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Influence of the re-evaluation of residual and waste materials on the GHG balance of first generation biofuels

Summary report

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Table of contents

List of abbreviations and symbols

Abbreviation	Explanation
DDGS	Dried Distillers Grains with Solubles; a co- product from ethanol production and a protein-rich animal feed
Eq.	Equivalent
EU RED	EU Directive for the promotion of renewable energies (2009/28/EC)
GHG	Greenhouse gas
ISO	International Organization for Standardization
kg	Kilogram
KST	Fuel
LHV	Lower heating value
MJ	Megajoule
REA	Renewable Energies Law

1 Introduction and objectives

In addition to a general objective of increasing the share of renewable energy sources in end-use energy consumption in Europe, the Directive for promotion of the use of energy from renewable sources (2009/28/EC) adopted in April 2009 also defines a concrete expansion objective for the share of renewable energy sources in the transport sector. From 2020, this objective obligates all member states to ensure a share of renewable energies of at least 10 %, measured against the energy content of overall fuel consumption. [1] With respect to the close proximity of this objective and the current status of technological developments, a substantial part of this amount would have to be provided using biofuels.

In reaction to the intensive debate surrounding the sustainability of increased use of biofuels, among other things, in October 2012 the European Commission published a proposal for the amendment of EU Directives 2009/28/EC (EU RED) and 98/70/EC (fuel quality directive). [2] This proposal puts a range of aspects up for discussion for the future configuration of the funding policy framework for biofuels at European level. In addition to the existing double counting, a substantial component of the proposal is the planned quadruple counting of biofuels from certain residual and waste materials to the individual contributions of EU member states with an overall European objective of 10 % renewable energy sources in transport. At the same time, the Commission suggests that the contribution of biofuels from cultivated biomass is restricted to a maximum of 5 %. Since the use of residual and waste material for biofuel production is associated with less risk of the occurrence of so-called indirect land-use change effects than the use of cultivated biomass, with this suggestion the Commission is reacting to one of the important discussion points surrounding biofuels in the sustainability debate. As it is to be expected that the implementation of the planned multiple counting will apply a strong economic incentive to use the allowable residual and waste materials in the transport sector, a range of follow-up questions result from the Commission's amendment proposal. In addition to the question as to how it can be guaranteed that no incentive for the "production" of waste material will result, the anticipated effects may also have repercussions on other sectors beyond the biofuels sector. Many of the residual and waste materials suggested for multiple subsidy are already in established material flows or already have a market value (e.g. straw) and are therefore not waste or residual materials in the proper sense.

A key point of the sustainability criteria introduced within the EU RED are the binding greenhouse gas reduction targets for biofuels. Fulfilment of these guidelines represents a prerequisite for the eligibility of biofuels with respect to the national biofuel quotas. In order to be taken into account in the national biofuel quota, the value of this GHG balance must currently be at least 35 % lower than the GHG value of fossil fuel. These target values gradually increase over the years. This, as well as the planned switchover of the quantity-based quota to a GHG-based quota, will in future make the GHG balance of biofuels an important competitive criterion.

The procedure for calculating this GHG mitigation potential is defined in the Annex of the EU RED. In addition to various specifications relating to system boundaries, the functional unit or the greenhouse gases (CO_2, CH_4, N_2O) that are to be taken into consideration, the directive also sets out specifications for the methodical handling of co-products. In this connection, EU RED describes a procedure for the distribution of emissions (allocation) of a process to the resultant products (primary and co-products such as e.g. ethanol and DDGS in ethanol production). Here, what is decisive is on the one hand the

algorithm for calculating this distribution key (in accordance with the guidelines of EU RED, calculation takes place on the basis of the lower calorific value of the products) and on the other hand the demarcation between products, residues rom processing, residues and wastes. In relation to this point, various concrete specifications also exist in the directive and in further-reaching communiqués from the Commission. **Within the framework of this specification, the biomass that has been declared as a residue (e.g. straw from the cereal production process) is explicitly excluded from consideration during allocation. This means that if straw is used, emissions from the process of biomass production (cereal cultivation) are not taken into account in the GHG balance.**

In the field of classical, scientific Life cycle assessment (LCA), the demarcation between products that are taken into account in the distribution of emissions and residues or wastes is frequently orientated on the demand or on the existing market for these. Hence in accordance with the logic of classical LCA, the currently discussed approach for stronger political promotion of the use of specific residues and wastes may necessitate the re-evaluation of allocation guidelines, where applicable (i.e. for consideration of what have been considered as residue up to now), in the GHG balancing of biofuels.

