps are summarized and interpreted. The methodology used for the allocation method and a possible influence on the final result will be more detailedly explained later.

3 Allocation method in ecological assessments and in the draft concerning BioNachV

3.1 Basic principles

When assessing and specially when comparing different products the equality of benefits[2] of the considered product systems represents an important criterion for the comparability. Different co-products[3] can occur during the production of bio-fuels depending on the raw material used. The following question arises against the background of comparing bio-fuels with fossil fuels and the requirement of an equality of benefits: How must these co-products be taken into consideration in view of the interpretation? In order to clarify the term of co-product, the following Figure 3-1 shows an extract derived from the process chain for the manufacture of bioethanol from grain. Distillers wash is produced as co-product in the distillation process that continues to be used in different ways.

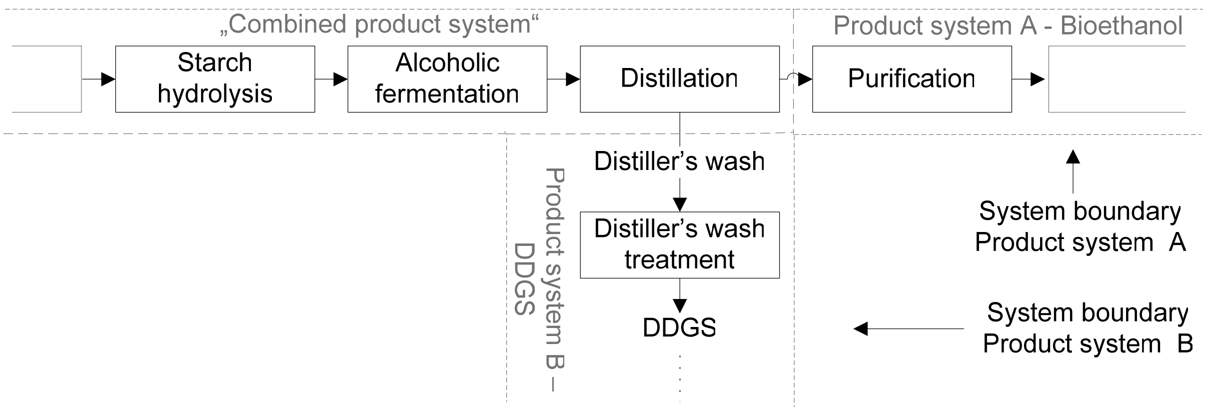


Figure 3-1 Co-production when producing ethanol from grain

[2] The concept of equality of benefits encompasses both the primary use of a product system (the provided product) as well as possible additional uses that can be created in the form of co-products.

[3] Definition of co-product: one of two or more products from the same process module or product system.

The so-called DDGS (Dried Distillers Grains with Solubles) is produced later from the distillers wash and sold as a product on the fodder market. That is why the processes up to the ethanol purification have to be attributed to both product systems and the occurring potential environmental impacts have to be shared between the involved product systems.

The choice of such a distribution method (allocation[4] method) has a considerable influence on the final result of the performed balance. Therefore, the DIN EN ISO 14044 for LCAs says: "wherever possible, an allocation should be avoided….". Such an allocation avoidance can happen in different steps (compare /1/, /2/). If an allocation avoidance is not possible, the norm requires that a sensitivity analysis be carried out in order to document the effects of the possible allocation methods on the final result. This shall clarify at this point that the "problem" of the allocation represents an absolutely critical and frequently discussed point in connection with the LCAs.

Co-products were differently considered and viewed in previous studies that dealt with the ecological assessment (that does not inevitably mean eco-balancing according to the valid DIN EN ISO) of bio-fuels. A kind of "credit/substitution method" was often applied if certain products were substituted by created co-products (e.g. "feed credit" for the rapeseed extraction meal as an example from the biodiesel production"). Although this method is not planned according to the valid DIN norm for LCAs, it can be appropriate in assessments that are not subject to a defined procedure.

The following Table 3-1 provides an overview on the common co-products found in the production of certain bio-fuels and the most typical ways they are considered in ecological assessments.

[4] Definition allocation: Partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems. /1/

Table 3-1 Common co-products found in the production of certain bio-fuels and their utilization

Bio-fuel/feedstock	Co-product	Process of production	Possible way of use	Current way of validation
Biodiesel/Rape	Rape cake	Pressing of oil	Used as animal feed	„Credit" due of the substitution of usually applied animal feed (e.g. cereals)
Bioethanol/cereal	Distillers wash	Distillation	Processing of distillers wash to DGGS and use as animal feed	„Credit" due of the substitution of usually applied animal feed (e.g. cereals)
Bioethanol/sugar beet	Pressed pulps	Pre-treatment of sugar beet	Used as animal feed	„Credit" due of the substitution of usually applied animal feed (e.g. cereals)
	Distillers wash	Distillation	Use as animal feed possible	„Credit" due of the substitution of usually applied animal feed (e.g. cereals)
Biomethane/Corn, cereals	Digestate	Anaerobe Fermentation	Fertilizer	„Credit" due of the substitution of usually applied fertilizers

3.2 Effects of different allocation approaches

According to the draft on the BioNachV a "greenhouse gas reduction potential" (of 30 % or 40% after January 01, 2001) must be proven, while generating so-called bio-fuels in comparison to fossil fuels. In order to calculate this potential, the ordinance draft proposes a concrete method in which it is also clearly defined how to deal with the resulting co-products. Such a general definition of the applied allocation method can be quite useful within the framework of a simplified greenhouse gas balance. By using this step, it is possible to simplify the method, to reduce the effort and, especially, to guarantee a long term comparability of the results.

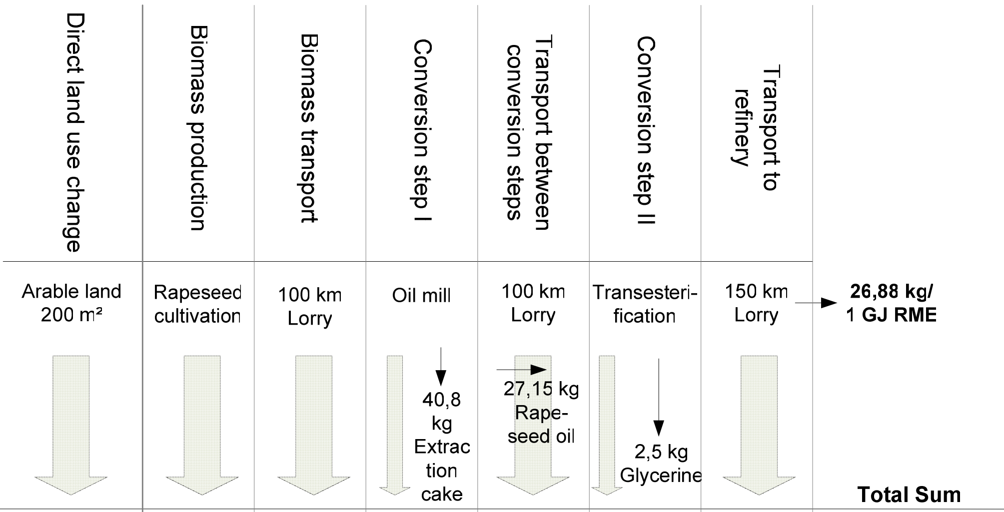
As for co-products, an allocation based on the lower heating values must be carried out and considered in future calculations of the "greenhouse gas reduction potential" of bio-fuels. At this point, it should be at least mentioned that allocation methods based on other physical relationships (e.g. mass or exergy content) would have been feasible too. For example, the monetary assessment of a co-product would be also possible in exceptional cases with respect to ecological assessments that are not tied to an defined method. This could be helpful if economical values better represent the market value of a co-product than would be possible when only using physical relationships.

However, an allocation based on physical quantities is in most cases preferable to a monetary assessment when carrying out a LCA according to the valid DIN norm (provided that a general allocation avoidance is not possible).

It is rather difficult or absolutely impossible to make a general statement to find out which of the allocation approaches for the determined calculation method concerning the “greenhouse gas reduction potential” of bio-fuels is the most suitable. It is much more important that the bio-fuel manufacturer, who will be subject to a future certification in accordance with the BioNachV, is aware of the effects the determined allocation method will have on the result of their special greenhouse gas balance. It is quite possible that the results of future calculations, within the framework of the BioNachV, will clearly differ from the results of previous ecological assessments because of different considerations of the co-products.

In order to clarify this aspect, the influence of the chosen allocation method should be clearly explained by the two following examples. Both examples are based on the values of the so-called “default table” from the annex 2 of the BioNachV. The first example is represented in Figure 3-2 and deals with the production of biodiesel based on the raw material rape seed. So-called rapeseed extraction cake is produced in the first conversion step of the biomass (This includes the processes of pressing and extracting of oil and the refining of rapeseed oil). This can be sold as an independent product on the feed market. The second co-product that occurs in the production of RME (rapeseed methyl ester) is glycerine. Glycerine is produced in the so-called conversion step 2. This step comprises the processes of transesterification (using methanol, caustic soda and hydrochloric acid) and the processing of glycerine. The objective is to distribute the environmental impacts that occurred up to the moment of separation of the product systems (after conversion step 1, the product system of the extraction cake separates from the one for the production of glycerine/RME, after conversion step 2 the product system glycerine separates from the product system RME) in accordance with the concerned product systems. The calculation of this distribution is carried out in the example according to three different allocation approaches.

The first approach is an allocation according the lower heating value (also called net calorific value), as will be indicated by BioNachV in the future. In the first step, the allocation of glycerine is performed. Approx. 2.5 kg of glycerine and 26.9 kg of RME are produced in the conversion step 2 as well as approx. 8.2 kg of CO_2. In case of an allocation according to the lower heating value, these emissions would be assigned to the product glycerine at approx. 4% and at approx. 96% to the product RME (26.8 kg *37.2 MJ/kg (heating value RME) + 2.5 kg * 17 (heating value glycerine) ~ 1042.4 MJ, share glycerine = 42.5 MJ ~ 4%. This allocation is valid up to the process steps that are also “used” by the resulting extra product rapeseed extraction cake. A new distribution of CO_2-emissions takes place between the intermediate product and the rapeseed oil when starting from the conversion step 1. This distribution happens analogously to the allocation between RME and glycerine and is valid for the processes from the conversion step 1 up to the distribution of the emissions through the land use changes.



