Product Category Rules

(PCRs)

For the assessment of the livestock production's environmental sustainability using Specialty Feed Ingredients

IFIF - International Feed Industry Federation

and

FEFANA – EU Association of Specialty Feed Ingredients and their Mixtures

Version 1.0

2015

Global Scenario[1]:

"With emissions estimated at 7.1 gigatonnes CO_2-eq per annum, representing 14.5 percent of human-induced GHG emissions, the livestock sector plays an important role in climate change. Beef and cattle milk production account for the majority of emissions, respectively contributing 41 and 20 percent of the sector's emissions. While pig meat and poultry meat and eggs contribute respectively 9 percent and 8 percent to the sector's emissions.

The strong projected growth of this production will result in higher emission shares and volumes over time. Feed production and processing, and enteric fermentation from ruminants are the two main sources of emissions, representing 45 and 39 percent of sector emissions, respectively. Manure storage and processing represent 10 percent. The remainder is attributable to the processing and transportation of animal products. Included in feed production, the expansion of pasture and feed crops into forests accounts for about 9 percent of the sector's emissions. Cutting across categories, the consumption of fossil fuel along the sector supply chains accounts for about 20 percent of sector emissions.

A 30 percent reduction of GHG emissions would be possible, for example, if producers in a given system, region and climate adopted the technologies and practice currently used by the 10 percent of producers with the lowest emission intensity.

There is a direct link between GHG emission intensities and the efficiency with which producers use natural resources. For livestock production systems, nitrous oxide (N_2O), methane (CH_4) and carbon dioxide (CO_2) emissions, the three main GHG emitted by the sector, are losses of nitrogen (N), energy and organic matter that undermine efficiency and productivity.

Possible interventions to reduce emissions are thus, to a large extent, based on technologies and practices that improve production efficiency at animal and herd levels. They include the use of better quality feed and feed balancing to lower enteric and manure emissions. Improved breeding and animal health help to shrink the herd overhead (i.e. unproductive part of the herd) and related emissions.

Manure management practices that ensure the recovery and recycling of nutrients and energy contained in manure and improvements in energy use efficiency along supply chains can further contribute to mitigation. Sourcing low emission intensity inputs (feed and energy in particular) is a further option.

Grassland carbon sequestration could significantly offset emissions, with global estimates of about 0.6 gigatonnes CO_2-eq per year. However, affordable methods for quantifying sequestration, as well as a better understanding of institutional needs and economic viability of this option, are required before it can be implemented at scale.

[1] Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G.,2013. *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities.* Food and Agriculture Organization of the United Nations (FAO), Rome.

A range of promising technologies such as feeding additives, vaccines and genetic selection methods have a strong potential to reduce emissions but require further development and/or longer time frames to be viable mitigation options.

Most mitigation interventions can provide both environmental and economic benefits. Practices and technologies that reduce emissions can often simultaneously increase productivity, thereby contributing to food security and economic development.

Substantial emission reductions can be achieved across all species, systems and regions. Mitigation solutions will vary across the sector as emission sources, intensities and levels vary amongst species, production systems and regions, but the mitigation potential can be achieved within existing systems; this means that the potential can be achieved as a result of improving practices rather than changing production systems (i.e. shifting from grazing to mixed or from backyard to industrial).

Recent years have seen interesting and promising initiatives by both the public and private sectors to address sustainability issues. Complementary multi stakeholder action is required to design and implement cost-effective and equitable mitigation strategies, and to set up the necessary supporting policy and institutional frameworks.

It is only by involving all sector stakeholders (private and public sector, civil society, research and academia, and international organizations) that solutions can be developed that address the sector's diversity and complexity. Climate change is a global issue and livestock supply chains are increasingly internationally connected. To be effective and fair, mitigation actions also need to be global."

(FAO 2014)

"IFIF (International Feed Industry Federation) and FEFANA (EU Association of Specialty Feed Ingredients and their Mixtures), both together representing the relevant industry sector, see the clear need to give guidance to all sector partners along the feed to food value chain, when they want to assess and improve the mitigation potential of environmental performance for the livestock sector. According to them, only the application of the same rules and methodologies will lead to transparent and comparable scenarios for the sustainability assessment of livestock production combined with the effective use of specialty feed ingredients."