In particular, the agricultural residues proposed for multiple counting fulfil what are in part important functions for the preservation of soil fertility and structure. If, during the removal of these materials for use as energy, measures such as compensation fertilisation or measures to equalise the humus balance are necessary, consideration of these measures should occur in the GHG balance of the fuels extracted from these residual materials.

Hence the objective of this study is to represent the influence of various guidelines for the consideration of agricultural residues in the GHG balance of biofuels. Here, it is to be demonstrated as to how the greenhouse gas balance is changed of a process chain for the production of a conventional biofuel (cereal-based ethanol) and that of a process chain for the production of a future biofuel (straw-based ethanol), with consideration of straw as a co-product (i.e. allocation of the emissions from cultivation between grain and straw) and/or straw as a residue (i.e. no emissions from cultivation for straw).

2 Prerequisites/Basic principles

The EU Directive and the Biofuel Sustainability Ordinance (BiokraftNachV) contain concrete guidelines for calculating this GHG reduction value [3]. For this, the GHG emissions from biofuel production and use are to be calculated first. In the following step, these will be compared to the emissions of the fossil comparison figure.

In addition to the calculation methodology, both guidelines contain a range of aggregated or disaggregated "default values" for various biofuel options. These "default 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. In accordance with the specifications of EU RED or the BioKraftNachV (Biofuel Sustainability Ordinance), the following three possibilities are permissible for the calculation of the GHG emissions saving potential of a biofuel:

1. Calculation of the GHG reduction 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 process steps of the process chain (e.g. biomass production) with the disaggregated default value for the rest of the process chain.

Further-reaching guidelines exist in Annex V of the EU Directive for the calculation of the GHG reduction potential on the basis of actual values. For example, these relate to the system boundaries (namely which processes have to be taken into consideration in the balance) and the consideration of co-products.

The guidelines for consideration of co-products primarily relate to the questions i) which process outputs are defined as a co-product and can hence be taken into consideration in the balance, and ii) in what manner can the allowable co-products be taken into account in the balance.

The guideline also contains a first orientation for the question as to which process outputs are defined as a co-product and can thus be taken into account in the balance. The predominant parts of the substrates that have been proposed in the current amendment proposal for multiple counting are residues or wastes. In accordance with the current guidelines of EU RED, these may not be taken into consideration as co-products for GHG balancing. With the example of ethanol made from wheat and ethanol made from wheat straw, this means that in accordance with the current calculation guidelines of EU RED, emissions from the wheat cultivation process will be exclusively assigned to the grain. If reversed, this guideline means that the balancing of ethanol production based on straw begins with the collection of the straw.

If the discussed amendment proposal for the EU RED is implemented, it is to be expected that primarily the demand for those residues and wastes that are already available for the corresponding conversion technologies for biofuel production will rise. In future, this may also lead to a change in the drivers behind specific agricultural production processes and hence may also necessitate re-evaluation of the co-product term. In the case of the use of straw, this could mean, for example, that agricultural production technology does not remain exclusively aligned on optimisation of the cereal yield as up until now, but in future may also move in the direction of the straw yield.

3 Influence of different approaches for consideration of straw as a co-product in the GHG balance of ethanol production

The following Figure 1 shows the typical GHG emissions from the production and use of ethanol from wheat and wheat straw from Annex V of EU RED. This Annex contains both the default values previously mentioned, as well as the typical values shown in the illustration. The difference between the typical values and the default values lies mainly in a calculated increase in the emissions from the production process. This increase is intended to confer a more conservative character on the default values in order to encourage biofuel producers to compile their own balances for their processes.

The typical values of EU RED show much lower GHG emissions for the production of ethanol based on wheat straw than for the production of ethanol based on wheat. This is primarily due to the much lower proportion from biomass cultivation (dark, spotted contribution). Second important factors are the emissions from the biomass processing procedure. Here, it should be mentioned that the database for the concept of ethanol production based on straw is primarily based on data from process simulation and demo or pilot plants.

