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Biodiesel based on animal fats and used cooking oils–Proposal for revision of the GHG standard value

Final Report

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List of abbreviations and symbols

Abbreviation	Explanation
Eq.	Equivalent
CHP	Combined heat and power plant
EU RED	EU Directive for the promotion of renewable energies (2009/28/EC)
kg	Kilogram
MJ	Megajoule
GHG	Greenhouse gas

1 Introduction

1.1 Background and objective

The introduction of binding requirements concerning greenhouse gas reduction for biofuels within the framework of the Directive for promotion of the use of energy from renewable sources 2009/28/EC (EU RED) [1] adopted in 2009 along with the planned conversion from the quantity-based biofuel quota to a GHG-relevant quota means that the greenhouse gas balance (GHG balance) is gaining increasing significance for producers.

The GHG reduction of a concrete biofuel is calculated according to the specifications set out in the method defined in Annex V of the directive. Besides this method, Annex V of the directive contains a series of standard values for various biofuel technologies and raw materials. These standard values can be used by biofuel producers for validation of the GHG reduction specifications, if the biofuel producers do not wish to or cannot conduct their own calculations.

The calculation of the standard values is based on conservative European average values for the relevant cropping systems, transport distances and conversion technologies representing the state-of-the-art in biofuel production before the directive was adopted. To be able to consider the effect of the changing framework conditions for biofuels, the Commission has envisaged a regular auditing and adaptation of these standard values.

In October 2012, the European Commission published a proposal for amending the EU RED [2] in respect to the multiple counting of biofuels from residual and waste materials to the biofuel quota and a limitation in the contribution of biofuels from cultivated biomass to maximum 5%. The European Parliament agreed to this proposal on 11.09.2013. The resolutions passed here differ from the proposal by the Commission in some points [3]. This primarily concerns the planned introduction of an upper limit for biofuels from cultivated biomass (the resolution of the Parliament envisages an upper limit of 6% instead of 5%) and multiple counting for biofuels from residual and waste materials. The resolution passed by the Parliament does not envisage any multiple crediting for biofuels from residual and waste materials contrary to the Commission's proposal. Instead, biofuels based on agricultural residual and waste materials are to be subsidised within the framework of a sub-quota (2.5%, consideration corresponding to its energy content) in future. Although the double counting proposed by the Commission remains for biofuels based on waste vegetable and animal oils , the resolution of the EU Parliament nevertheless calls for a more restrictive use of waste for biofuel production concurrent with the waste management plans and waste avoidance programmes established in Directive 2008/98/EC [3][4]. The funding policy framework for biofuels based on waste animal and vegetable oils is expected to lead to increasing demand for residual and waste materials. Consequently, it can also be necessary to revise the assumptions regarding calculation of the standard values for these biofuels in Annex V of the EU RED. Above all, this concerns the assumptions concerning the transport distances for the residual and waste materials used as well as the expenditures derived from this for calculation of the emissions from transport.

Against this background and the fact that no corresponding measures on the part of the EU Commission were known up until April 2013 in respect to the examination of the standard values for biodiesel from waste vegetable and animal oils planned in Article 19 (7) of the EU RED, the UFOP had asked the DBFZ at that time to draw up proposals for adapting the GHG standard value for biodiesel based on animal and vegetable waste oils and fats.

The JRC Consortium (European Commission's Joint Research Centre) has meanwhile updated the database of standard value on behalf of the EU Commission (referred to below as JRC 2013) [5], on the basis of which an adaptation of the standard values of the EU RED is to be expected. The initial situation and procedure of this study have consequently changed, as described below.

1.2 Initial situation and further procedure

The original terms of reference of this study involved examining the effect of transport distances on the supply of fats and oils on the total GHG balance, based on particular calculations concerning the biodiesel production from waste vegetable and animal oil, comparing the results with the EU RED standard value for biodiesel from waste vegetable and animal oil and deriving a potential need to adapt the standard value from the resultant discussions.

As already mentioned, the JRC Consortium has (in May of this year) published a report (JRC 2013), which describes the assumptions and principles for recalculation of the standard values. The report firstly contains the update of the database (stipulated in Article 19 (7) of the EU RED) in respect to the individual biofuel options of the biofuel portfolio contained in the EU RED. Secondly, the portfolio has been extended by certain biofuel options. While the EU RED intends a single value for biodiesel from waste vegetable and animal oil, JRC 2013 reports biodiesel from used cooking oil and biodiesel based on animal fats separately.

According to this, the options biodiesel from used cooking oil and biodiesel from animal fats are also considered separately within the context of this study. In Chapter 3, a GHG balance for a basic scenario is first compiled for biodiesel from used cooking oil based on existing own data. A possible effect of the transport processes for the supply of the waste food fats and oils on the total GHG balance is then examined by means of an example. The effect of different by-product definitions and their consideration according to EU RED on the GHG balance for biodiesel production from used cooking oil is to be examined subsequently. The results are then compared with the existing standard value for biodiesel from waste vegetable and animal oil as well as the possible future standard value calculated on the basis of the JRC 2013 data for biodiesel from used cooking oil.

Chapter 4 deals exclusively with the option of biodiesel from animal fats. A GHG value is calculated here based on the corresponding data from JRC 2013 and this is compared with both the existing standard value for biodiesel from waste vegetable and animal oil as well as a value taken from the inventory database ecoinvent 2.1 [6]. In contrast to Chapter 3 and the sensitivity considerations conducted there, the consideration here focuses on the examination of possible substitution effects. What effect does the use of animal fats in various energy utilisation options have on the GHG emissions?

Possible consequences and recommendations derived from the investigations are finally outlined in Chapter 5.

2 Principles and method

The EU RED contains concrete specifications for calculating the GHG emissions from biofuel production and use as well as for the calculation of the corresponding GHG saving potential.