(IFIF and FEFANA 2014)

General Comments:

This is a Product Category Rules (PCR) document developed on the basis of specific LCA study on the use of amino acids and phytases in pig and poultry production. These two types of Specialty Feed Ingredients (SFIs) have been used as examples for all other SFIs represented by that product category. Further definition on the different types of feed additives respectively specialty feed ingredients is given in the Regulation (EC) 1831/2003[2].

The present PCR document is operating in accordance with ISO 14025:2006 and the following international standards:

- ISO 14040, LCA - Principles and procedures
- ISO 14044, LCA - Requirements and guidelines

This PCR document specifies the rules for the underlying life cycle assessment (LCA) of specialty feed ingredients in livestock production covering all relevant life stages of the products from upstream processing, production and the final downstream use phase.

The present PCR document is the first version and will be updated and modified according to the further developments of LCAs within the product category of specialty feed ingredients and to the further developments of national or international rules.

[2] REGULATION (EC) No 1831/2003 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 September 2003 on additives for use in animal nutrition,(2003), Official Journal of the European Union L 268/29

1. Introduction:

1.1 PCR in General

According to the general understanding, Product Category Rules (PCRs) provide category-specific guidance for estimating and reporting product life cycle environmental impacts, typically in the form of product environmental footprints given through life cycle assessment studies (LCAs). Since global harmonization between PCRs or sector guidance documents is still missing, sometimes the developments of duplicate PCRs for same products are causing problems. Thus, as a direct consequence, differences in the general requirements (e.g. product category definition, reporting format) and LCA methodology (e.g., system boundaries, inventory analysis, allocation rules, etc.) make the comparability of products' claims irrelevant.

Life cycle assessment (LCA) is an established methodology used to quantify the environmental performance of products, processes or services, and is increasingly being used as a basis for information to purchasers along the supply chain, including the final consumers (Fava et al. 2011). Studies for Life cycle-based quantitative claims always recommend choices regarding the sources of data, the boundaries of the system, allocation of impacts between co-products or recycled products, and the choice of metrics used to estimate impacts, among others. Despite existing and emerging international standards for these methodologies, there is insufficient standardization to make fair comparable claims, which are essential for differentiating products, processes and services in the marketplace based on their environmental performance.

Programs and international standards for life cycle based quantitative claims, provide some general guidance to promote consistent assessments. The ISO 14040 series of standards set principles, requirements and guidelines for carrying out LCA. The ISO 14025 standard for developing Type III EPD[3]s (aimed primarily at business-to-business communication) states that program operators should provide general guidance (general program instructions) to guide the overall administration of the program. Product carbon footprints standards (such as the PAS 2050, the GHG Protocol Product Standard (WRI and WBCSD 2010)) provide requirements and guidance for all products - based on ISO 14040 but more specifically related to carbon footprint. However, general guidance is still insufficient in providing enough specificity. As a consequence, assumptions and measurements are not consistent and comparable claims cannot be made, within programs and across programs. To simplify at least the evaluation of sustainability performance in the feed to food sector, FAO recently published the first set of guidelines to assess the sustainability of the feed supply chains (LEAP 2015)[4].

The purpose of defined PCRs is to specify rules for the aspects to be included in the environmental impact analysis for a given product category and how the calculations are to be carried out in the assessment. By setting PCRs, the environmental assessments for products, processes and services for alternative products within the same product category have the most uniform basis possible. The final PCR guidelines must be based on existing life cycle assessments (LCAs) for

3 EPD: Environmental Product Declaration

4 LEAP, 2015. Environmental performance of animal feeds supply chains: Guidelines for assessment. Livestock Environmental Assessment and Performance Partnership. FAO, Rome, Italy.

representative products within the category. Where no LCA exists, an LCA must be prepared to be used as a basis for PCR work. The LCA must be prepared in accordance with ISO 14040 and ISO 14044 for LCA (Guidelines for preparing Product Category Rules (PCRs) Danish environmental product declarations program, EPD-DK 2011).

Scope:

The present document summarizes all important aspects on data sourcing and data collection for LCA studies on the use of specialty feed ingredients (SFIs) in livestock production to provide consistent, robust and independently verified data about the environmental impacts and aspects of the use of SFIs for proper life cycle analysis (LCA). Since the use of SFIs significantly influences the environmental performance of animal production, the present document on the PCRs for SFIs shall also make the link between the feed and the food part to make LCA data transparent and applicable for the whole value chain. This is mandatory to guarantee proper communication on environmental information and improvement potentials through the whole value chain to the final consumer. This recommendation is also laid down in the LEAP guidelines.[5]

The present document summarizes the specific findings of the pilot study on the environmental benefits of the use of SFIs in livestock production (FEFANA IFIF SFIS Joint Study 2014) in general statements for defining PCRs for all types of SFIs. Further the document shall not only give guidance for the evaluation of the production processes of SFIS, but also how to investigate the impacts of the application of SFIS in the use phase on the farm level. Thus, all relevant life stages downstream and upstream are covered.