	Direct land use change	Biomass production	Biomass transport	Conversion step I	Transport between conversion steps	Conversion step II	Transport to refinery	Total Sum
GHG emission:	**54,9**	**48,8**	**0,7**	**12,1**	**0,2**	**8,2**	**0,3**	**125,3 kg CO_2-Eq.**
1. Allocation acc. to the LHV*								
Allocation factor	59,7 %	59,7%	59,7%	59,7%	96%	96%	100%	
GHG emission related to RME	32,8	29,1	0,4	7,6	0,2	7,6	0,3	**78,1 kg CO_2-Eq./ GJ RME**
2. Allocation acc. to mass								
Allokationsfaktor	39 %	39%	39%	39%	92%	92%	100%	
GHG emission related to RME	21	18,8	0,3	4,7	0,2	7,5	0,3	**52,8 kg CO_2-Eq./ GJ RME**
3. Substitution method								
Credit				13,1		2,9		**109,2 kg CO_2-Eq./ GJ RME**

*LHV = lower heating value

Figure 3-2 *Process flow in the production of RME and subdivision of the occurring protential environmental impacts between main and co-products /6/, /8/, own calculations*

The second allocation approach represented in the Figure 3-2 suggests a distribution of the occurring emissions based on the masses of the products created. The distribution of the occurring emissions would be performed here e.g. at 92% for RME and at 8% for glycerine (2.5 kg + 26.88 kg = 29.4 kg, contribution of glycerine to the total amount ~ 8%). The allocation of the process steps starting from the land use change up to the conversion step 1 takes place in an analogical way.

For the third example, the Figure 3-2 shows a distribution of the occurring emissions based on a so-called credit. This method can cause the strongest result fluctuations since it depends on certain simplifying suppositions (e.g. the question which product can be substituted by the created co-product). In the represented example it was supposed that the produced glycerine substitutes an equivalent product coming from the chemical industry. Rapeseed extraction cake would be able to substitute an equivalent feed (e.g. barley). The CO_2-emissions that would be generated in the "conventional" production of these substituted products, are considered as credit and subtracted from the CO_2-impacts of the product system RME. Nevertheless, one must pay attention to the fact that the "conventional production" of the substituted products often differs from the production of the co-products.

Due to this fact, when using the "credit method" it is difficult to determine the exact contribution of a co-product to the total occurring emissions and, according to this, to separate it from the emissions caused by the "main product". Furthermore, the credit often takes place at a certain point of the product life cycle (e.g. of the conversion). This complicates a fine and exact classification of the emissions that occurs along the different life cycle sections.

When using such a substitution method it must be checked exactly whether the choice of the used system boundaries had been the same for all the considered products. If this is not so, it can cause a clear result shift. One should also bear in mind that, as for the relevant example, the influence of the land use change has not yet been considered in the conventional production of the co-products. The amount of the "credited" CO_2-emissions could still grow according to this and the total result could shift in favour of the product RME.

Figure 3-3 again shows the different results of the three allocation approaches. In order to provide a better comparison of the three allocation approaches, the influence of the direct land use changes were disregarded here.

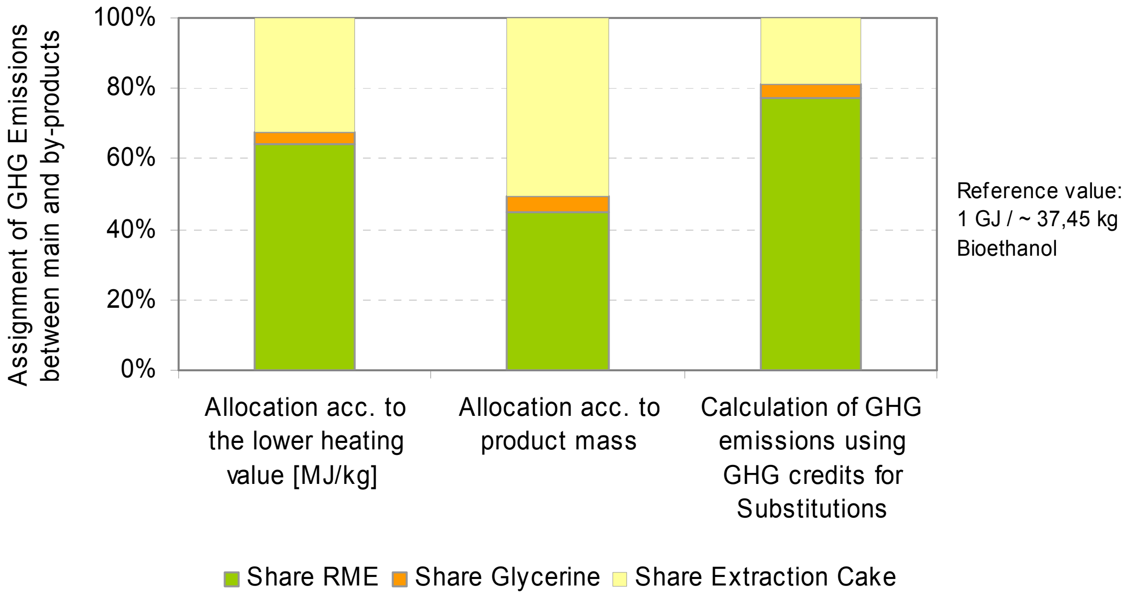


Figure 3-3 Graph of the influence of the allocation on the total result explained by the example of the bio diesel production

It is clear to see that the second-biggest part would be attributed to the main product RME in case of a distribution of CO_2-emissions based on the masses of the created products. Accordingly, the biggest quantity would be obtained in the production of the by-product extraction cake. When applying the other two allocation keys that were observed, the results shifted to detriment of the RME products.

Along the lines of this first example, the following Figure 3-4 shows the process flow for the production of bioethanol out of wheat. There were three different allocation approaches observed here as well. The calculation was performed analogously to the example set for biodiesel.

	Direct land use change	Biomass production	Biomass transport	Conversion step I	Transport between conversion steps	Conversion step II	Transport to refinery	
	Greenland → Acre 174 m²	Wheat seed cultivation	100 km Lorry	not applicable	not applicable	Fermen-tation → 51,5 kg DDGS	150 km Lorry	→ 37,5 kg/ 1 GJ Ethanol
								Total Sum
GHG emission:	**47,8**	**40,7**	**1,3**	**-**	**-**	**62,6**	**0,4**	**152,8 kg CO_2-Eq.**
1. Allocation acc. to the LHV*								
Allocation factor	55 %	55%	55%	-	-	55%	100%	
GHG emission related to EtOH	26,2	22,3	0,7	-	-	34,3	0,4	**83,9 kg CO_2-Eq./ GJ EtOH**
2. Allocation acc. to mass								
Allocation factor	42 %	42%	42%	-	-	42%	100%	
GHG emission related to EtOH	20,1	17,1	0,55	-	-	26,3	0,4	**64,5 kg CO_2-Eq./ GJ EtOH**
3. Substitution method								
Credit						22,7		**130,1 kg CO_2-Eq./ GJ EtOH**

*LHV = lower heating value

Figure 3-4 Process flow in the production of bioethanol and distribution of the obtained potential environmental impacts over the main and co-products /6/, /8/, own calculations

The same restrictions as in the example of the product biodiesel are valid for the substitution method considered in this example. The results of this example and the influence of the allocation methods on the total result are represented in the following Figure 3-5.

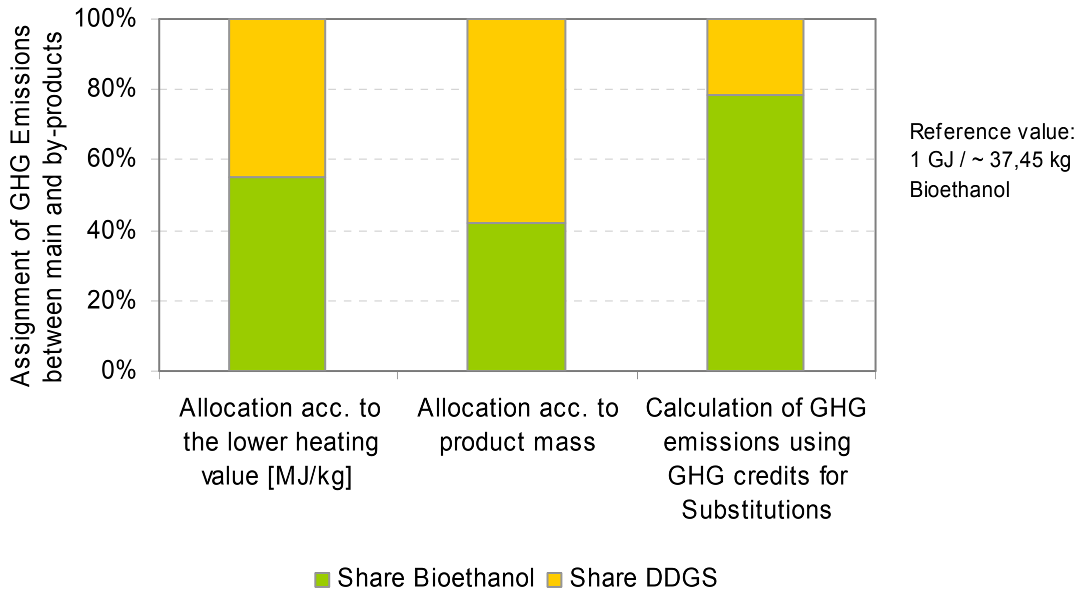


Figure 3-5 Graph of the influence of the allocation on the total result following the example of the bioethanol production

In this example, there are also clear result divergences. Due to the high amount of distillers wash or the obtained DDGS, the second-biggest contribution would be assigned to the product system bioethanol in an allocation based on the masses. When using the other two considered allocation keys the result shifts to the detriment of the product bioethanol.