In addition to these specifications, Annex V of the EU RED contains the standard values "default values" for various biofuel options. These standard values can be used by biofuel producers to determine the GHG saving potential if they cannot or do not wish to make their own calculation. The following three options are permissible for determination of the GHG emissions and the GHG reduction potential associated with this:

1. Calculation of the GHG saving potential in accordance with the defined calculation methodology,

2. Utilisation of the aggregated default value for the considered biofuel pathway,

3. Combination of own calculations for individual elements of the process chain (e.g. biomass production) with the disaggregated default value for the rest of the process chain.

Further- guidelines can be found in Annex V of the EU Directive for the calculation of the GHG emissions based on actual values. For example, these relate to the system boundaries of the consideration (which processes have to be taken into consideration in the balance) and the consideration of by-products.

System limits. The system boundaries for the biodiesel options considered in this study are shown in Figure 1. Corresponding to the waste and residual material definition of the EU RED, the balancing of the biofuel production based on waste and residual materials begins with their collection. Moreover, the system boundaries contain all processes downstream of the collection, such as treatment of the fats, conversion to biodiesel and finally distribution of the fuel. The emissions from the fuel utilisation are equated with the carbon uptake from the biomass production, corresponding to the assumption that only biogenic carbon dioxide is emitted during the internal combustion of motor vehicles. The process chains in question differ in respect to the supply processes. While the processes upstream of the biodiesel production are restricted to the collection and transport processes in the case of biodiesel from used cooking oil, the expenditures from the rendering plant are also considered besides the transport of the fats to the production plant when it comes to the process chain for biodiesel from animal fats. This process is integrated in the rendering plant and is only used for obtaining fats for further processing, which means it therefore has to be balanced as well.

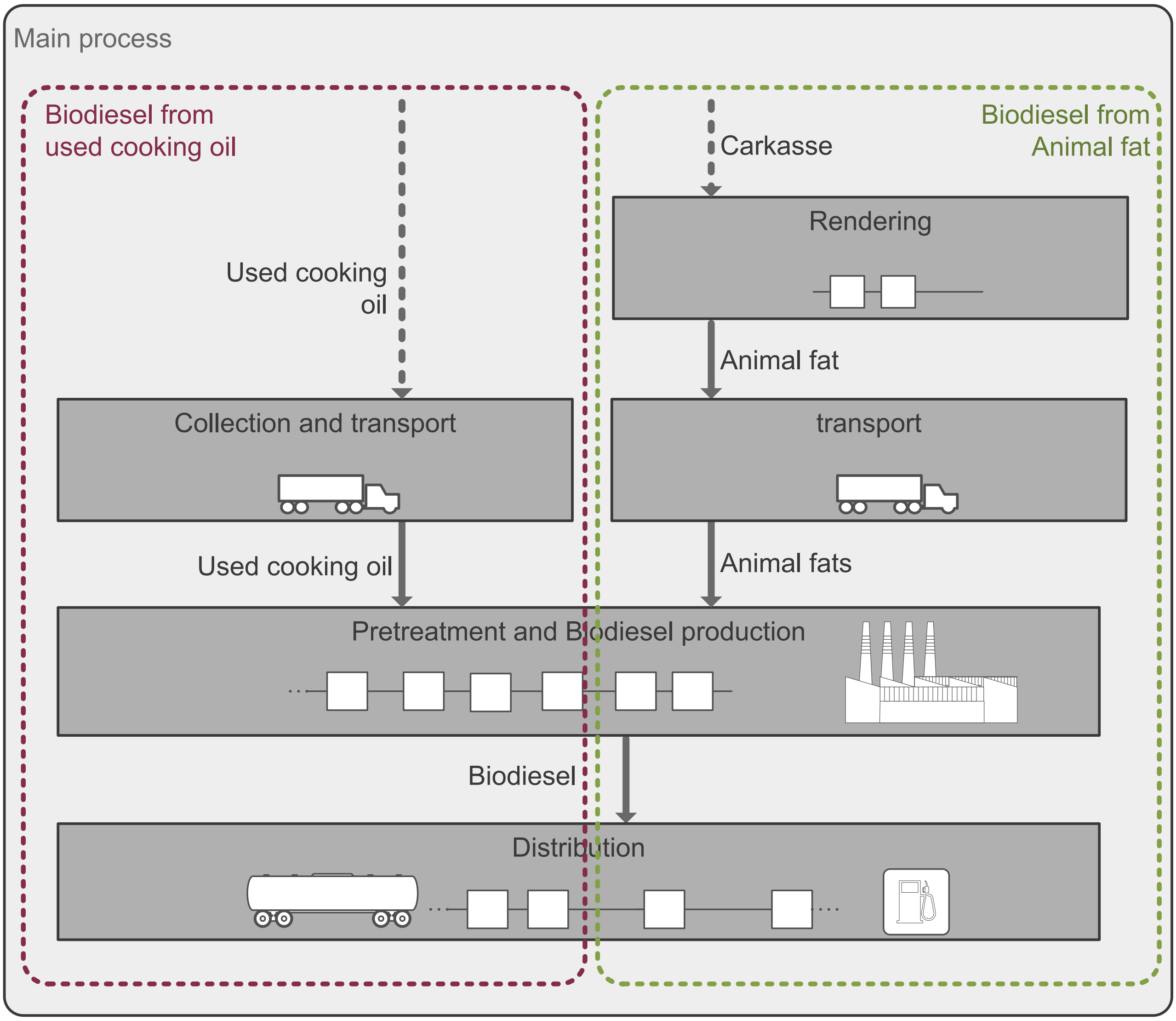


Figure 1 System boundaries of GHG balancing

Allocation. According to EU RED, by-products by means of allocation are considered. This means that the sum of the expenditures and the associated emissions and energy expenditures resulting until production of the by-products are divided between the main product and the by-product. The allocation is conducted for liquid biofuels as well as gaseous biofuels corresponding to EU RED according to the lower calorific value.