1.2 Specialty Feed Ingredients

Livestock production is recognized as a significant source of emissions in the environment in a liquid, gaseous or solid form. This environmental impact can be mitigated by adopting feeding management practices, such as phase feeding or technical measures in housing at farm level. The use of SFIs in animal nutrition further contributes to the mitigation of environmental impact of animal production, by e.g. reducing the excretion of certain nutrients (nitrogen, phosphorus), improving the performance of the animals, reducing the feed consumption or allowing the use of locally based or unusual feed materials such as co-products from food production or food processing.

To investigate the key role of SFIs, amino acids and phytases have been used as examples to demonstrate the positive impact of feeding measures based on the use of SFIs in a pilot LCA study initiated by the relevant industry sector under the umbrella of the International Feed Industry Federation (IFIF) and the EU Association of Specialty Feed Ingredients and their Mixtures (FEFANA) (FEFANA IFIF SFIS Joint Study 2014). The study was run under different local conditions to evaluate the validity of the assumptions made. Thus, not only one specific local

5 LEAP, 2015. Environmental performance of animal feeds supply chains: Guidelines for assessment. Livestock Environmental Assessment and Performance Partnership. FAO, Rome, Italy.

production scenario was assessed. In addition, the study has focused on the most relevant animal species in the different regions of the world.

Categories

SFIs are defined as feed ingredients, incorporated into compound feeds, with a view to achieve a particular nutritional, technological, sensory or zoo technical function. They are added intentionally in the compound feed and participate to the performance of the feed, in combination with the other feed ingredients. In order to ensure a high level of efficacy of the compound feed, a proper formulation of the feed (choice of the feed ingredients, appropriate levels of nutrients) combined with the inclusion of the appropriate SFI(s) is the right approach.

Function

With the exception of subsistence farming, where the animals are scavenging their feed (e.g. backyard production of poultry and pigs (MacLeod, et al., 2013)), the animals are provided with feeds composed of mixtures of different feed ingredients (including SFIs). In such cases, it is possible to optimize the composition of the feeds, taking into account the characteristics of the feed ingredients used and the animal requirements.

A proper and efficient nutrition is based on the following basic principles:

- the digestibility of the nutrients from the different feed ingredients
- the animal requirements for the specific nutrients.

It is important for a proper animal nutrition to ensure that most of the animal requirements, depending on its stage of production are covered by the feed. The animals will only express fully its genetic potential, when all the nutrients' requirements are covered. If one of the nutrients is deficient in the ration, the genetic potential of the animals is not achieved. The animals will then perform up to the level provided by the deficient nutrient or it will consume more feed to overcome the limitation. In the latter case all other not limited nutrients will lead to a surplus and thus will be wasted.

1.3 LCAs in Livestock Production

The LCA of a product covers the whole ″cycle in the life of any product beginning from the early provision of raw materials through manufacturing and application by consumers to the final disposal of waste″. LCA according to the internationally accepted standards of ISO 14040 to 14044 consists of 4 main parts. The most relevant one is the definition of the functional unit (FU) and the system boundaries (SB). Both are guarantees to design independent and valid results in the final LCA study. The more precise the FU and SB are, the stronger the environmental claims can be at the end of the implementation phase. LCA is a systematic approach for evaluating all environmental impacts of a product through its life cycle. According to international standards a LCA study must consist of several parts such as goal definition and scope, inventory analysis, impact assessment and interpretation. As part of the scope the Functional Unit (FU) is a tool to quantify the performance of a product system.

2. PCRs for the use of SFIS in livestock production

In general, a LCA approach on the use of SFIs intends to analyze the environmental effects of livestock production systems in a holistic way using a cradle-to-farm gate approach for different geographical regions with different feeding alternatives comprising different compound feeds with and without the use of SFIs. Attributional LCA modelling is applied. According to International Life Cycle Data System (ILCD), attributional modelling describes the potential environmental impacts that can be attributed to a system (e.g. a product) over its life cycle. Attributional modelling makes use of historical, fact-based, measurable data of known uncertainty, and includes all the processes that are identified to relevantly contribute to the system being studied (ILCD).