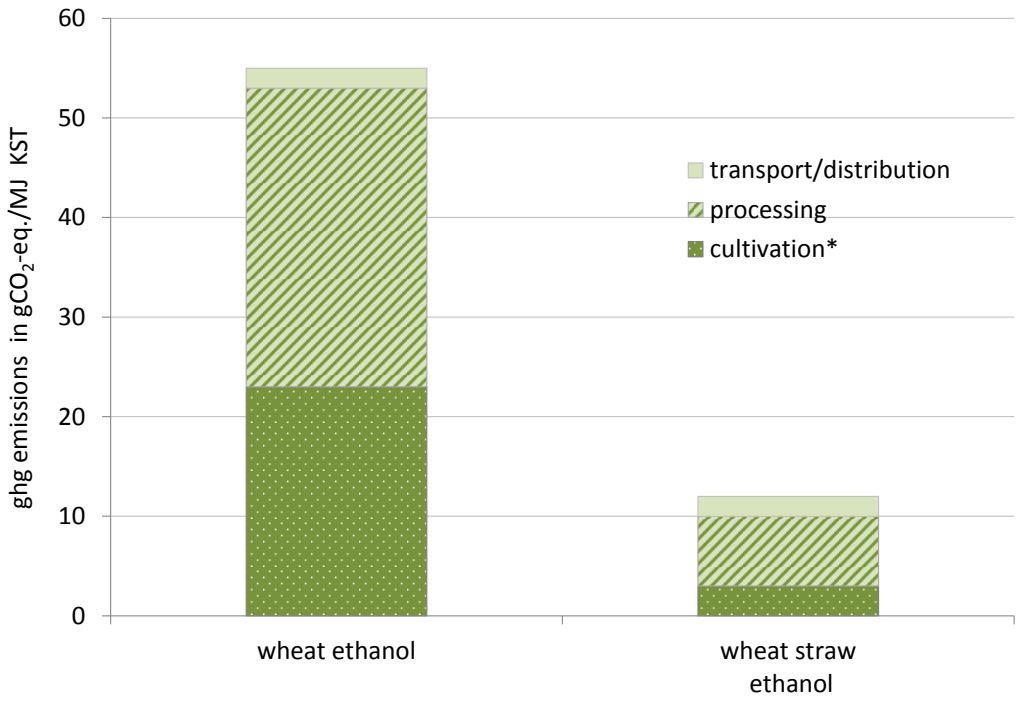

Figure 1 typical GHG emissions for ethanol based on wheat and wheat straw (in accordance with Annex V EU RED); * = in the case of straw, the balance begins with straw gathering; agricultural production processes are not included

The following section describes the possible influence of the consideration of straw as a co-product in the GHG balance of the two represented biofuel pathways. The represented calculations are based on the available information relating to the background assumptions and the database of typical values from Annex V of EU RED (e.g. [4]).

Figure2 shows the disaggregated typical GHG emissions of the different process steps for the production of bioethanol based on wheat from Annex V of EU RED. Since straw is excluded from the

allocation in accordance with the guidelines for GHG balancing in the Annex of EU RED ("residues" as per definition), the emissions from wheat production will be exclusively apportioned to the grain. The production of ethanol results in a co-product, the feedstuff DDGS, that can be correspondingly taken into account in the balance. This is already taken into consideration in calculating the represented typical figures for ethanol based on wheat. The represented figures show the already-allocated emissions from ethanol production. The emissions attributed to the co-product DDGS have already been subtracted (in accordance with EU RED, allocation is made on the basis of the lower calorific value).