3.3 Conclusion

Against the background of a future certification of bio-fuels and of the relevant calculations of a “greenhouse gas reduction potential”, the definition of a single allocation method is quite appropriate for the consideration of co-products. This step leads to a simplification of the calculation and a reduction of the effort. A unified method simplifies above all the comparability of calculated greenhouse gas balances.

It is important for bio-fuel producers to exactly estimate the given allocation method regarding the result of future calculations. Great importance is attached to this fact since the results of future calculations can diverge considerably from previous results due to changes in the calculation methodology.

It is necessary to prove in the individual cases whether such a possible development allows for a different and appropriate use of co-products obtained. It would be possible to use certain co-products in the actual (core) product system. Thus, the distillers wash obtained in the ethanol manufacture could be fermented and the resulting biomethan could serve to cover the energy demand for the process. In this way, the emissions that result from the production of the distillers wash would be assigned to the ethanol production system, but this would conversely result in a cost savings of primary energy. However, it is necessary to check the individual cases in order to determine the best possible method.

4 Aspects of the land use change

4.1 Basic Principles

According to the draft on BioNachV it is intended to consider possible land use change effects in view of the certification of bio-fuels and in the calculation of greenhouse gas balances (GHGB). This point was hardly or only insufficiently taken into consideration in previous ecological assessments of bio-fuels (compare /7/). Nevertheless, this approach also seems to be quite practical for the consideration of possible environmental impacts caused by the exploitation of areas under cultivation of raw material for the bio-fuel production. In this context, the carbon storage capacity of soils and vegetation is taken into account. A change of the sort of land use can cause an increase or decrease of the stored carbon amount. Natural CO_2-reductions of the global carbon cycle can continue to be lost due to the destruction of natural ecosystems (e.g. destruction of natural rain forest in South America for the cultivation of sugar cane or soy). This circumstance can be at least considered as an approach by taking into account the land use changes in ecological assessments. The following Figure 4-1 clarifies the influence of the use type of an area on the carbon amount stored in soil and vegetation. Therefore, a natural ecosystem is converted into an agriculturally used area as shown in the first example (in this case a forest area). The total amount of stored carbon (represented by the yellow line) falls due to the change of the use type. In the second considered time period there is no more change of land use. The amount of the stored carbon remains constant.

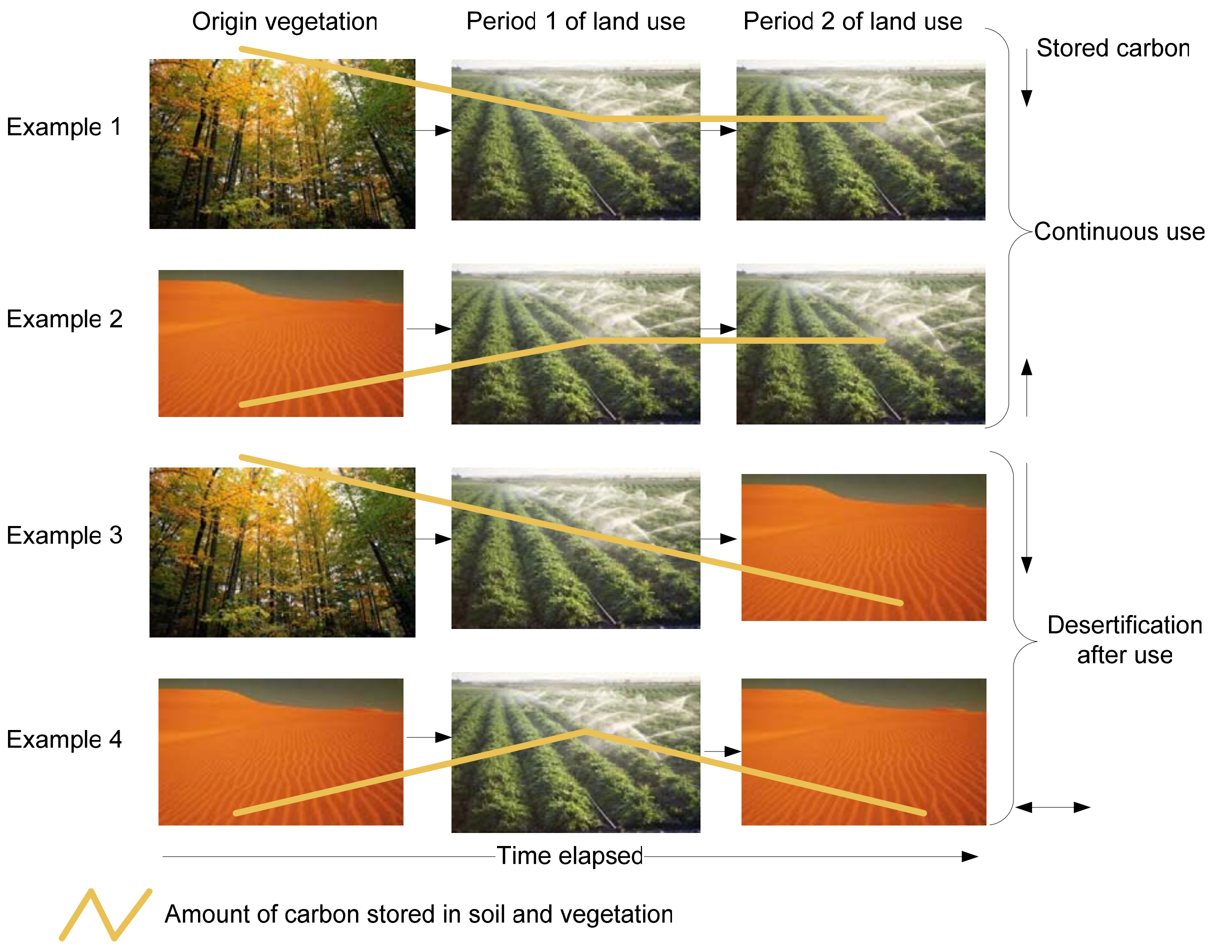


Figure 4-1 Influence of the land use change on the amount of carbon stored in soil and vegetation /3/

In accordance with BioNachV it is necessary to determine the influence of the land use change on the amount of carbon stored in soil and vegetation by means of a special calculation method developed by the IPCC /4/, /5/, /6/, /8/. This method is based on the use of vast inventory lists and should be shown in the following section by a simple example.

4.2 Description of the methodology

The council of experts at the IPCC used to deal intensively in the past with the question, among other things, which influence a change of agricultural use type of an area can exert on the CO_2-emission and how this emission can be quantitatively represented. Among other things, the report "Good Practice Guidance for Land Use, Land Use-Change and Forestry" from the year 2003 as well as Volume 4 of the "IPCC Guidelines for National Greenhouse Gas Inventories" from the year 2006 were published to go help define this aspect /4/, /5/.

The IPCC guidelines contain a complex and extensive calculation model which one can use to help describe the influence of land use or of a land use change on the carbon pools of soils and vegetation. Due to the complexity and the magnitude of the calculation method as well as of the complete documentation in the above-mentioned IPCC reports, it is important to explain briefly the basic principles of the calculation methodology at this point.

In accordance with the IPCC model the carbon pools in the soil and vegetation can basically influence the CO_2-amount found in the atmosphere due to a corresponding increase or decrease, i.e., if the CO_2-flow increases in relationship with the atmosphere, the amount of the carbon stored in the soil or vegetation decreases in change.

The change of the amount of stored carbon in soil and vegetation of a certain area can be represented by means of the following equation 4 - 1.

$$\Delta C = \sum_{ijk} \left[Ai_{jk} \left(C_I - C_L \right)_{ijk} \right]$$

Equation. 4-1

ΔC	Change of carbon stock in tonnes of carbon per year (t_C/a)
A	Land area in hectare (ha)
ijk	Parameters und factors on climate region i, kind of vegetation j, kind of land use k, etc…
C_I	Growth rate of stock in t_C/(ha a)
C_L	Loss rate of carbon stock in t_C/(ha a)

In order to determine the concrete influence of a land use change on the carbon pool (in soil and vegetation) of an area, there is a list of numerous approaches and extensive data tables in the IPCC guidelines. The following strongly simplified example should briefly clarify the basic procedure.

An area of arable land of 100,000 ha is forested. It is supposed that this forest is created on a soil of the so-called Ultisol[5] class in a region with a tropical climate and high air humidity. There is a list of numerous inventory tables in the IPCC guidelines in which the size of the carbon pool of different soil types is quantitatively described. It is possible to determine a size of the carbon pool for the soil class Ultisol and the chosen climate type of 47 tc/ha using the table 2.3 regarding the IPCC guidelines Volume 4 Chapter 2.

Firstly, the original type of the land use is taken into account in order to determine the size of the carbon pool at the beginning of the change period. Agricultural products were grown here every year using a conventional soil treatment and no fertilizers. The arable products were completely removed during the crop and no residues remained on the fields.