In the following sections the general recommendations for a LCA approach will be described and summarized, on the basis of the pilot study on amino acids and phytases (FEFANA IFIF SFIS Joint Study 2014) to achieve the harmonization of LCA studies on SFIs. This includes in particular the identification of specific products to be assessed, the supporting product systems, system boundaries, allocation procedures, cut-off criteria and data quality aspects.

2.1 Relevant impact categories

Definition:

For properly conducting a LCA it is necessary to identify and to define the specific impact categories that are relevant within the different systems investigated. The identified impact categories should be internationally recognized and transparent. In most cases, there are always a couple of so-called impact indicators contributing to one specific impact category.

The present document for setting PCRs for the use of SFIs in livestock production provides guidance for the recommended minimum impact categories to be assessed for adequately describing the environmental influences. Additional impact categories can optionally be added, if required. In any case the additional use or deletion of categories should be explained transparently on a scientific basis.

To compare the different indicators due to their relevance within the impact categories, so-called equivalence factors have been developed. The Table 1 shows the specific impact categories which are seen as the most relevant ones for the agricultural production of food within the feed and food chain. The PEFCR given by the European Commission recommend overall 15 impact categories, of which the selected ones for SFIs are included[6]. Depending on the final outcome of the PEFCR initiative the present document probably needs to be adapted within the next revision.

For example, to figure out the dimension of the contribution to the GWP, 3 main impact indicators have been identified for their specific contribution per functional unit (FU); fossil carbon dioxide (CO_2), dinitrogenoxide (N_2O) and methane (CH_4). All of them are weighted due to their relevance for environmental pollution expressed as kg CO_2-equivalents per functional unit (Kg CO_2e/FU). The fossil carbon dioxide (CO_2) is set as reference and thus it has the dimension of 1.0 Kg CO_2e/FU, whereas dinitrogenoxide (N_2O) contributes 310 times more to the GWP and is labelled with 310 Kg CO_2e/FU. Since methane (CH_4) increases GWP 21 times higher than fossil carbon dioxide (CO_2), it will have the dimension of 21 Kg CO_2e/FU.

The indicators of the other impact categories are calculated in the same manner and referred to the specific dimensions shown in Table 1.

Table 1: None exhausting list of relevant impact categories for feed and food production. Source: UBA 2000, Environmental Agency of Germany, proposal 2000, IPCC 1996)

Impact Category	Life Cycle Inventory Parameter	
Resources consumption	Cumulated energy demand CED_{fossil} $CED_{nuclear}$ $CED_{regenerative}$	MJ/FU
Global warming potential Greenhouse gas effect	CO_2 N_2O CH_4	Kg CO_2e/FU
Acidification	NO_x NH_3 SO_2 HCl HF	Kg SO_2e/FU
Eutrophication	NH_3 NO_3^-, COD N-compounds P-compounds	Kg PO_4e/FU

6 Guidance for the implementation of the EU PEF during the EF pilot phase - Version 4.0, Product Environmental Footprint Pilot Guidance for the implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) pilot phase

In addition to the impact categories listed in Table 1, there are also other relevant categories that can be of interest depending on the specific systems investigated such as resources depletion, smog forming potential (POCP/NCPOCP)[7], human toxicity potential or ecological toxicity potential[8].

It is common to mention the so-called carbon footprint to normally explain the contribution to the Global Warming Potential (GWP). But agricultural systems are also characterized by even more significant effects on the acidification and eutrophication potentials.

These two impact categories are typical for nitrogen based emissions to the air, the soil and the water.

Nitrogen is the most important component for the growth of the plants as well the recycling back of natural compounds within the global nitrogen circle. Also the circulation of phosphorus shows clear influence on these impact categories.