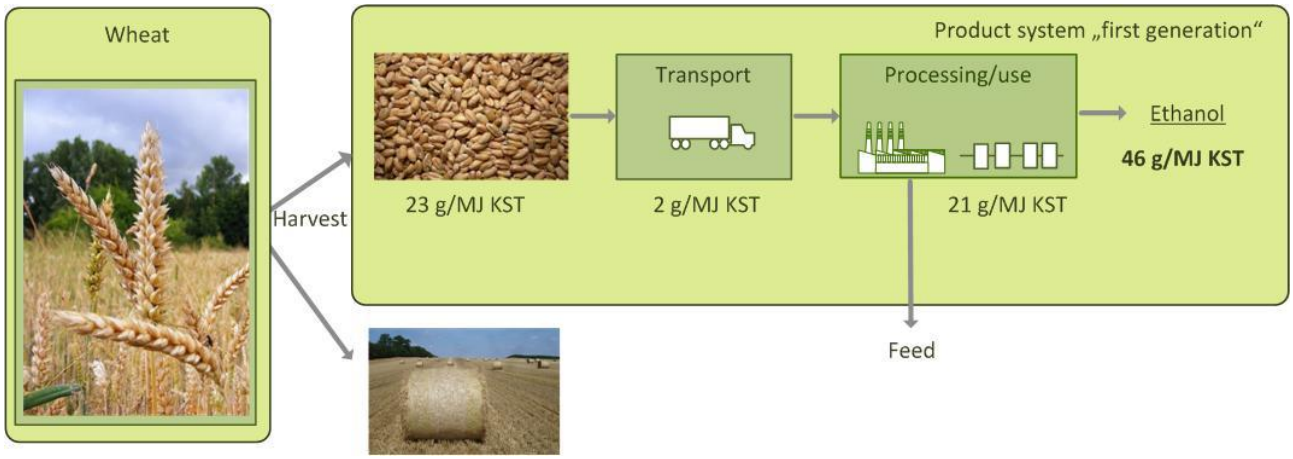

Figure2 disaggregated typical GHG emissions for the production of ethanol based on wheat grain (when using natural gas in a conventional boiler; in accordance with Annex V EU RED)

In Figure3, the disaggregated GHG emissions from ethanol production based on wheat straw have been added. As the emissions from the wheat production are assigned exclusively to the wheat grain, the emissions shown of 3 g CO_2 Eq./MJ are due only to the efforts associated with straw collection. For calculating the typical values in Annex V of EU RED, no additional co-products from the production of ethanol from wheat straw were taken into account.

In a comparison of the values for biofuel production, the clear difference between the two biofuel pathways again becomes apparent.