5 Ultisol: Soil class according to USDA-soil classification

The size of the carbon pool at the beginning of the land use change can be determined by means of the following equation 4 – 2:

$$C_{Area} = C_{Stock} \cdot F_{LU} \cdot F_{MG} \cdot F_{I}$$ *Equation 4-2*

C_{Area} Carbon stock (rate) of a certain area in t_C/ha

C_{Stock} Initial carbon stock (rate) according to inventory tables in t_C/ha

F_{LU} Factor of land use of IPCC

F_{MG} Factor of mechanical treatment and cultivation of IPCC

F_{I} Factor of nutrient input of IPCC

The three IPCC factors for area utilization, cultivation and the nutrient input can be determined with the help of an inventory table. The corresponding values can be found in the Chapter 5, Table 5.5. The following equation 4-3 can be set up with the help of these values and of the known C-inventory-value.

$$C_{Area} = 47 \, {}^{t_C}\!/_{ha} \cdot 0{,}48 \cdot 0{,}92$$ *Equation 4-3*

Thus, the resulting carbon pool size is approx. 20.8 °tc/ha for the considered area prior to the land use change. According to the IPCC model the effects of the land use change comprise a time span of approx. 20 years. Based on the assumption that the carbon pool acquires a size of 47 Tc /ha after the conclusion of the land use effects again.(comp. IPCC guidelines Volume 4, Chapter 4, “Tier 1”) the following equation 4-4 is conclusively obtained to calculate the annual change of the amount of stored carbon in the considered area.

$$\Delta C = \frac{47 \, {}^{t_C}\!/_{ha} - 20{,}8 \, {}^{t_C}\!/_{ha}}{20\, a}$$ *Equation 4-4*

Therefore, an annual carbon pool change of approx. 1.3 t_C/ha is the result of this land use change. This would mean an annual increase of the carbon pool in the soil and vegetation of approx. 130,000°tc for the viewed area of 100,000 ha. If the approach of the IPCC is followed consisting in the reduction of the CO_2-content in the atmosphere resulting from an increase of the carbon pool in soil and vegetation, the consequence would be an annual reduction of the CO_2-content in the atmosphere of approx. 0.48 million t for the considered area. This example is represented in a summarized version as flow diagram in the appendix once again.

4.3 Determination of possible greenhouse emissions through land use changes in the “default table” of the BioNachV

The possible contribution of a land use change to the raw material production for the production of bio-fuels is once again found in the so-called “default-table” in the annex 2 of the ordinance draft. The values mentioned there are to be taken into account in the calculation of the “greenhouse gas reduction potential” if its own values are not available for the bio-fuel producers and if it cannot be proven that a direct land use change caused by the raw material production can be excluded.

One should try to understand the respective values of the “default-table” in what follows afterwards. For this purpose, it is necessary to know the fundamental suppositions to calculate these values. These should be represented on the basis of the explanation paper of the IFEU Institute /8/ and the methodology described in Section 4.2 for the production of the raw materials “wheat from Europe”, “maize from North America” “rapeseed from Europe” and “sugar beet from Europe”.

The basic supposition for all mentioned paths consists first of all in the fact that the raw material production takes place on former grassland areas that were converted into cropland for the production. The size of the carbon soil pool of such areas is approx. 63 t_C/ha /5/. The total stored carbon amount rises to 70°tc/ha due to the carbon stored in the aboveground and underground biomass.

By changing the use type, the considered areas are converted into cropland. The size of the carbon pool of such areas is approx. 55 t_C/ha /5/ (size of the soil storage tank: 50 t_C/ha, carbon amount in the aboveground and underground stored biomass: 5 t_C/ha). A difference in the stored carbon amount of 15°tc/ha is obtained for the considered areas by changing the use type. Furthermore, it is supposed that the effects of this land use change can be distributed uniformly over a time span of 20 years /5/. An annual decrease of the stored carbon amount of 0.75 t_C/(ha*a) is obtained as a result for the considered areas. On the other hand, an annually emitted CO_2-equivalent amount of 2.75 t_{CO2}/(ha*a) is obtained from this amount.

The determined value of the annual CO_2-emission is calculated with the special area use that is necessary for the provision of a GJ fuel in order to determine the contribution of the land used change to the greenhouse gas–emission in the supply chain of a bio-fuel.

The assumed dates represented in the following Table 4-1 were taken as a basis in the “default table” for the calculation of the CO_2-production from direct land use change effects producing the raw materials (feedstock) “wheat from Europe”, “corn from North America” “rapeseed from Europe” and “sugar beets from Europe”.

Table 4-1 Feedstock, required bio-fuel mass and area per GJ

Feedstock	Required mass of bio-fuel in kg per GJ	Required area per GJ bio-fuel
Wheat, Europe	37,5 kg, 1 GJ	174 m²
Maize, North America	37,5 kg; 1GJ	131 m²
Rape, Europe	26,88 kg; 1GJ	200 m²
Sugar beet, Europe	37,5 kg; 1GJ	89 m²

A summarizing overview regarding the calculation of the land use change values for a choice of bio-fuels is provided by Table 4-2.

Table 4-2 Calculation of carbon stock change due to land use change of selected bio-fuels (default values for the German bio-fuel quota legislation) /5/,/8/

		Wheat Europe	**Maize North America**	**Sugar cane tropical Latin America**	**Sugar beet Europe**	**Rapeseed oil Europe**	**Soybean oil tropical Latin America**	**Palm oil South East Asia**
Initial land use	**t_C/ha**	**Green land**	**Green land**	**Savannah**	**Green land**	**Green land**	**Savannah**	**Rain forest**
C-Stock total	**t_C/ha**	**70**	**70**	**134**	**70**	**70**	**134**	**265**
Biomass above and below surface	t_C/ha	6,3	6,3	87	6,3	6,3	87	205
Stock in soil	t_C/ha	63	63	47	63	63	47	60
Land use		**Field**	**Field**	**Field**	**Field**	**Field**	**Field**	**Plantation**
C-Stock total	**t_C/ha**	**55**	**55**	**55**	**55**	**55**	**55**	**110**
Biomass above and below surface	t_C/ha	5	5	7,5	5	5	5	50
Stock in soil	t_C/ha	50	50	47,5	50	50	48	60
Change [a]	**t_C/ha**	**-15**	**-15**	**-79**	**-15**	**-15**	**-81**	**-155**
Annual values	a (years)	20	20	20	20	20	20	20
	t_C/(ha*a)	0,75	0,75	3,95	0,75	0,75	4,05	7,75
resulting emissions	**t CO_2/(ha*a)**	**2,75**	**2,75**	**14,5**	**2,75**	**2,75**	**14,8**	**28,7**
Specific required land area								
without Allocation	ha/GJ	0,0174	0,0131	0,0121	0,0089	0,0200	0,0607	0,0079
with Allocation	ha/GJ	0,0095	0,0072	0,0107	0,0057	0,0107	0,0168	0,0038
Emissions related Bio-fuel								
without Allocation	kg CO_2-Eq./GJ	**47,8**	**36,1**	**175,5**	**24,5**	**54,9**	**901,1**	**223,9**
with Allocation [b]	kg CO_2-Eq./GJ	26,2	19,8	154,7	15,6	32,8	282,4	106,6

a) negative values correspond to a loss of carbon stock
b) taking into account an allocation according to lower heating values along the production chain until end products (Ethanol, FSME)

4.4 Conclusion

The approach with regard to the future consideration of the influence of direct land use change effects within the framework of greenhouse gas balances for bio-fuels seems to make sense, especially, when you compare the raw materials produced in Europe such as rapeseed, or wheat with foreign raw materials such as sugar cane or soy. The observance of a good agricultural practice and certain sustainability criteria can be quantitatively represented by the size of this effect (expressed in kg CO_2-equivalents per GJ bio-fuel). Furthermore, the additional expenditure of a sustainable agricultural production is recompensed by this regulation, whereas access to the German bio-fuel market with non-sustainable produced raw materials becomes difficult.

The illustration of the calculation methodology as well as the represented example in Section 4.2 show clearly at which extent the quantification of possible land use change effects are dependent on the predetermined values and inventory tables of the IPCC. These values are partially based on heavily simplified model calculations and suppositions. Therefore, the calculation results can be interpreted rather as reference values and quantities to be compared among one another than as absolute values. One should always bear this aspect in mind when taking into account these values in ecological assessments.

It is necessary to carry out a possible simplification of the complicated IPCC calculation method or to publish a comprehensible guideline[6] for the practical realization. By taking such a measure it would be possible to continue the reduction of the effort of the total calculation method and make it more transparent to the involved parties.

The question whether or not to consider the influence of the land use change in the product systems of the fossil bio-fuels has come up as well when comparing bio-fuels with fossil reference values as planned by the BioNachV in the future in view of the determination of the "greenhouse reduction potential". There is no statement in the BioNachV about the reason why this influence was neglected or generally excluded in the fossil reference systems.

[6] As stated in Part B of the argumentations concerning the conclusion of the ordinance draft it is planned to provide a guideline for the calculation of the „greenhouse reduction potential".

5 Discussion of the “Default-values” in the draft on BioNachV

The presented draft on the BioNachV (Biomass Sustainability Ordinance) provides a table with so-called “default-values” apart from a concrete calculation model regarding the “greenhouse gas balancing” of bio-fuels too. This table is useful if producers of bio-fuels cannot have any access to their own data or if they can only get to incomplete data in connection with the calculation of the “greenhouse gas reduction potentials” that is necessary within the framework of the intended certification. The values of this table can be used or assumed either modularly or completely. The table supplies both CO_2-equivalent values for certain bio-fuels (i.e. natural plant oils, biodiesel on the basis of the esterification/transesterification of plant oils, biodiesel on the basis of plant oil hydration as well as bioethanol on the basis of sugar and starch containing feedstock) and for individual life cycle sections of these bio-fuels. It is indispensable to become more familiar with the suppositions and simplifications regarding the ecological inventory of these life cycles since certain suppositions in individual life cycle sections can have a strong influence, more or less, on the result of an ecological assessment. A resulting assessment without such knowledge is only possible in a very restricted way. In order to make this aspect clearer, possible influence factors have been represented along a bio-fuel supply chain as shown in the following Figure 5-1.