PRODUCT CATEGORY RULE:

LCA studies on the use of SFIs in livestock production shall be carried out with the focus on at least the impact categories contributing to

- **The Global Warming Potential (GWP)**
- **The Eutrophication Potential (EP)**
- **The Acidification Potential (AP)**
- **The Resource Consumption (ADP Abiotic Depletion Potential)**

(As already mentioned above, these impact categories are proposed by the project group as the most relevant ones for the assessment of the application of SFIs in livestock production. This is a non-exhausting list which can be completed or extended for example to match the recommendations of the PEFCR initiative of the European Commission or the LEAP Guidelines[9][10]

7 POCP/NCPOCP = Photochemical Ozone Creating Potential

8 UBA (2000), Environmental Agency of Germany, Background paper on the interpretation of LCAs, Hintergrundpapier "Handreichung Bewertung in Ökobilanzen", Umweltbundesamt Berlin

9 Guidance for the implementation of the EU PEF during the EF pilot phase - Version 4.0, Product Environmental Footprint Pilot Guidance for the implementation of the EU Product Environmental Footprint (PEF) during the Environmental Footprint (EF) pilot phase

10 LEAP, 2015. Environmental performance of animal feeds supply chains: Guidelines for assessment. Livestock Environmental Assessment and Performance Partnership. FAO, Rome, Italy.

2.2 Functional Unit

Definition:

The FU unit defines the quantification of the identified functions (performance characteristics) of the product. A FU will always be needed to provide a reference to which all inputs and outputs of the analyzed system are related. The consistency and comparability of the different results of LCA can be ensured in that way. A system may have a number of possible functions and the one(s) selected for a study depend(s) on the goal and scope of the LCA.

Comparability of LCA results is particularly critical when different systems are being assessed. Thus it is evident that such comparisons are made on a common and transparent basis. Part of that is the proper definition of a reference system with reference flows in each production system in order to fulfil the intended function. Thus it is proposed to conduct always compared lifecycle assessment, where two or more equal production systems are compared.

The basic definition is given by ISO 14044 2006. Section 4.2.3.2, defines: "The scope of an LCA shall clearly specify the functions (performance characteristics) of the system being studied. The functional unit shall be consistent with the goal and scope of the study. One of the primary purposes of a functional unit is to provide a reference to which the input and output data are normalized (in a mathematical sense). Therefore the functional unit shall be clearly defined and measurable."

Functional unit is defined in ISO 14044 2006 as: "Quantified performance of a product system for use as a reference unit, its primary purpose is to provide a reference to which the input and output data are normalized. Reference flow is a measure of the outputs from processes in a given product system required to fulfill the function expressed by the functional unit".

To assess the application of SFIs in livestock production, consequential LCA (CLCA) should be applied, since mostly feed option supplemented with SFIs will be compared with unsupplemented ones. A CLCA provides information about the consequences of changes in the level of output (and consumption and disposal) of a product, including effects both inside and outside the life cycle of the product. CLCA models the causal relationships originating from the decision to change the output of the product, and therefore seeks to inform policy makers on the broader impacts of policies which are intended to change levels of production. Whereas ALCAs are generally based on stoichiometric relationships between inputs and outputs, and the results may be produced with known levels of accuracy and precision, CLCAs are highly dependent upon economic models representing relationships between demand for inputs, prices elasticities, supply, and markets effects of co-products.

Such models rarely provide known levels of accuracy or precision and should therefore be interpreted with caution. [11]

Comment:

The other option, is an attributional LCA (ALCA), which provides information about the impacts of the processes used to produce (and consume and dispose of) a product, but does not consider indirect effects arising from changes in the output of a product. ALCA generally provides information on the average unit of product and is useful for consumption-based carbon accounting. Therefore ALCA is not really applicable for the assessment of the environmental improvement potential of SFIs in livestock production.

Description of the rules

In terms of life cycle thinking respectively methodology farm animals can be seen as intermediate products to be further processed into different final products to be primarily used as food. Thus, they are also described as so-called food-producing animals compared to pets as non-food producing animals. Thus, the functional unit given in LCA studies for SFIs should not consider any other additional functions for further processing. To guarantee the equivalency of function within each production system, the definition of the FU shall be set for the quality and properties of the produced live weight, which shall not be altered between the different alternatives and scenarios. The live weight as functional unit is the only correct data format to make the assessment of feed through animal performance on farm level and as such livestock production transparent.

PRODUCT CAREGORY RULE:

The functional unit (FU) quantifies performance and function of a product system for use as a reference unit. For the evaluation of SFIs, the Functional Unit is the live weight of the animals produced, when leaving the farm for being slaughtered.

The functional unit must be reflected by all options used in the LCA comparisons. Only thus, the functional equivalence recommended by the ISOstandard can bec given.

The different options which shall be compared, should consist at least of one unsupplemented feed without SFIs or with a rather low level of SFIs applied (negative control) and one feed completely supplemented with all SFIs und investigation and covering best practice for the animal performance and welfare (positive control).