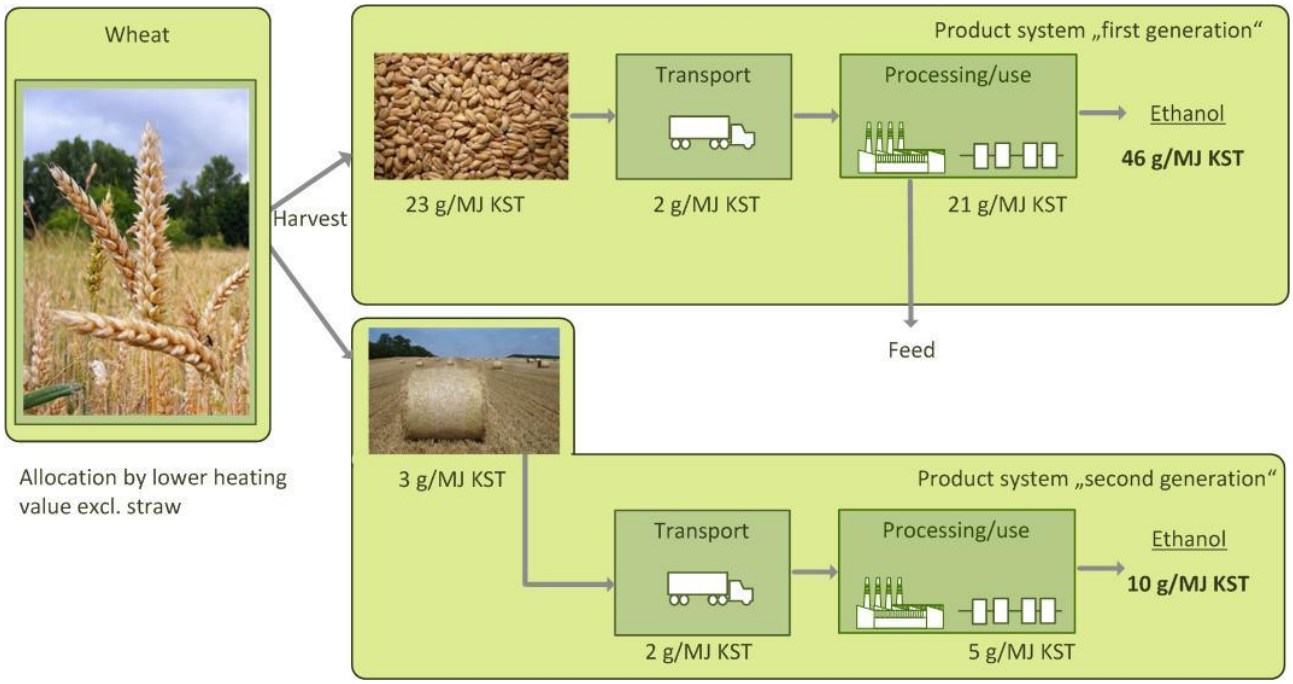

Figure3 disaggregated typical GHG emissions for the production of ethanol based on wheat grain (when using natural gas in a conventional boiler) and wheat straw (in accordance with Annex V EU RED)

If co-products occur in the production of biofuels, in accordance with the guidelines of EU RED the emissions can be distributed up to the corresponding process between the main product and the co-product. In the example of ethanol based on wheat, the emissions from the process of biomass production, transportation and biomass conversion (up to production of the DDGS) are distributed between ethanol and DDGS. This allocation takes place on the basis of the lower calorific value of the two products (see also [5]).

If the drivers behind certain agricultural processes change due to a change in demand for the residues and wastes mentioned in the amendment proposal (e.g. in perspective, the grain-straw ratio could change due to an increased demand for straw), then an adaptation of the co-product term could also become necessary within the framework of GHG balancing. In this case, the sustainability criteria defined in EU RED, such as the observation of good agricultural practice (also includes a well-adjusted humus balance) and land protection, must also apply to straw production. In order to clarify the possible influence of the consideration of straw as a co-product, new calculations will be carried out for the shown examples of ethanol based on wheat and wheat straw on the basis of diverse allocation approaches.

Figure 4 shows the already-mentioned typical values for the two biofuel pathways of the new calculation with consideration of straw as a co- product (shown in red). In this calculation, a grain-straw ratio of 1:2 and calorific values of 17 MJ/kg for grain and 14 MJ/kg for straw are assumed. [6] In addition, not all of the resultant straw was taken into consideration in the balance. Since a certain proportion of the straw must remain on the field due to technical restrictions and for soil fertility, an estimated straw availability of 60 % was used for the calculation. [7]