3 Biodiesel from waste food fats and oils

3.1 Greenhouse gas balance for biodiesel from waste food fats and oils

Corresponding to the process chain outlined in Figure 1, greenhouse gas emissions for the supply of biodiesel from used cooking oil were calculated based on data from the project database of the DBFZ and the inventory database ecoinvent 2.2. The data comprises all relevant input and output flows of the individual process steps. The process, which is based on the calculation, is referred to as base case and is the basis for the sensitivity analysis.

Figure 2 shows the results of the GHG balancing. The combustion of fossil energy sources is determinative for the GHG emissions of the processes transport, conversion (and distribution. . First of all this is fossil diesel as a fuel for the transport processes (also distribution). The conversion process has the largest share of the overall GHG emissions. The expenditures from the supply of heat and steam based on natural gas, the supply of fossil-based methanol and an electricity mix for Europe [5] are primarily responsible for the climate-relevant emissions here. The total greenhouse gas emissions of just under 14 gCO_2-equiv./MJ_{FAME} of the base case correspond to a reduction potential of 83% in comparison to the fossil reference value defined in EU RED[1].

Although the values for the basic scenario and the EU RED standard value are similar in respect to the level of the overall GHG emissions, there are significant differences in the process-specific assignment of the emissions. These are essentially emissions from the transport and distribution processes. The aggregated value of the standard value does not seem to represent the expenditures for the transport processes sufficient in comparison to the base case (which was an intention behind commissioning this study as described at the beginning). This impression is reinforced when looking at the GHG emissions that were balanced based on the data from JRC 2013 for biodiesel production from waste food fats. This value[2] is above the two other values at just under 17 gCO_2-equiv./MJ_{FAME} on account of the higher emissions from the transport process. The background and effect of a parameter variation in the collection and transport processes form the subject of the following sensitive investigations.

[1] The comparative value for gasoline and diesel is set at 83.8 gCO_2-equiv./MJ.

[2] In order to emphasise the conservative character of the standard values, a 40% increase in the actual values was reckoned with for calculation of the emissions from the conversion. Although the database from JRC 2013 and the EU RED standard value do not differ on the level of the conversion, the value for JRC 2013 (only the actual values were reckoned with here, the 40% increase is absent) is significantly higher than the standard value here. The reasons for this are possibly due to the use of different emission factors. More extensive studies are required to clarify the precise reasons for these discrepancies.

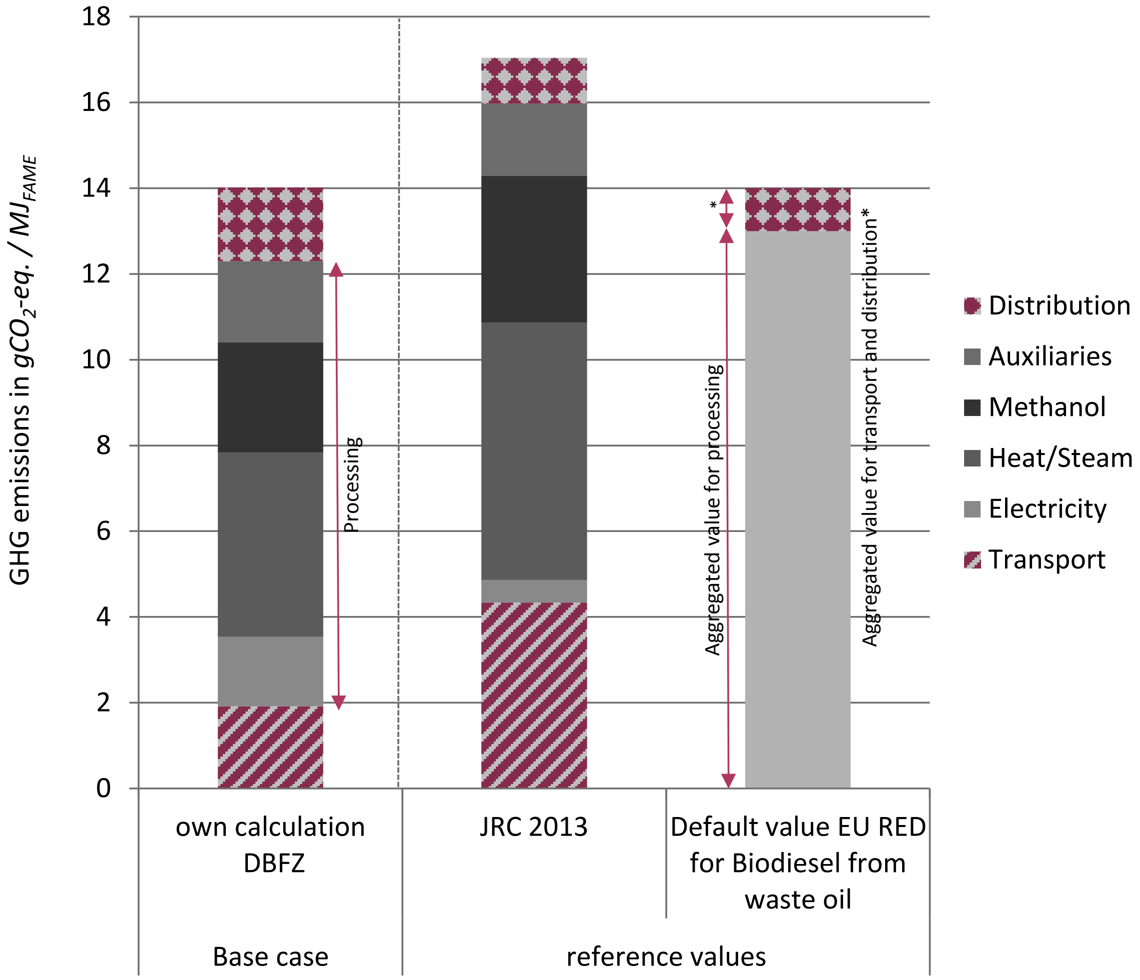


Figure 2 GHG emissions from the base case scenario in gCO_2equiv./MJ_{FAME} in comparison to the values corresponding to JRC 2013 and the standard value of EU RED