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11 Brander, M., Tipper, R. Hutchison, C., Davis, G.1,Technical Paper (2008), Consequential and Attributional Approaches to LCA: a Guide to Policy Makers with Specific Reference to Greenhouse Gas LCA of Biofuels

2.3 System Boundaries

Definition:

Applying life cycle analysis means to cover and to evaluate all inputs and outputs of a product during its whole life span from the early beginning of the production until the final decomposition or the disposal. So it is important to trace system boundaries for the life cycles of the products.

LCA is conducted by defining product systems as models that describe the key elements of physical systems. The system boundary defines the unit processes to be included in the system. Ideally, the product system should be modelled in such a way that inputs and outputs at its boundary are elementary flows. However, resources need not be expanded on the quantification of such inputs and outputs that will not significantly change the overall conclusions of the study.

The choice of elements of the physical system to be modelled depends on the goal and scope definition of the study, its intended application and audience, the assumptions made, data and cost constraints, and cut-off criteria. The models used should be described and the assumptions underlying those choices should be identified. The cut-off criteria used within a study should be clearly understood and described.

The criteria used in setting the system boundary are important for the degree of confidence in the results of a study and the possibility of reaching its goal. Principally two approaches are generally used for the LCA even within the methodological framework of different standards applied. Provided that the set of system boundaries is properly described and published, the results of both systems can be interpreted easily and compared with each other.

In general system boundaries shall cover all relevant upstream processes (i.e. production of all agricultural inputs, crop cultivation, harvesting and storage), the core processes (production of SFIs) and downstream activities (feed milling as default and performance on farm level up to the farm gate).

The assessment from “Cradle to Gate” covers all inputs and outputs from the raw material sourcing up to the production and storage until the product leaves the production plant. External transport, the product use phase and the waste disposal are then not covered.

The LCA of goods and services according to the principle from “Cradle to Grave” starts in the early beginning offering the different raw materials for the different production processes, either in chemical or biotechnological manufacturing as well as in the agricultural one (electricity, fuels, chemical, petrochemical raw materials, fertilizers, sugars, ammonia, etc.).

Also specific effects and benefits through the use phase of the products shall be covered. The analysis is finally closed with the decomposition of the excrements.