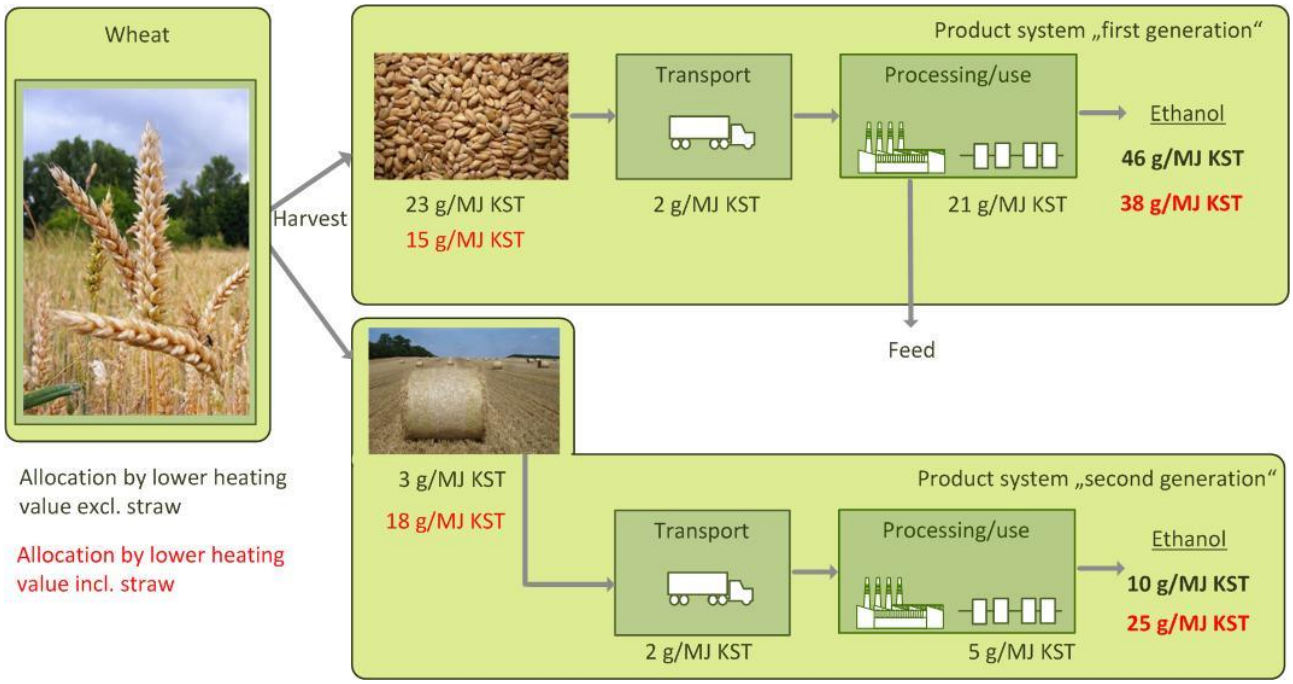

Figure 4: GHG emissions from the production and utilisation of ethanol based on wheat and wheat straw with consideration of straw as a co- product (when using natural gas in a conventional boiler, allocation in accordance with lower calorific value, all calculations based on the typical values in appendix V of EU RED)

The results of the recalculation with consideration of the wheat straw clearly show higher emissions for the process of bioethanol production based on straw and a corresponding reduction in the emissions for the pathway based on grain. This is due to the new distribution of emissions from the cereal production process. In contrast to the calculation for the typical figures, the emissions from the cultivation process are no longer exclusively assigned to the grain but to a certain proportion to the grain. With this allocation approach, the emissions of the concept based on straw increase from 10 g CO_2Eq./MJ to approx. 25 g $_2$ Eq./MJ. In contrast, the emissions from bioethanol production based on grain are reduced from 46 g CO_2 Eq./MJ to approx. 38 g CO_2Eq./MJ.

In addition to the allocation of wheat straw based on the lower calorific value, the results for an additional approach for allocation of wheat straw as a co-product are shown in the Figure 5. In this approach, the GHG emissions from the cereal production process are allocated on the basis of the masses of the various products. In this case, this allocation approach is used accordingly also when accounting for the co-product DDGS from grain-based ethanol production.