3.1.1 Effect of the parameter variation of collection and transport processes on the GHG balance

The subject of climate-relevant emissions from transport processes and their effect on the total greenhouse gas balance shall be explained in more detail, primarily from two causal aspects. Firstly, the GHG emissions from the transport processes of the EU RED standard value are very low and are significantly below those of comparable processes. This is particularly significant in respect to the funding policy directives mentioned at the beginning. The EU RED standard value at 83% exhibits a very high GHG reduction potential in comparison to the fossil reference. The GHG reduction potential becomes a market-dominating factor in view of the current double crediting of biodiesel from waste food fats and oils to the biofuel quota (in relation to the energy content) or the conversion of the quota to a GHG reference in 2015. A value with which biofuel producers can identify the GHG reduction potential of their fuel without reference to the actual values should not only have a conservative character on the level of the conversion, but should also at least be realistic in the upstream and downstream transport processes. Secondly, it is to be expected that the demand for used cooking oil for biofuel production will increase on account of the above framework conditions such as double crediting and GHG-relevant quota as well as the proposed coverage at 5 or 6% for biofuels from cultivated biomass. This, in turn, could lead to increased imports of these fats from Malaysia and China, for example. This circumstance was taken into account in JRC 2013. The database for biodiesel from used cooking oil includes the transport of the biomass by sea and transoceanic tanker over 18,500 km. This explains the relatively high GHG emissions for the transport (Figure 2). The emissions from ocean transport are responsible for 95% of the total transport emissions here. However, the expenditures for collection of the biomass, transport to the port and from the port to the production plant appear to be too low at 100 km/t biomass per truck (40t) in this supply chain, similar to the standard value currently applicable. The expenditures for collection and transport that were assumed for the base case scenario are the basis for the scenarios formulated in regard to the sensitivity considerations. The supply of the biomass is based on these assumptions in respect to collection of the biomass in every scenario, irrespective of whether it includes overseas transportation or not. The scenarios under consideration are indicated in Table 1.

Table 1 Scenarios for collection and transport processes and their assumptions

Scenario	Truck 4t[3]		Truck 24t[4]		transoceanic tanker		freight train [5]	
	Proportion of biomass [%]	Distance [km]	Proportion of biomass [%]	Distance [km]	Proportion of biomass [%]	Distance [km]	Proportion of biomass [%]	Distance [km]
Base case	45	150	55	350	-	-	-	-
Scenario 1	45	150	55	350	100	18,500	100	800
Scenario 2	45	150	55	350	30	18500	30	800
JRC 2013			100	100 (40t)[6]	100	18500		

Figure 3 below shows the results of the GHG balancing for these scenarios. As is to be expected, the emissions of scenario I, in which a 100% proportion of import biomass was assumed, are significantly above the emissions of other scenarios. The majority of the transport emissions are incurred from the ocean transport. However, road and rail transport also causes significantly higher emissions than assumed for the standard value.

[3] Includes collection of the used cooking oil and their transport to the conversion plant, referred to as collection transport below

[4] Includes collection of the used cooking oil and their transport to the conversion plant, referred to as collection transport below

[5] In conjunction with transoceanic transport, transport from the port to the biodiesel plant

[6] Transport with a 40t truck was assumed for JRC 2013.