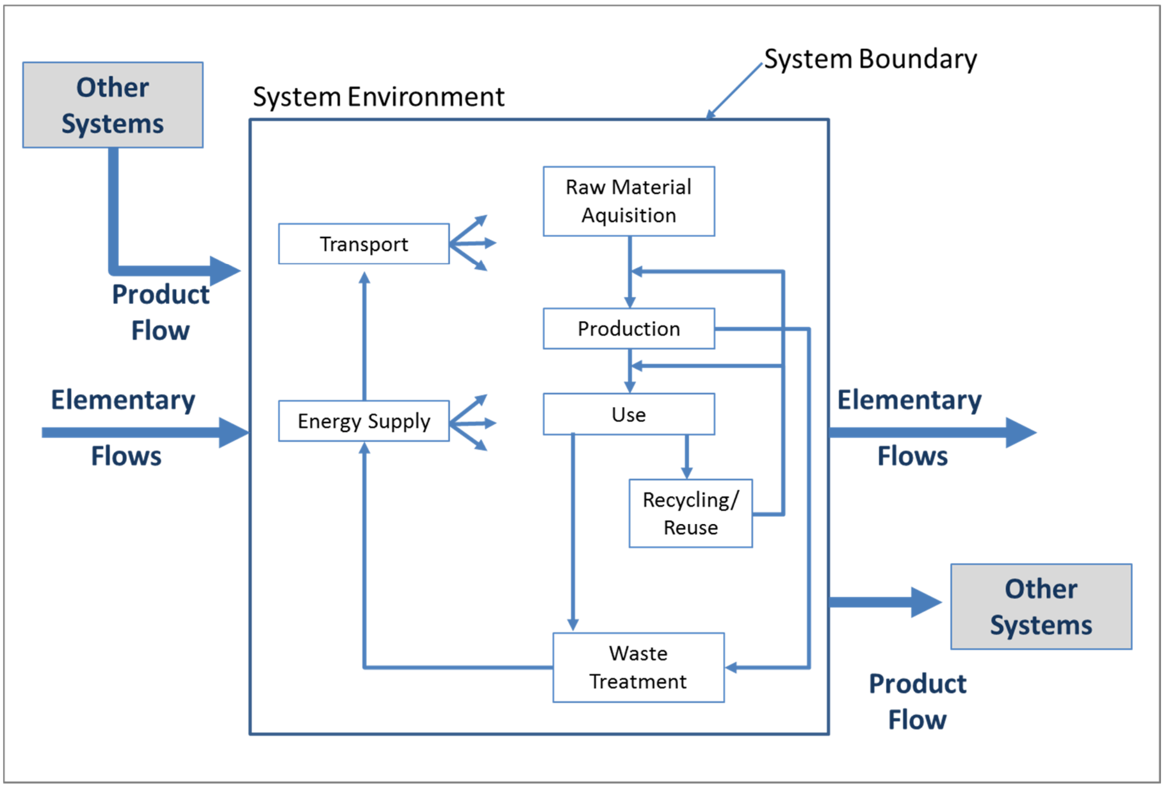

Figure 1: System boundaries proposed by DIN EN ISO 14040:2006

For livestock production systems it is important to extend the “cradle to gate (farm entrance)” approach of animal feed to a ”cradle to farm gate (outlet)” approach to cover also the animal performance on farm level. This is the only transparent way also to include the improvement potential of SFIs and the animal performance significantly contributing to the final mitigation potential of food production systems.

Description of the rules

The system boundaries shall be defined as given in the pilot study on the use of amino acids and phytases in livestock production (FEFANA IFIF Joint SFIS Report 2014). Figure 2 below shows further details which reflect the recommendations by the ISO Standard 14040:2006 projected to the specific conditions of animal production on farm level.

Generally spoken, the system boundaries comprise all relevant inputs and outputs for the animal production on the farm level considering the wholesome material flow from the field edge over the feed mill to the farm gate.

In that context, animals (live weight) are intermediate products for further processing to mainly food and other co-products and not further considered when they passed the farm gate. It is assumed that the composition of animal live weight and consequently further down-stream processing steps are not affected by the different feed compositions. But all other relevant environmental life cycle stages regarding the production of animal live weight are included. Thus, all co-product- and waste-treatment are within the system boundaries such like manure management - in particular manure storage and manure field application.

Therefore the system boundary ends with the departure of the animal from the farm and the functional unit is the animal live weight (also in accordance with the goal of the pilot study).

The system boundaries are defined to be cradle-to-farm gate (outlet). The system boundaries shall include

- **Production SFIs** (in general the data are primary data provided by the initiator of the intended LCA study, if he is a manufacturer of SFIs)

- **Feed production** (in general, these data will be sourced by officially available publications i.e. FEFANA IFIF Joint SFIS Report 2014 or as primary data provided by the initiator of the intended LCA study, if he is a feed manufacturer, if the feed production shall be included the applicant shall follow the LEAP guidelines for the feed supply chain[12]).

- **Use on farm level** (in general, these data will be sourced by officially available publications i.e. FEFANA IFIF Joint SFIS Report 2014)

- **Manure Management** (in general, these data will be sourced by officially available publications i.e. FEFANA IFIF Joint SFIS Report 2014)

- **Regional Adaptations** (In general the functional unit and the relevant option for comparison reflect an average. If necessary, specific regional conditions should then further be considered through the application of a sensitivity analysis).

The details for setting the system boundaries as well as the elementary flows are displayed in Figure 2 below.

12 LEAP, 2015. Environmental performance of animal feeds supply chains: Guidelines for assessment. Livestock Environmental Assessment and Performance Partnership. FAO, Rome, Italy.