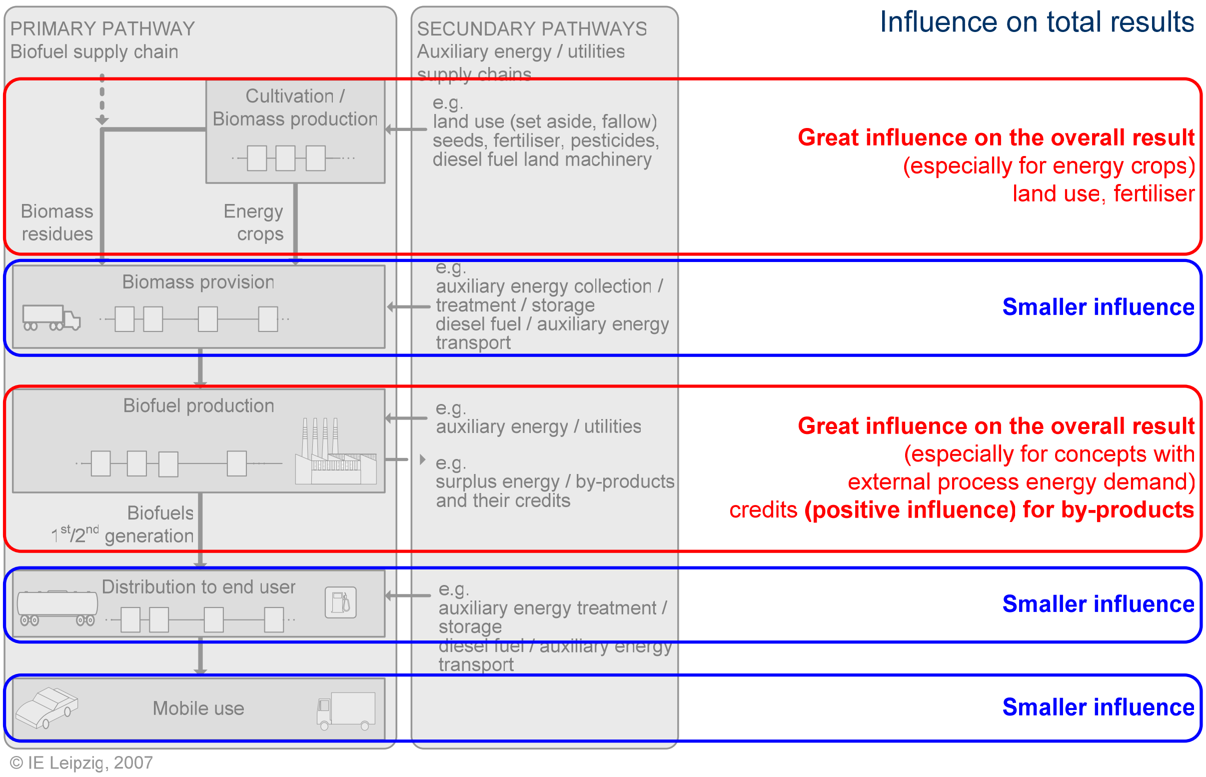


Figure 5-1 Influence of certain factors on the result of an ecological assessment in dependence on the considered impact category (e.g. greenhouse effect)

The statement that a great part of the emissions completely generated along the product life cycle is created in the life cycle sections of the biomass production and the bio-fuel production (conversion) is also found in the values of the "default-table". Further, - as previously described – the influence of the land use change was taken into consideration which represents the biggest negative contribution to the total result by far.

It is intended to provide a general understanding of the order of magnitude of individual values with the help of the explanations published by IFEU Institute /8/ regarding the "default-table" and some own experience values in the following.

The default values are graphically represented in the following Figure 5-2 once again. The table with the original values of the ordinance draft is found in the appendix of this paper.

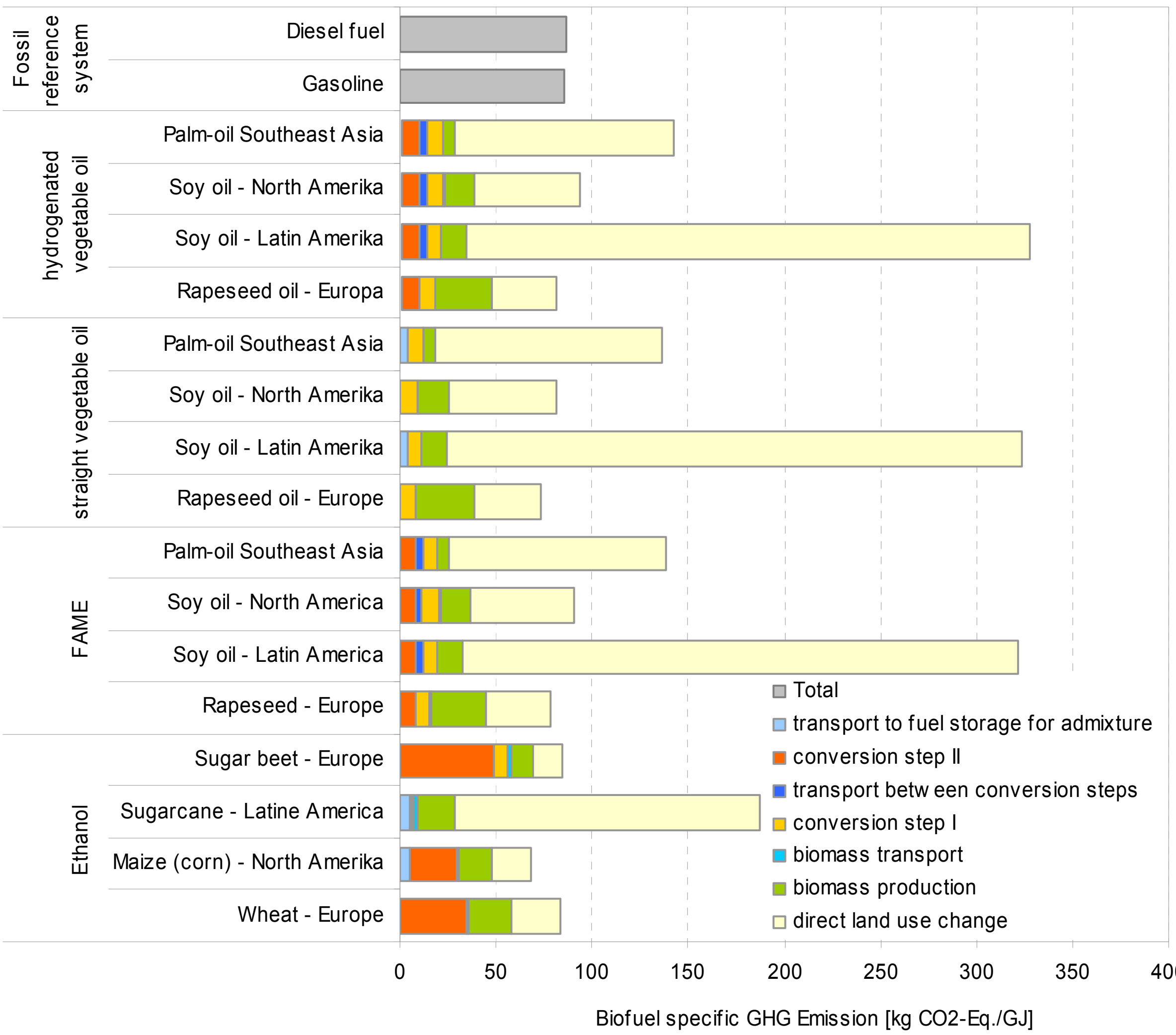


Figure 5-2 Graphical representation of the "Default-values" in the draft on BioNachV

In the following Table 5-1 the individual life cycle sections of the production of the considered bio-fuels are taken into account in greater detail in order to provide a qualitative clarification of the default values, and to develop an understanding for their order of magnitude. In this context, the influence factors that lead to the formation of the CO_2-equivalent values of the single life cycle sections are listed once again. Furthermore, as far as it is possible, a comparative value for the path “ethanol from wheat” is confronted respectively with the values of the “default table”.

Table 5-1 possible influence factors with respect to the calculation of “Default values”

step of production chain	Description of the main influence factors for the calculation of the overall result according to /8/	Comparison of the default value range with IE experience values (using the example of wheat ethanol; different calculation approach)
direct land use change	The direct land use change presents the biggest influence to the overall results. Especially for the production of soy oil, sugar cane and palm oil in Latin America and Southeast Asia the default table gives significant high results. These calculations have been based on the assumption that natural ecosystems are partially destroyed by the conversion into agricultural crop land. The calculation of the corresponding default values is based on a calculation procedure of the IPCC /5/ and on the assumption of the specific crop yield for the bio-fuel production. The necessary data for the calculation of the influence of the direct land use change are provided by Table 4-2 in chapter 0.	Until now, the influence of the direct land use change was neglected in most life cycle assessments dealing with bio-fuels. The default values for the direct land use change can be recalculated following the necessary assumptions /8/ and the IPCC calculation procedure /5/ .
biomass production	The main influence factors to the overall result in this life cycle step are the use of agricultural machinery, manuring and a good agricultural practice. Please note that the use of these auxiliary materials depends on the soil composition and the climate of the considered region. A corresponding itemization is not given within the default table.	The corresponding default value for the path „Ethanol from wheat - Europe“(40,7 kg CO_2-$_{Eq.}$/GJ) matches experience values of the IE (40 – 44 kg $_{CO2\text{-}Eq.}$/GJ_{KS} (without allocation)).
biomass transport	The main influence factors to the result in the in the transport process are the transport distance and the transport technology as well as the physical characteristics of the transported feedstock (e.g. bulk density etc.).	The important magnitudes for the calculation of the GHG emissions from the biomass transport (means of transport, transport distance) are documented within the methodology guidance for the default values /8/. The corresponding „default value“ for the path „Ethanol from wheat – Europe“ matches experiences of the IE Leipzig (1,7 kg $_{CO2\text{-}Eq.}$/GJ (without allocation of by-products)).
conversion steps	The GHG emission of this step strongly depends on the efficiency of the chosen conversion plant concept. This efficiency can be increased by the regeneration and circuitry of the used auxiliary materials as well as with an energetic process optimization. Concepts with an intern process energy supply based on renewable energy sources show experiential better results than concepts using extern fossil energy sources..	The corresponding default value is partially based on conservative assumptions. Therefore it can be assumed that a state of the art conversion plant will show a better result for the GHG emissions of the conversion step. (IE reference values for biomass conversion in the path “Ethanol from wheat – Europe” (with allocation of by-products: 23 – 36 kg $_{CO2\text{-}Eq.}$/GJ)

fossil reference values	Diesel fuel: 86,2 $kg_{CO2\text{-}Eq}$/GJ; Gasoline: 85 $kg_{CO2\text{-}Eq}$/GJ	The calculation of the given reference values for diesel fuel and gasoline is not documented. IE reference values are slightly higher. The possible influence of direct land use change is not included in these values. Diesel: 91,2 $kg_{CO2\text{-}Eq.}$/GJ; Gasoline: 93,8 $kg_{CO2\text{-}Eq.}$/GJ

By looking at the "Default Table" in the draft on the BioNachV the high amount of the direct land use change with regard to the total result is the first aspect to be noticed. This quantity was hardly observed in previous ecological assessments of bio-fuels (compare /7/). The general integration of such absolute values should be exactly verified due to the complexity of the calculation method in view of the contribution of the land use change as well as the heavy dependence on model ideas and simplifying suppositions. Taking this quantity into consideration can be quite practical since it provides a general comparability of various bio-fuels in which the calculation of the land use change for all product systems takes place according to a unifying method. However, an additional simplification of the calculation methodology or the publication of a comprehensible guide would be necessary and useful in this case.