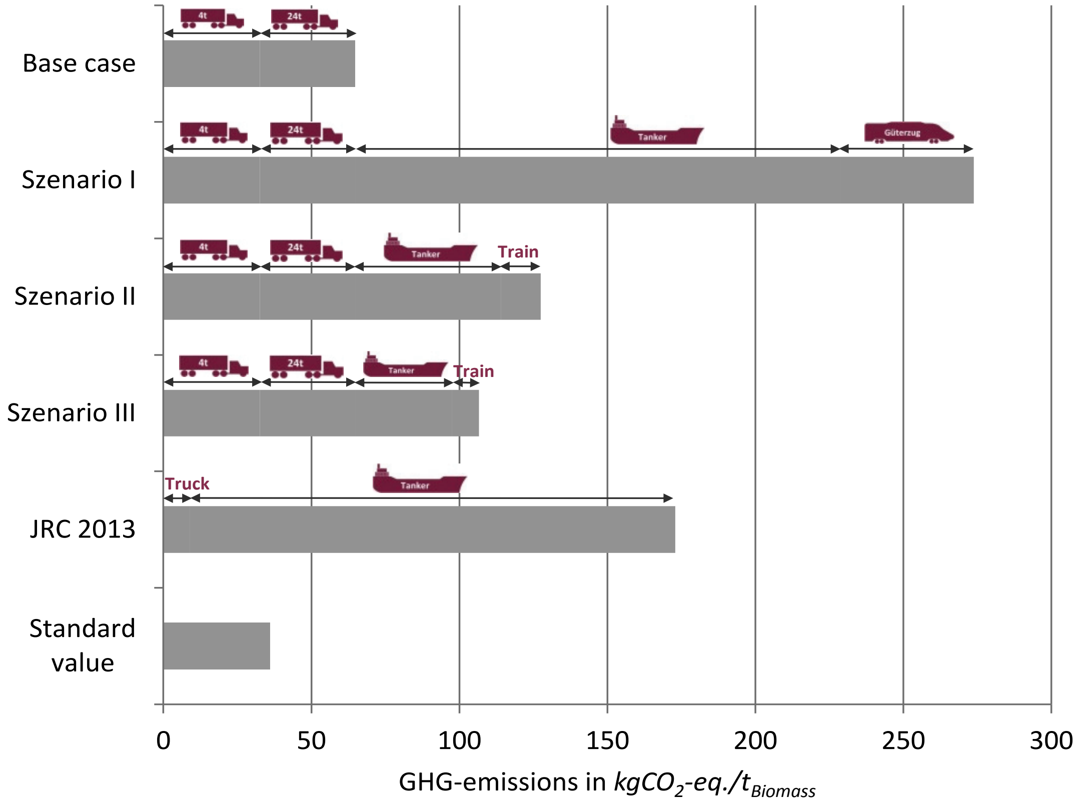
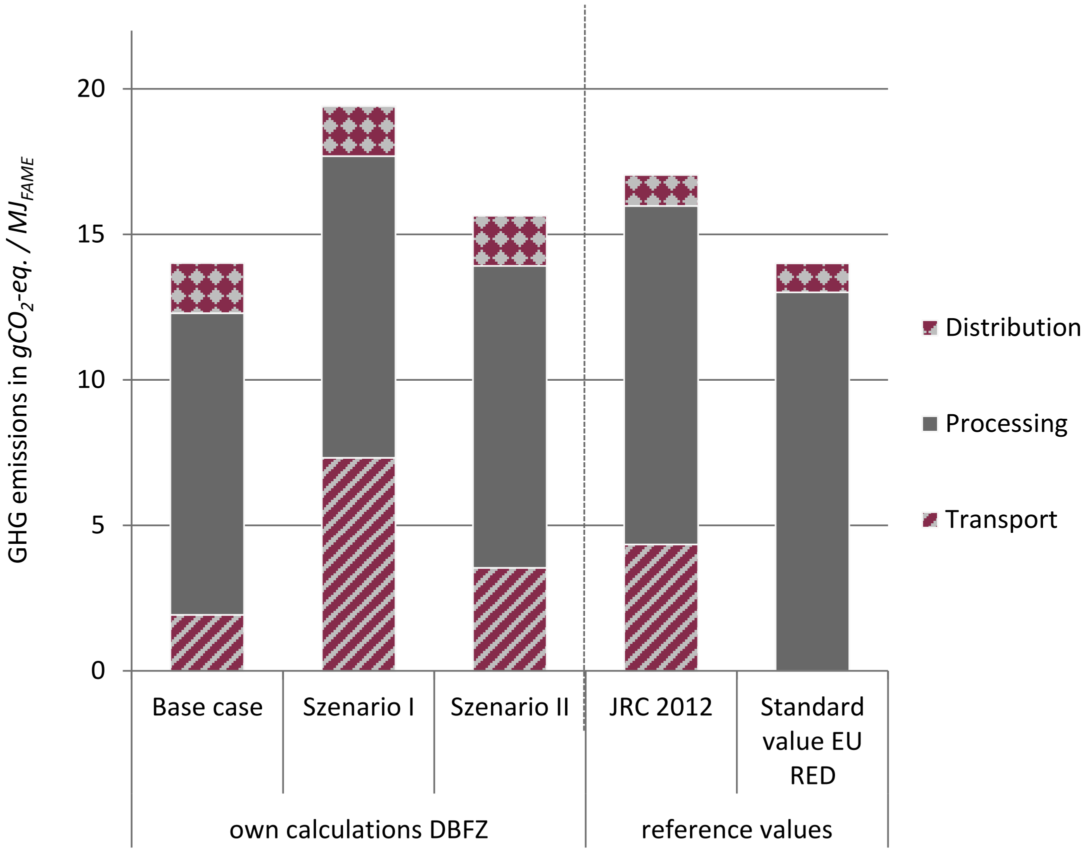


Figure 3 GHG emissions of the transport scenarios in gCO_2-eq./t used cooking oil

If we transfer the results of the scenario consideration to the overall greenhouse gas emissions of the biodiesel production, the effect of the variation in the transport parameters will become clearly apparent. Scenario I (this value corresponds to the specifications from JRC 2013 plus the emissions from the collection transport and the transport from the port to the production plant) is significantly above the EU RED standard value and exhibits a GHG reduction potential of 77% in comparison to the fossil reference (cf. footnote 1). The transport emissions are responsible for almost 38% of the total emissions in this scenario. These expenditures for the collection transport and the transport from the port to the production plant should be incorporated in the database along with the ocean transport. For the currently applicable standard value, this would lead to a decrease in the GHG reduction potential to 74%.



Excursus used cooking oil from private households

Increased demand for used cooking oil could enable further potentials to be opened up regarding collection in private households. The recycling of used cooking oil in private households is not widespread in Germany. In Austria, collecting systems with 3.5 l vats has been implemented in private households to this end [7]. There are hardly any studies on the ecological effects. A study concerning different collecting systems in Barcelona indicates a spectrum from 242 to 344 $kgCO_2$-equiv. per t biomass, depending on the collecting system [8]. Besides the expenditures for the collection and acquisition of used cooking oil from private households, however, the loads on the sewage systems and treatment plants prevented by the collection should also be considered, as used cooking oils are normally disposed of via the sewage system in private households.

3.1.2 Effect of the allocation on the GHG balance

As already described, by-products are considered in the GHG balance by means of allocation according to their lower calorific value. Whether glycerine from the biodiesel production represents a by-product as previously assumed (the balances shown represent allocated values) or a processing residue as defined by the directive and an allocation complies with the directive, shall be explained below. The communication by the European Commission (2010/C 160/2) states: "A processing residue is a substance that is not the end product(s) that a production process directly seeks to produce. It is not a primary aim of the production process and the process has not been deliberately modified to produce it..." [9]. If there is no treatment stage for the crude glycerine to glycerine within the biodiesel conversion process, (crude) glycerine is not, by definition, a by-product but instead a processing residue to which no emissions are assigned according to the directive. An allocation is excluded in this case.

However, as the amounts of glycerine resulting from the biodiesel production process can be classified as rather marginal, consideration of the glycerine by means of allocation does not lead to any significantly lower total GHG emissions, as Figure 4 shows.