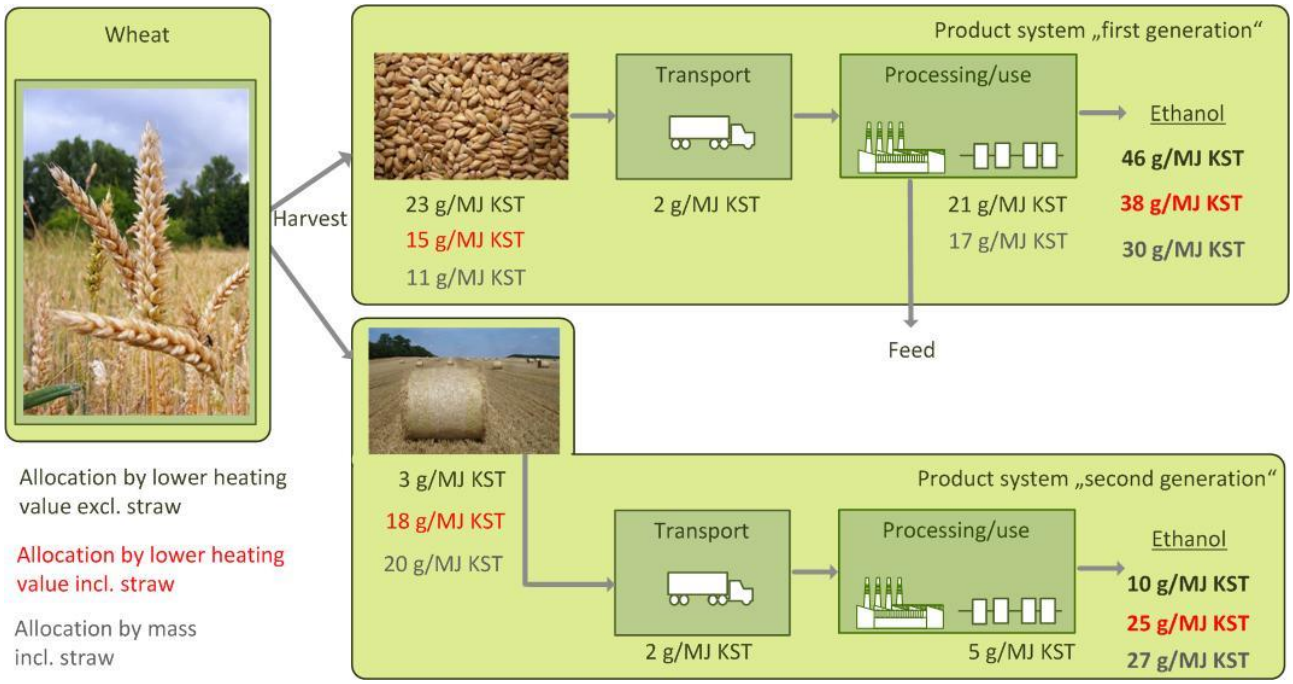

Figure 5 Overview of the GHG emissions from the production and utilisation of ethanol based on wheat grain and wheat straw with consideration to various allocation approaches for straw as a co-product (when using natural gas in a conventional boiler; allocation in accordance with lower calorific value and mass, all calculations based on the typical values in Annex V of EU RED)

In comparison with allocation based on the lower calorific value, distribution of the emissions from the wheat production process leads to a marginal increase in the overall emissions of ethanol production based on wheat straw. A much greater difference between the selected allocation approaches becomes clear for the concept of bioethanol based on grain. Here, it can be seen that allocation based on mass can considerably reduce the result for the primary product ethanol due to the high quantity of produced DDGS.

Figure 6 summarises the represented consideration for the percentage distribution of the resulting GHG emissions to the products for the various allocation approaches.

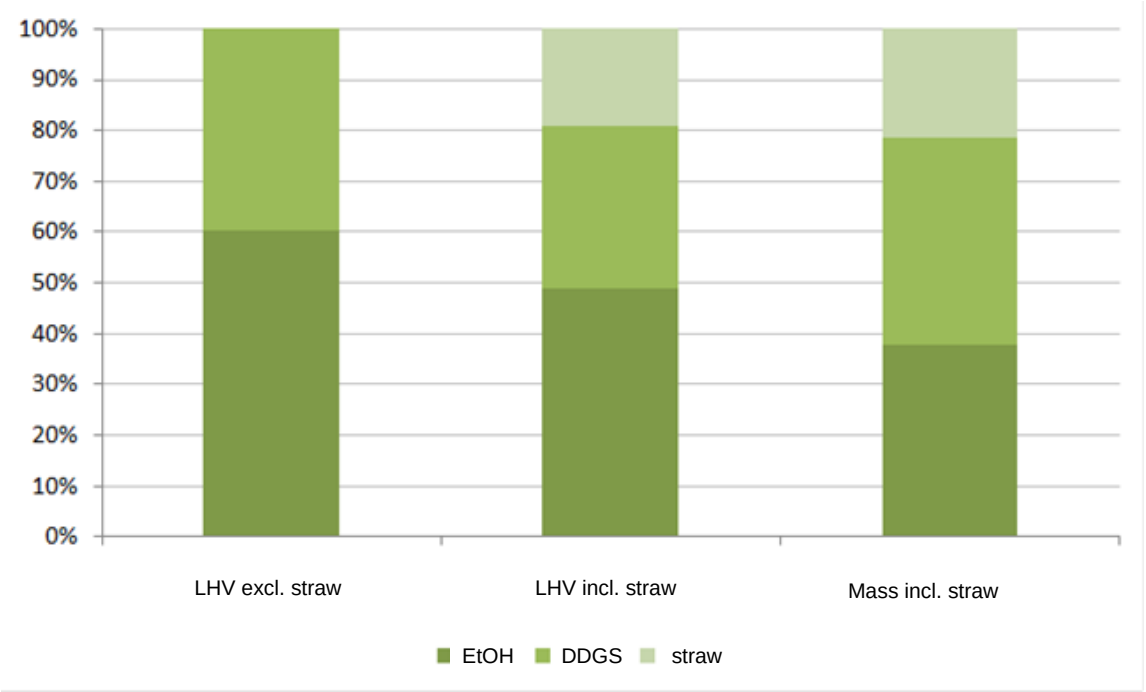

Figure 6 Relative proportion of the total emissions from the 'ethanol from wheat grain' pathway for the various products with different allocation approaches (LHV = lower calorific value)

The following Figure 7 compares the typical values from Annex V of EU RED for bioethanol production based on cereal grain and straw with the results of the new calculations considering straw as a co-product.