Unfortunately there is no documentation in the "default table" on the data principles related to the creation of the reference values for the fossil fuels gasoline and diesel neither in the ordinance draft nor in the explanation paper of the IFEU Institute. Nevertheless, this would be important in order to create a transparent and intelligible calculation method. The existence of the necessary requirements of the comparability (equality of benefits, system boundaries, maybe the consideration of the land use change in the "fossil product systems" too) must be evident, since the determination of the "greenhouse reduction potential" represents a comparison of various product systems. It is impossible to supply a conclusive assessment of the general comparability of the bio-fuels with the fossil reference systems if the corresponding data base is not published.

Apart from the data of the actual main process chain (cultivation, transportation, conversion, etc.), the producers of bio-fuels also require information on the emissions occurring in the manufacture of the used auxiliary materials in order to calculate the "greenhouse reduction potential". For example, in the sector of LCAs it often falls back on to data and data modules from established and loadable data bases (e.g. Ecoinvent, Probas or Idemat) because the provision of this data is connected with an enormously high effort. In order to create a consistent and transparent calculation method that provides results with a long term comparability, it is necessary to determine additional issues (e.g. the establishment of a unitary data base for the balancing of the used auxiliary materials) in the area of LCI or also a more extensive and more detailed "default table" provided with single values related to the previous chains of certain auxiliary materials. An intelligibility and comparability of the calculation results is not guaranteed without such additional issues, since data modules from different data bases can partially differ strongly from one another. In addition, it becomes more complicated to provide an exact assessment of the values because this data is most represented in a very compressed form. For this reason, the determination of a unifying data base for LCIs of the used auxiliary materials could substantially simplify the calculation method and increase its transparency. A comparability of the calculation results is impossible or only restrictedly possible without the determination of a unifying and sufficient data base.

The values of the "default table" were formed on the base of certain suppositions. These are documented in the explanation paper of the IFEU Institute /8/. It is important to appreciate whether the suppositions made in this case were favourable or had the tendence to be rather unfavourable (worst case situation), since these suppositions represent the base of the calculation result and therefore of the single values of the "default table".

This relationship is denominated as conservativism of the made suppositions in the explanation paper of the IFEU Institute.

It can be assumed that it tends to rather "better" results that can be obtained (in comparison with the "default table") in the case of an optimized bio-fuel extraction (raw material extraction, conversion technology, etc) in accordance with the state of the technology/8/. The following table 5-2 provides an overview on the conservativism of the "default values" in order to better assess the character of the made suppositions.

Table 5-2 Categorization of the conservatism of the „Default Values"/8/

step of production chain	Category of conservatism
direct land use change	Worst case situation, contradicts generally criteria for sustainability (conversion of areas with high carbon storage).
biomass production	The figures are based on median values of IFEU calculations. The consideration of fertiliser and pesticide use has been made upon conservative values (upper value range).
biomass conversion	Assumption of a typical case of unfavourable energy source (lignite) → conservative; Treatment of possible energy excesses, calculation of emission factors → conservative
transport (transport of biomass, transport between conversion steps, transport to fuel storage for admixture)	The following assumptions have been made for the calculation of the GHG emissions in the transport process: Transport distance: median values of IFEU calculations; Utilized capacity & consideration of back transports: Full efficiency of the transports is assumed, Assumption of empty runs for biomass transport (conservative), No empty return transport for ships assumed; The calculation of the fuel consumption and the transport emission factors have been made upon median standard values

It can be assumed that the greenhouse gas balance for bio-fuels with a raw material extraction and conversion based on a good agricultural practice or in accordance with the state of technology shows more favourable results since the default values of the life cycle sections biomass extraction and biomass conversion are partially based on conservative suppositions / values. Regarding the default table, it must be mentioned in addition that the table should be completed in perspective and in a sensible way by means of further bio-fuel pathways (e.g. biomethane, bio-fuels based on lignocellulose, bio-fuels of the so-called 2nd generation). In this context, it is also relevant to think about the question of how straw as possible raw material of future bio-fuel options should be assessed in order to avoid a disadvantage of certain fuel paths of the first generation towards the future fuel options such as ethanol from lignocellulose (in this case, the raw material would be theoretical created without environmental impacts, since the generated emissions will be assigned to the cereal grain at 100 %.).

6 Possible influence of the BioNachV on the German bio-fuel market

The ordinance draft concluded by the German Federal Cabinet on December 5th, 2007 and presented by the Federal Government completes the Federal Immission Control Law § 37d (BImschG) and the Energy Tax Law § 68 (EnergStG). According to the ordinance, the observance of certain minimum requirements concerning a sustainable cultivation of agricultural areas, as well as the protection of natural habitats should be guaranteed in area of the bio-fuel production. In addition, bio-fuels must possess a determined “greenhouse gas reduction potential” in the future. The ordinance suggests a concrete calculation model for the determination of these potentials that includes the consideration of the total production, processing and supply step chain of the produced bio-fuels.

According to the ordinance, a so-called calculation factor will be introduced. With help of this, fuel should comply with the obligations in accordance with § 37a par. 1 Clause 1 and 2 in connection with § 37a Par. 3 BimschG. This factor goes into effect on January 1, 2011. The allowance towards the energetic quota (according to the § 37a par. 3 of the Federal Immission Control Law) according to a multiplication of the amount really put in circulation of the respective bio-fuel of this factor takes place with bio-fuels having a higher “greenhouse reduction potential” than the base value (30 % in comparison with the fossil gasoline or diesel fuel reference system, or 40 % from the January 1, 2011. The calculation factor results from the “greenhouse reduction potential” of the considered fuel (in percentage related to the fossil reference system) divided by the average greenhouse gas reduction potential (in percentage) of all bio-fuels put in circulation and compelled to meet its obligations in the pre-previous year according to § 37a par. 3 phrase 1 des BimschG. The average value required for this calculation of the pre-previous year can be determined with the help of the certificates of the fuels put into circulation. These certificates contain the “greenhouse gas reduction potential” of the fuel, apart from other relevant data. A new certification of the corresponding bio-fuel is necessary in order to deliver a proof of an improvement in form of a more favourable “greenhouse balance”. /6/

For example, a calculation factor of 1.7 is obtained with an average “greenhouse reduction potential” of the pre-previous year of 30 % for a bio-fuel with a “greenhouse reduction potential” of 50 %

$$Calculationfactor = \frac{50\%}{30\%} = 1{,}7$$

The bio-fuel considered in this example would be allowed to go towards the fuel quota according to BioKraftQuG with the 1.7 times its energetic value.

This means that a correspondingly lower amount of a bio-fuel with a high greenhouse gas reduction potential can be used to fulfil the legal bio-fuel quota.

On the basis of the assumption that bio-fuels with a high “greenhouse reduction potential” would be specially promoted by this approach, it could be alleged that the average “greenhouse reduction potential” of all bio-fuels annually put in circulation will be increasing in future.

As a consequence, it will be more difficult to reach a high calculation factor (i.e. a high greenhouse reduction potential of the respective bio-fuel proportionally to the corresponding potential of the bio fuel mix) for the respective fuel year by year.

The ordinance represents a new orientation of the promotion of bio-fuels by turning away from the defined bio-fuel quantities through to the specific greenhouse gas efficiency of the bio-fuels put in circulation. These points can be also be seen against the background of the decarbonisation strategy at a European level and the planned amendment of the bio-fuel quota law (BioKraftQuG). The amendment of the BioKraftQuG plans net greenhouse gas savings in the traffic sector that should be realized by using bio-fuel (see also /10/). All in all, this represents an essential change of the energy policy general conditions for the German bio-fuel market. The national or also the international market value (i.e. market price, average price, current, medium price range) of bio-fuels depends on great number of market mechanisms and influence parameters. Among others, this includes the development of raw material costs or prices concerning national and international markets (market versus contract prices, especially in case of plant oils and cereal grains) and their influence on the bio-fuel costs, as well as their market value (market versus contract prices, especially in the case of plant oils and cereal grains) and their influence on the bio-fuel costs, as well as their market value. In future, the “greenhouse gas reduction potential” that must be proven in the form of a certificate according to the BioNachV will play a significant role in determining the price of a bio-fuel. The demand for bio-fuels with a high “greenhouse reduction potential” will increase due to a change of promotion. According to the “default-table” contained in the BioNachV, especially the fuels imported from Latin America and South East Asia (e.g. bioethanol from sugar cane, bio diesel from soy or palm oil) have a high “greenhouse reduction potential”, provided that it can be proven that direct land use changes can be excluded /6/. On the one hand, an increased demand for these bio-fuels is expected, if this advantage should also be maintained after a certification and the control of the defined requirements regarding the biomass cultivation. On the other hand, this could lead to a substantial pricing pressure on German bio-fuels. A growing displacement of “domestic” bio-fuels from the market would even be possible for the medium and long term as a result of this circumstance and the competition disadvantage due to the prices regarding European bio-fuels /11/.