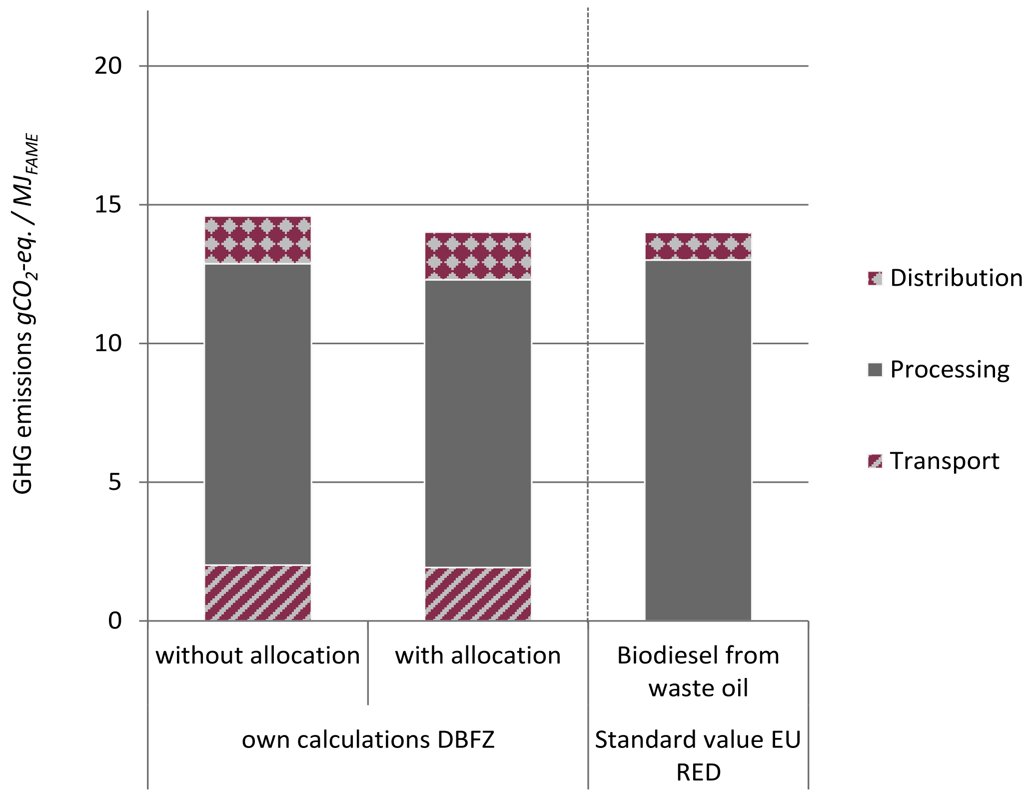


Figure 4 GHG emissions with and without allocation in gCO_2-equiv. /MJ_{FAME} in comparison to the standard value.

3.2 Substitution effects

Besides biodiesel production, used cooking oils are also sometimes used in CHPs and fermentation plants [10]. However, as very little information is available in regard to this, it is difficult to estimate and quantify possible substitution effects in the case of increased use of used cooking oil in biodiesel production.

4 Biodiesel based on animal fats

4.1 GHG balancing

Corresponding to the process chain outlined above (Figure 1), greenhouse gas emissions for the supply of biodiesel from animal fats were calculated based both on data from the project database of the DBFZ and the inventory database ecoinvent 2.1 as well as based on the data from JRC 2013. The results were then compared with the standard value for biodiesel from waste oils. The results of the GHG balances are significantly above the common standard value for biodiesel from used cooking oil and animal fat, as shown in Figure 5. The higher total emissions are primarily caused by the expenditures for the fat rendering plant. This process is not included in the database for the standard value. If we assume that the data from JRC 2013 for biodiesel from animal fats serves as a basis for a new standard value, the actual value (cf. footnote 2) would exhibit a GHG reduction potential of 70% in comparison to the fossil reference (cf. footnote 1). Presupposing that we retain the practice involving a 40% increase in the GHG emissions from the conversion and the process of the fat rendering plant is not affected by this, the GHG reduction potential is reduced to 67%.