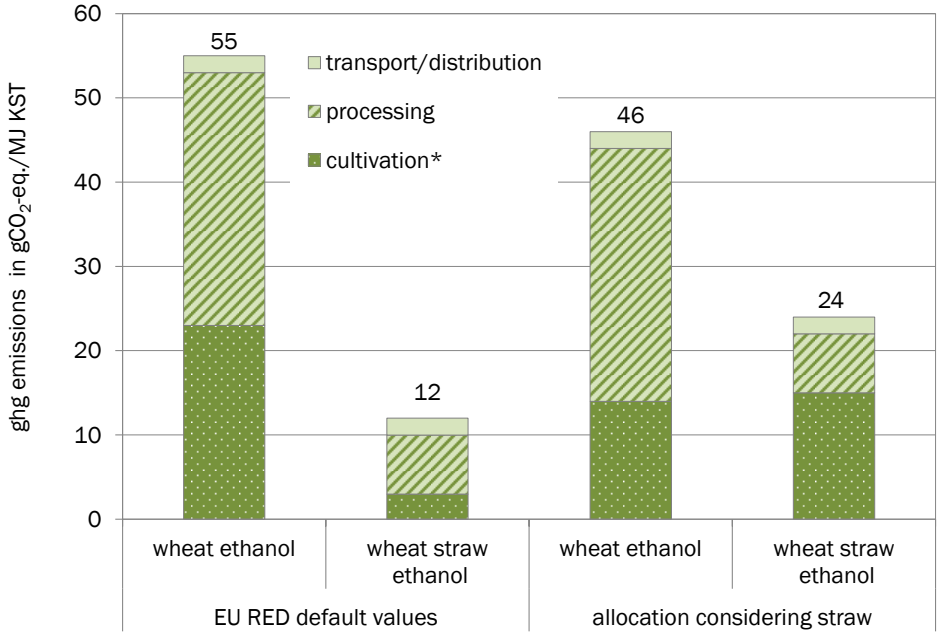

Figure 7 Comparison of the typical values for ethanol from wheat grain and wheat straw (when using natural gas in a conventional boiler; from Annex V of EU RED) and the GHG emissions of both pathways based on the new calculations performed considering straw as a co-product

4 Summary

If the proposal for the amendment of the EU RED and FQD submitted by the European Commission in October 2012 is implemented, it is to be expected that demand for the residual and waste materials proposed for multiple counting will increase in future. In turn, this could lead to a change in the drivers behind certain agricultural processes (e. g. in perspective, the grain-straw ratio could change due to an increased demand for straw) and, in perspective, an adaptation of the co-product term could be required within the framework of GHG balancing (in the context of the EU RED). This would correspond with the procedure of eco-balancing in accordance with the international standardsISO 14040 and 14044. In the case of many residues and wastes that have been proposed for multiple subsidy, following these balancing principles would at least mean a consideration of compensating measures by fertiliser extraction and organic material for the humus balance and thus also a prevention of an otherwise possibly increasing overuse of residual materials. Since many of the residual and waste materials contained in the amendment proposal are already in established material flows, an assessment of the effects of the amendment proposal from the Commission in the form of a so-called impact assessment appears to be required.

A corresponding re-evaluation of the residues and waste materials would also have an influence on the GHG balance of the corresponding pathways. In particular with respect to straw as a raw material in biofuel production, a consideration of the emissions from the agricultural production process would appear to be expedient in the medium term. The listed calculation examples have shown that a corresponding consideration of the obtained straw as a co-product of cereal production would have an effect on both the GHG balance of “conventional” ethanol production (based on grain) and on ethanol production based on straw. In consequence, the results of the GHG balances for both biofuel pathways would clearly converge.

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