However, a certification of the respective bio-fuel is required in the first instance in order to be able to take part in the bio-fuel market. The quality and accuracy of this certification system as well as the control of the sustainability requirements defined in the ordinance represent an essential premise for the success of the ordinance. If these criterions are not successfully fulfilled in the Non-EU-States, German bio-fuel producers will be threatened by substantial competition disadvantages. Again, the question is put why there were no definitions of minimum requirements for the work conditions and social standards in the ordinance, or why these were cancelled from the ordinance again (compare /12/ and /6/).

Such requirements would be quite appropriate according to this sustainability, which rests to a great extent on the three cornerstones: ecology, economy and social conditions. This magnitude in the production of biomass used for the manufacture of bio-fuels represents a decisive influential factor on the competitiveness of bio-fuel producers.

Furthermore, success performing in the future energy policy of bio-fuels depends definitively on a continuous and permanent competition involving innovative bio-fuel concepts with high "greenhouse reduction potentials". It would be practical and feasible, e.g. to create appropriate fiscal and legal general conditions at a European and national level in order to guarantee this competition for a long term too and compensate possible competition disadvantages of German bio-fuel producers (e.g. subsidies from single Non-EU-States, such as, e.g. what the USA granted for exported fuels).

It is difficult to judge the future development on the German bio-fuel market, since bio-fuel producers compete together with other markets for raw materials (e.g. plant oils, cereals grains). First of all, it should be assumed that this could lead to significant consequences for the German bio-fuel producers when putting the sustainability ordinance into practice /11/. Ultimately, however, it remains to be seen how bio-fuel producers and mineral oil industry will behave in the market.

7 Summary

The draft on the BioNachV is planning a certification of bio-fuels in the future. An essential part of this certification system is represented by the proof of the so-called “greenhouse reduction potential” for the considered bio-fuel. The draft suggests a concrete calculation model in order to calculate this potential and lays down regulations on system boundaries and the treatment with co-products. An allocation based on the lower heating value (net calorific value) should be applied for them in future. In the future, it will play an important role for bio-fuel producers to know the possible influence of the allocation method on the result of an ecological assessment in order to exactly assess the influence of the given method on their result. This is decisive since the results of future calculations can differ quite considerably from those of previous calculations by specifying a new and unifying allocation methodology. Such a development can be encountered, for example, by using the obtained co-products in an energetically efficient way (among others, possible recycling e.g. fermentation of distillers wash and use of the obtained energy as process energy). It is questionable how the procedure with co-products will look in the future, which cannot be taken into account or can only be limitedly considered taking an allocation approach based on the heating value (e.g. biogenic CO_2 from the bioethanol production that would be able to substitute the industrially produced CO_2). In this case, it would be necessary to create an appropriate and correspondingly recognized procedure. In this context, is advisable to think about the treatment with straw as a raw material of future bio-fuel options too in order to avoid a disadvantage of bio-fuels of the first generation towards the future bio-fuel options.

In accordance with the draft, it is intended to consider the influence of possible land use changes regarding raw material extraction in the calculation of total emissions. This magnitude was hardly observed in previous ecological assessments of bio-fuels or only insufficiently considered. (Compare /7/). Nevertheless, this approach also seems to be quite practical for the consideration of possible environmental impacts caused by the exploitation of areas under cultivation of raw material for the bio-fuel production. In this context, the carbon storage capacity of soils and vegetation is taken into account. However, when taking this magnitude into consideration it should always be remarked that the calculation for the determination of the land use change depends very heavily on the given inventory tables of the IPCC. Since these values are partially based on strongly simplified model calculations and assumptions, the obtained values should be interpreted rather as reference points and orientation guide. Furthermore, a simplification of the calculation method concerning the land use change and / or the publication of a guideline would be necessary for the practice with the aim to carry out a correct and accurate calculation. Otherwise, a lot of difficulties can occur in the calculation and the expenditure regarding the certification can rise due to the complex and not quite intelligible calculation method of the IPCC. This would contradict the efforts in connection with the creation of a simplified calculation method (unitary allocation approach, fixed system boundaries).

It is necessary to prove precisely, against the background of the comparison of bio-fuels with fossil bio-fuels, whether the influence of the land use changes should also be taken into consideration regarding the product systems of the fossil fuels, or whether this influence can be generally disregarded here.

Above all, the balancing of the used auxiliary materials is often connected with high efforts in the ecological assessment of products since there are usually no own data available for this process chains or the provision of this data is often only possible in an unrestricted way. For this reason, one often falls back on corresponding data modules from recognized and loadable databases in the area of LCAs (e.g. ecoinvent, idemat etc). An appropriate enhancement of the “default table” or also the creation of a corresponding database would be necessary in order to give the bio-fuel producers a stimulus to the presentation of own balances and not to complicate the incentive according to the ordinance to develop innovative bio-fuel conceptions and a permanent competition for high greenhouse gas reductions. The lack of such a common data base would complicate the comparability of the calculation result.

If it is not possible for a bio-fuel producer to perform its own calculations to determine the “greenhouse gas reduction potential” due to lacking or incomplete data, a table with so-called “default values” will be useful in this case. This table can be applied in a modular way if single bits of data are lacking. The calculation of these “default values” is partially based on conservative assumptions and values (values of the direct land use change, of the biomass extraction and the conversion processes). When considering rules of good agricultural practice and sustainability as well as a biomass conversion according to the state of technology, these “default values” for the bio-fuel production can be surely “exceeded”.

For the time being, the influence of the BioNachV on the German bio-fuel market remains to be seen. An increased demand on fuels with a high greenhouse gas reduction potential is expected. This is due to the change in the general energy policy conditions to that promoting the greenhouse gas efficiency of bio-fuels and the change from a purely quantitative fuel quota to promoting fuels with an especially good greenhouse gas balance (calculation factor). In particular, the fuels imported from Latin America and South East Asia (bioethanol from sugar cane, bio diesel from soy or palm oil) have a high “greenhouse reduction potential” according to the values of the “default table” if the influence of direct land use change effects can be excluded in this case /6/. An increased demand for these bio-fuels is expected if this advantage should continued to be maintained after a certification and proof that there are no direct land use change effects. On the other hand, this could lead to a substantial pricing pressure on “domestic” bio-fuels. An increasing displacement of “domestic” bio-fuels from the market would be even imaginable for a medium and a long term performing a price competition /11/.

The quality and accuracy of the certification systems that should be introduced plays a decisive role in order to verify the requirements defined in the ordinance and to create conditions for equal competition. If these criterions are not successfully fulfilled in the Non-EU-States, German bio-fuel producers will be threatened with substantial competition disadvantages. Therefore, an additional enhancement of the defined requirements by social minimum requirements would be necessary according to a real “sustainability”. Furthermore, succeeding in performing in the future energy policy of bio-fuels depends definitively on a continuous and permanent competition of innovative bio-fuel concepts with high “greenhouse reduction potentials”.

In order to also guarantee long term competition and compensate possible competition disadvantages of German bio-fuel producers, it is indispensable, e.g. to create appropriate fiscal and legal general conditions at a European and national level.

Since bio-fuel producers compete together with other markets for raw materials (e.g. plant oils, cereals grains), it is difficult to judge the future development on the German bio-fuel market. First of all, even though it can be assumed that this can lead to significant consequences for the German bio-fuel producers if the sustainability ordinance is put into practice, the exact behaviour of bio-fuel producers and mineral oil industry remains to be seen at the market.

Bibliography

/1/ DIN EN ISO 14040: 2006; Umweltmanagement – Ökobilanz – Grundsätze und Rahmenbedingungen

/2/ DIN EN ISO 14044: 2006; Umweltmanagement – Ökobilanz – Anforderungen und Anleitungen

/3/ Friedrich, A: The Contribution of Future Fuels to the European Low Carbon Economy.Euromot – Annual Meeting 2007, unveröffentlichte Präsentation, Wolfsburg 2007

/4/ Intergovernmental Panel on Climate Change (IPCC): Good Practice Guidance for Land Use, Land-Use Change and Forestry [J. Penman, M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner (eds.)]. Published by the Institute for Global Environmental Strategies (IGES) for the IPCC, ISBN 4-88788-003-0, Kanagawa, 2003.
Download unter: http://dev.aspen.grida.no/jm/gpg/tool.htm.

/5/ Intergovernmental Panel on Climate Change (IPCC): Eggleston H.S., Buendia L., Miwa K., Ngara T. und Tanabe K.; IPCC Guidelines for National Greenhouse Gas Inventories; Volume 4, Agriculture, Forestry and Other Land Use; Tokyo 2006
Download unter: www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm.

/6/ Entwurf einer Verordnung über Anforderungen an eine nachhaltige Erzeugung von zu Biokraftstoffen verwendeter Biomasse (Biomasse-Nachhaltigkeitsverordnung - BioNachV) Endfassung vom 05.12.2007

/7/ Sachverständigenrat für Umweltfragen (SRU); Klimaschutz durch Biomasse; Sondergutachten; Juli 2007; Download unter: http://www.umweltrat.de/02gutach/downlo02/sonderg/SG_Biomasse_2007_Buchlayout.pdf

/8/ Fehrenbach, H., Giegrich, J., Gärtner, S., Reinhardt, G., Rettenmaier, N.: Greenhouse Gas Balances fort he German Bio-fuels Quota Legislation – Methodological Guidance and Default Values, IFEU Institut Heidelberg, November 2007

/9/ KTBL, 2006: Energiepflanzen: Daten für die Planung des Energiepflanzenanbaus; KTBL-Datensammlung mit Internetangebot / Red.: Henning Eckel. Hrsg.: Kuratorium für Technik und Bauwesen in der Landwirtschaft. Darmstadt 2007.

/10/ Das Integrierte Energie- und Klimaprogramm der Bundesregierung. Hintergrundpapier. Meseberg August 2007. Download unter: http://www.bmu.de/files/pdfs/allgemein/application/pdf/hintergrund_meseberg.pdf

/11/ Henke, Jan: Wirtschaftliche Auswirkungen der geplanten Nachhaltigkeitsverordnung. Präsentation zur UFOP- Fachkommission „Ökonomie und Markt“. Berlin Dezember 2007.