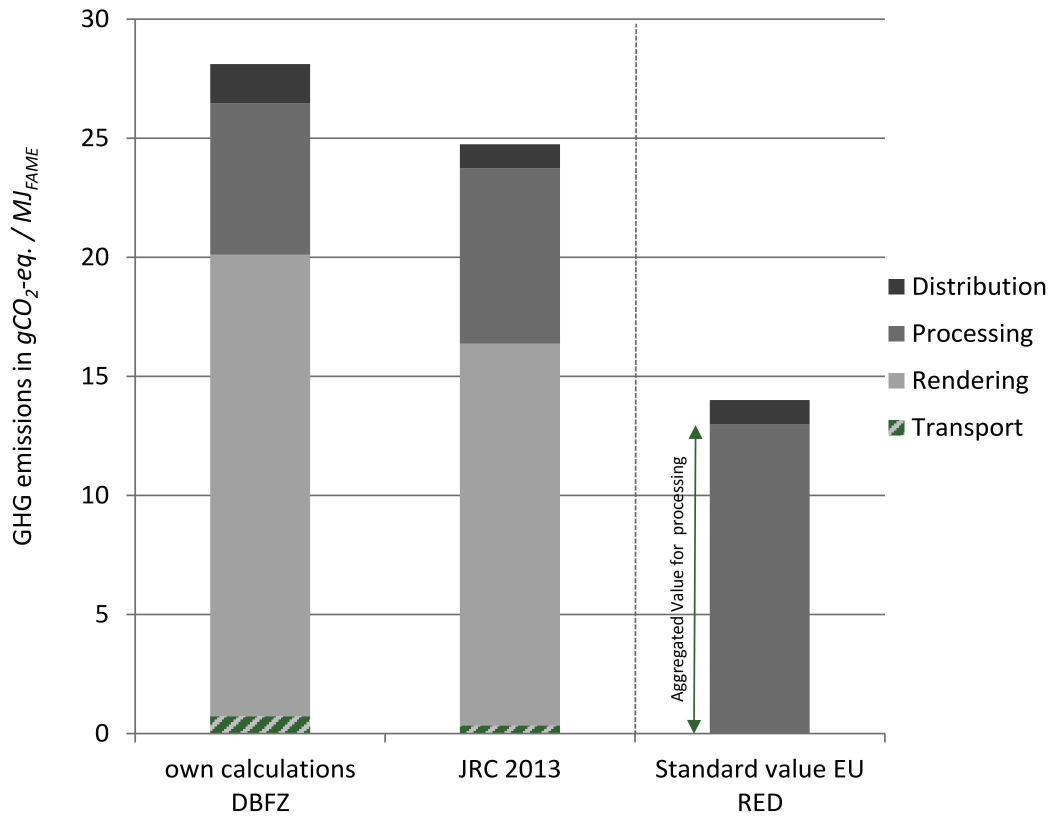


Figure 5 GHG emissions for biodiesel production from animal fats in gCO_2-eq./MJ_{TME}

4.2 Substitution effects

Animal fats are also used energetically as a fuel substituting fossil fuels amongst others. The use of animal fats in biodiesel production could, for all intents and purposes, lead to animal fats being removed from the previous energy utilisation and possibly having to be replaced by fossil fuels there.

The fact that the fats are typically replaced by fossil fuels during the thermal utilisation means the fossil CO_2 is released at another point (e.g. could a process that has so far been supplied with energy from thermal utilisation now be converted again to natural gas, oil or coal?).

Various scenarios have been developed and compared with one another in order to examine the consequences of biodiesel production from animal fats on the environment. As a large part of the animal fats are already supplied to a material or energy utilisation at present reductions due to the use of animal biodiesel cannot be calculated against the fossil reference, but instead have to be offset with the resultant greenhouse gas emissions in the exchanged processes owing to the re-utilisation then in place, for a consideration concerning society as a whole.

In order to estimate the GHG reduction potential of biodiesel from animal fats, the utilisation options involving own-utilisation of the fats (for example steam generation in rendering plants), thermal utilisation (for example cement work as representative for a secondary fuel utilisation) and biodiesel production were combined in varying scenarios. The scenarios are outlined in Figure 6.

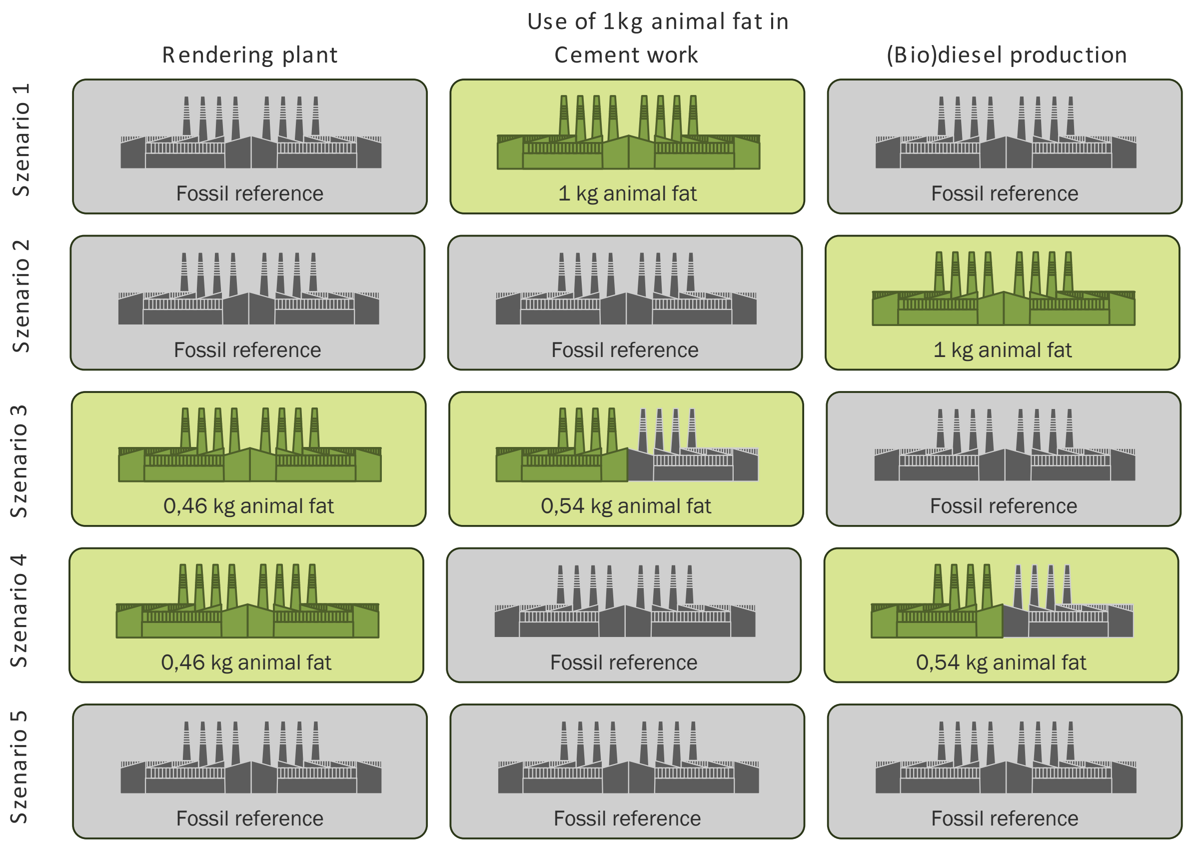


Figure 6 Scenarios involving the energetic utilisation options for animal fats (the use of animal fats in the corresponding utilisation options is shown in green)

Estimation of the GHG emissions of the various fat utilisation scenarios, as illustrated in Figure 7, led to the result that no additional greenhouse gas saving can be achieved in the energy system through a re-utilisation of the animal fats already in use in this case. Rather, the reduction possible as a result of biodiesel production from animal fats (scenario 2) is lower than that for the other scenarios examined.

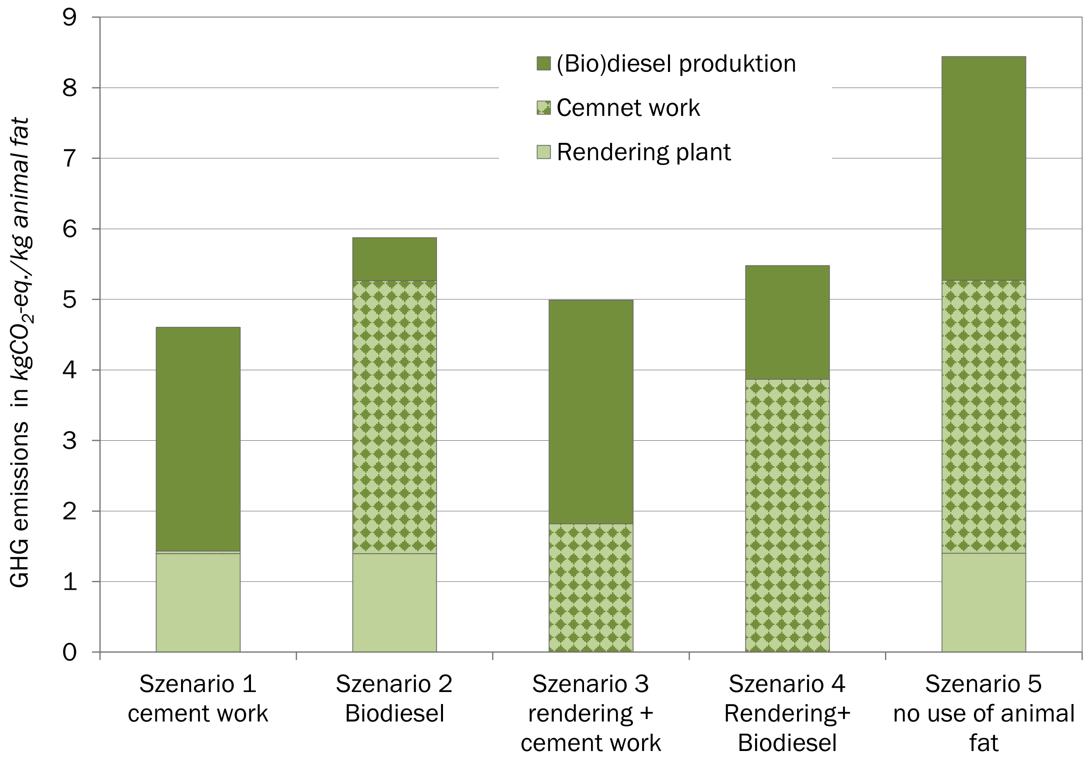


Figure 7 Estimation of the GHG emissions from the various fat utilisation options in $kgCO_2$-eq./$kg_{Animal\ fat}$

5 Summary

On account of funding policy framework conditions such as double counting and the planned GHG-relevant biofuel quota, as well as the proposed 5 or 6% coverage for biofuels from cultivated biomass, the demand for used cooking oils for biofuel is set to rise and the GHG reduction potential for a biofuel will become a market-dominant factor. Based on the standard values for various biofuels published in Annex V of the EU RED, biofuel producers can identify the GHG reduction potential of their biofuel. The framework conditions for biofuels based on residual and waste materials may mean that it is necessary to revise the assumptions for calculation of these standard values for these biofuels. Above all, this concerns the assumptions concerning the transport distances for the residual and waste materials used as well as the expenditures derived from this for calculation of the emissions from the transport. A comparison of GHG balances for biodiesel from used cooking oils based on both own data as well as the database published in JRC 2013 with the standard value contained in the EU RED for biodiesel from waste oil shows the effect of emissions from the transport processes, while revealing that the expenditures implied from the standard value for the transport processes are estimated too low. Because, as already mentioned, the standard values contained in the EU RED can be incorporated to validate the GHG reduction potential of a biofuel, the assumptions upon which the standard value for biodiesel from waste oil is based should:

- be mapped realistically for collection transportation and
- contain the corresponding expenditures for ocean transport and the associated transport from the port to the biodiesel plants when using import biomass.

To be able to estimate the possible ecological and economic effects of a more intensive utilisation of residual and waste materials in already established material flows and hence effectively assess the current proposals of the Commission, the following questions urgently need to be examined in more detail:

1. How great are the potentials for used cooking oils from private households and what economical and ecological effects would a separate collection have? How high are the expenditures for the collection and how high are the avoided expenditures for sewage systems and treatment plants?
2. How are used cooking oils currently used and what substitution effects result in the case of a more intensive utilisation of the waste materials for biodiesel production?

So far, there has not been any explicitly identified EU RED standard value for the production of biodiesel from animal fats. The report JRC 2013 contains data for biodiesel from animal fats as a possible basis for the calculation of a corresponding standard value. Besides the actual conversion process, expenditures of the rendering process integrated in the animal carcass processing plant were taken into consideration for the calculation of this value. As a result, the GHG emissions are significantly above those of the EU RED standard value for biodiesel from vegetable and animal waste oils. As animal fats have diverse uses, the following questions arise similarly to the waste food fats and oils regarding the more intensive use of animal fats for biodiesel production:

1. How are animal fats currently utilised (in particular energy use)?

2. What substitution effects result in the case of a more intensive use of animal fats for biodiesel production?
3. How can these effects be quantified?
4. Furthermore, the assumptions for the transport processes should also be depicted realistically here.

More extensive information concerning corresponding interaction and substitution effects is required if we are to be able to evaluate the possible ecological and economic effects of a more intensive use of residual and waste materials.

Table of Figures

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