/12/ Entwurf einer Verordnung über Anforderungen an eine nachhaltige Erzeugung von zu Biokraftstoffen verwendeter Biomasse (Biomasse-Nachhaltigkeitsverordnung - BioNachV) Entwurfsfassung vom 24.10.2007

/13/ Schmitz, Norbert.: Innovationen bei der Bioethanolerzeugung und ihre Auswirkungen auf Energie- und Treibhausgasbilanzen. Münster 2005

Annex

Table with “Default-Values“/6/

The following table includes the „default values“for the most common bio-fuels and their main sours of origin.

According to § 4 par. 1 Clause 3 of the ordinance draft the default values have to be used to calculate the “greenhouse gas reduction potential” of a bio-fuel if its producer is not to perform this calculation due to lacking or incomplete data. This table can be applied in a modular way if single bits of data are lacking (see column 1 of the table). The total value, given in the last row of the table has to be taken as overall result of a bio-fuels CO2-eq. Emission if there are no values for any of the considered steps of the production chain available.

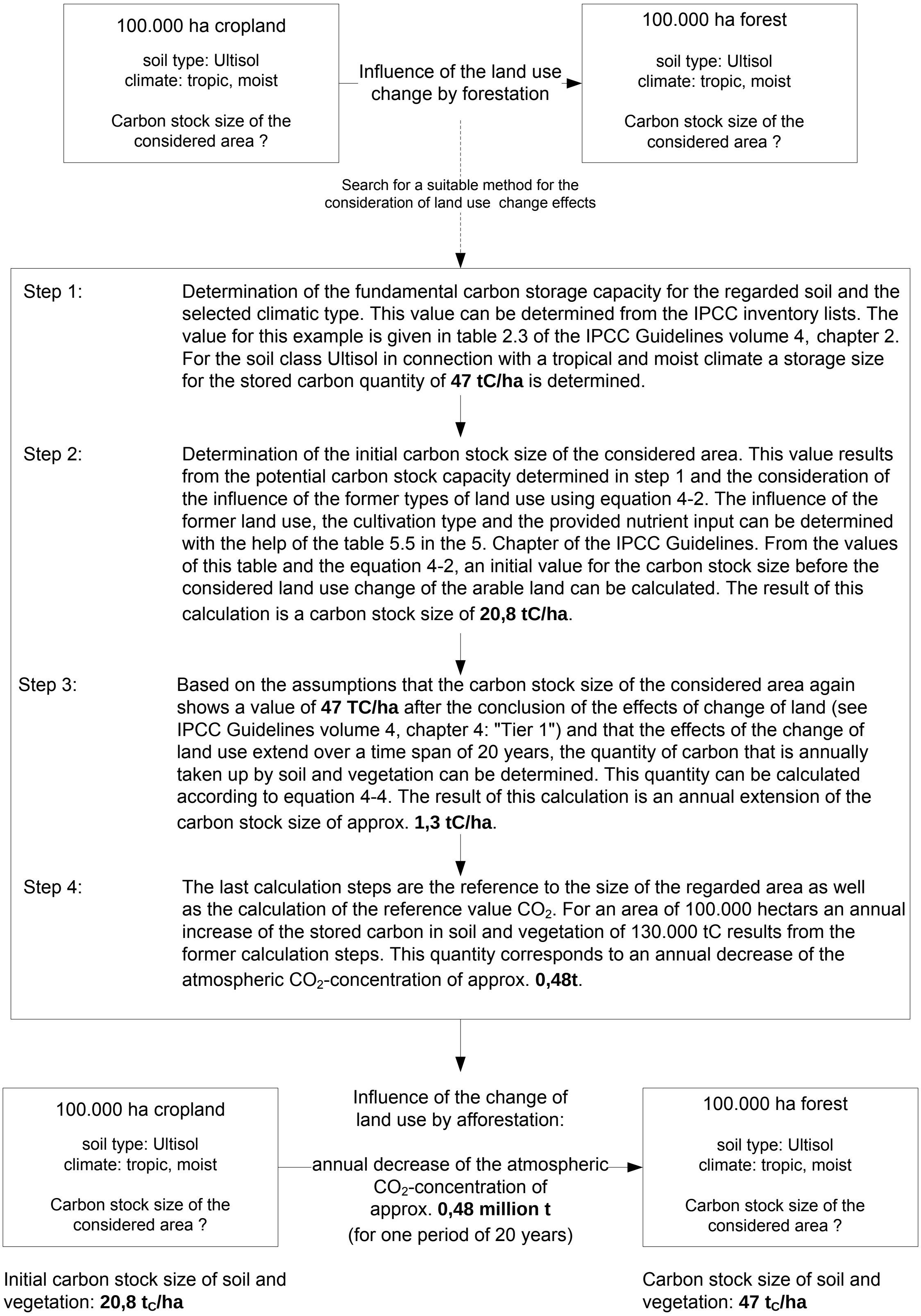
All values given as kg CO_2-Eq. per GJ /6/

Bio-fuel / Biomass origin / step of production chain	**Ethanol**				**FAME**			
	Wheat Europe	Maize (corn) North America	Sugarcane Latin America	Sugar beet. Europe	Rapeseed Europe	**Soybean** Latin America	**Soybean** North America	Palm-oil Southeast Asia
direct land use change	26,2	19,8	158,8	15,6	32,8	289,6	54,5	112,8
production of biomass	22,3	17,8	19,5	11,3	29,1	12,9	15,2	6,6
transport of biomass	0,7	0,7	1,5	1,7	0,4	0,5	0,5	0,1
conversion step I 1	-	-	0,8	6,6	7,6	7,3	9,2	6,9
transport between conversion steps	-	-	-	-	0,20	3,8	3,4	4,3
conversion Stepp II	34,3	25,0	1,0	48,9	7,6	7,7	7,7	7,7
transport to fuel storage for admixture	0,4	4,8	5,5	0,4	0,3	0,3	0,3	0,3
total	83,9	68,0	187,1	84,4	78,1	322,0	90,7	138,7

Explanation: FAME = fatty acid methyl esther

All values given as kg CO_2-Eq. per GJ /6/

Bio-fuel / Biomass origin / step of production chain	**straight vegetable oil**				**Hydrogenated vegetable oil**			
	Rapeseed oil Europe	**soybean oil**		Palm-oil Southeast Asia	Rapeseed oil Europe	**soybean oil**		Palm-oil Southeast Asia
		Latin Amerika	North Amerika			Latin Amerika	North Amerika	
direct land use change	34,2	298,8	56,2	117,4	33,2	293,4	55,2	114,3
production of biomass	30,4	13,1	15,5	6,9	29,5	13,0	15,4	6,7
transport of biomass	0,5	0,6	0,6	0,1	0,4	0,8	0,5	0,1
conversion step I 1	7,6	7,1	9,0	7,4	7,3	6,8	8,6	7,2
transport between conversion steps	-	-	-	-	0,2	3,8	3,5	4,3
conversion Stepp II	-	-	-	-	9,7	9,7	9,7	9,7
transport to fuel storage for admixture	0,2	3,9	-	4,4	0,7	0,7	0,7	0,7
total	72,8	323,5	84,7	136,2	81,1	328,2	93,5	143,1


100.000 ha cropland
soil type: Ultisol
climate: tropic, moist
Carbon stock size of the considered area ?
Influence of the land use change by forestation
100.000 ha forest
soil type: Ultisol
climate: tropic, moist
Carbon stock size of the considered area ?
Search for a suitable method for the consideration of land use change effects
Step 1:
Determination of the fundamental carbon storage capacity for the regarded soil and the selected climatic type. This value can be determined from the IPCC inventory lists. The value for this example is given in table 2.3 of the IPCC Guidelines volume 4, chapter 2. For the soil class Ultisol in connection with a tropical and moist climate a storage size for the stored carbon quantity of **47 tC/ha** is determined.
Step 2:
Determination of the initial carbon stock size of the considered area. This value results from the potential carbon stock capacity determined in step 1 and the consideration of the influence of the former types of land use using equation 4-2. The influence of the former land use, the cultivation type and the provided nutrient input can be determined with the help of the table 5.5 in the 5. Chapter of the IPCC Guidelines. From the values of this table and the equation 4-2, an initial value for the carbon stock size before the considered land use change of the arable land can be calculated. The result of this calculation is a carbon stock size of **20,8 tC/ha**.
Step 3:
Based on the assumptions that the carbon stock size of the considered area again shows a value of **47 TC/ha** after the conclusion of the effects of change of land (see IPCC Guidelines volume 4, chapter 4: "Tier 1") and that the effects of the change of land use extend over a time span of 20 years, the quantity of carbon that is annually taken up by soil and vegetation can be determined. This quantity can be calculated according to equation 4-4. The result of this calculation is an annual extension of the carbon stock size of approx. **1,3 tC/ha**.
Step 4:
The last calculation steps are the reference to the size of the regarded area as well as the calculation of the reference value CO_2. For an area of 100.000 hectars an annual increase of the stored carbon in soil and vegetation of 130.000 tC results from the former calculation steps. This quantity corresponds to an annual decrease of the atmospheric CO_2-concentration of approx. **0,48t**.
100.000 ha cropland
soil type: Ultisol
climate: tropic, moist
Carbon stock size of the considered area ?
Influence of the change of land use by afforestation:
annual decrease of the atmospheric CO_2-concentration of approx. **0,48 million t**
(for one period of 20 years)
100.000 ha forest
soil type: Ultisol
climate: tropic, moist
Carbon stock size of the considered area ?
Initial carbon stock size of soil and vegetation: **20,8 t_C/ha**
Carbon stock size of soil and vegetation: **47 t_C/ha**

Institut für Energetik und Umwelt gGmbH (IE)
Torgauer Straße 116
04347 Leipzig
info@ie-leipzig.de

UNION ZUR FÖRDERUNG
VON OEL- UND PROTEINPFLANZEN E. V.
Claire-Waldoff-Straße 7 • 10117 Berlin
info@ufop.de • www.ufop.de