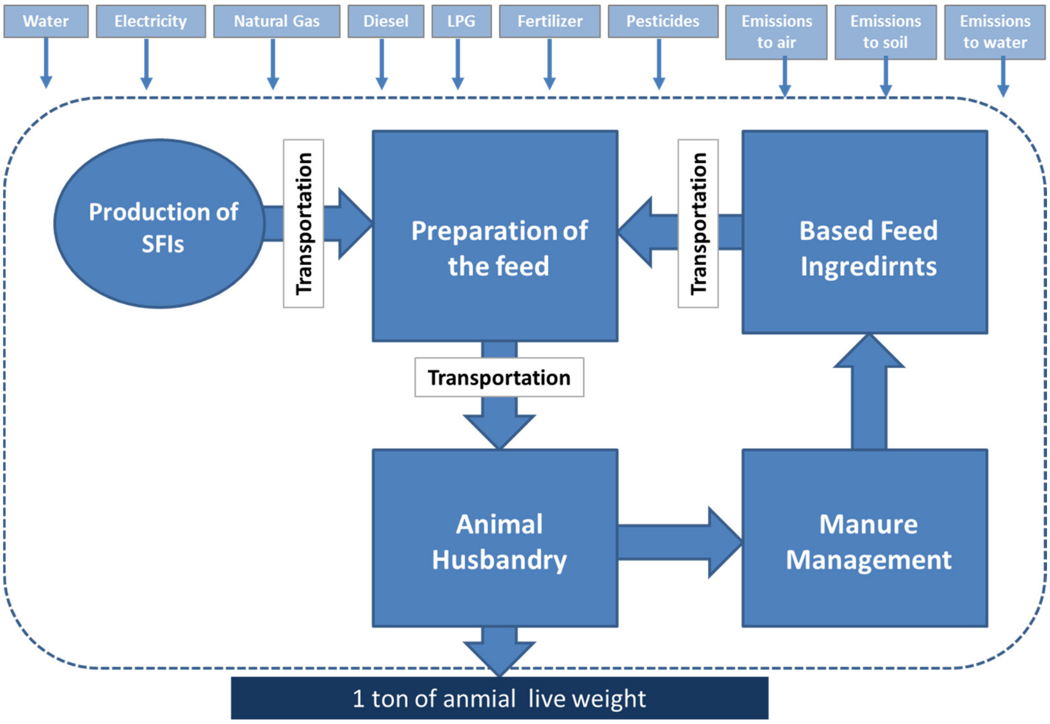

Figure 2: **Exemplary overview/template of the system description for defining the boundaries (including the subsystems production of base feed ingredients (BFI), specialty feed ingredients (SFI), preparation of feed, animal husbandry and manure management).**

(Source: FEFANA IFIF Joint SFIS Report 2014)

The sub-systems which are also elements within the system boundaries are listed in Table 2:

Table 2: System Boundaries for the assessment of SFIs in livestock production

Included	Excluded
✓ Base feed ingredients production ✓ Base feed ingredients processing ✓ Specialty feed ingredient production ✓ Feed preparation ✓ Transports ✓ Animal husbandry ✓ Manure storage ✓ Manure application	×Infrastructure (construction of buildings, roads, etc.) ×Veterinary medicines ×Processing, Use phase and End of Life of the final product

To fulfil the time coverage recommendations, normally one dedicated production year is used as a reference time for the production of 1 ton animal live weight. Although the industry is constantly developing, it is estimated that results are valid for a time period of 5 years (FEFANA IFIF Joint Report 2014). In the foreground system co-product treatment is required for manure applied on the field: A credit shall be given according to the nitrogen, phosphate and potassium contents which actually reach the field (FEFANA IFIF Joint Report 2014).

All wastes flows shall be modelled to their respective end of life by considering the allocation of upstream data (energy and materials):

- For all chemical refinery products used in the manufacturing of SFIs and utilities used in feed production, allocation by mass and net calorific value is applied. The manufacturing route of every refinery product is modelled and so the effort of the production of these products is calculated specifically. Two allocation rules are applied:
    1. The raw material (crude oil) consumption of the respective stages, which is necessary for the production of a product or an intermediate product, is allocated by energy (mass of the product * calorific value of the product); and

    2 The energy consumption (thermal energy, steam, electricity) of a process, e.g. atmospheric distillation, being required by a product or an intermediate product, are charged on the product according to the share of the throughput of the stage (mass allocation). (FEFANA IFIF Joint SFIS Report 2014). Further details are also discussed in the specific chapter.

- For all basic feed ingredients and by-products from other production processes used for the production of animal feed, the allocation rule most suitable for the respective product is modelled. (FEFANA IFIF Joint Report 2014) a detailed explanation for the allocation rules is given in the relevant sub-chapter.

Product Category Rule:

The livestock production system under investigation shall always include all relevant steps from cradle to farm gate including manure management which means in detail:

- **Production SFIs**
- **Feed production (basic feed ingredients)**
- **Use on farm level (animal rearing)**
- **Manure Management**
- **Feed Milling (for the production of compound feed within the feed mill, secondary data from literature can be used as default. If specific primary data might be available for the specific region under investigation, these can be used as well)**

2.4 Allocation methodologies

Definition:

Allocation is defined as 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

Allocation shall be managed in principle by applying economic factors for the different sub-systems respectively co-products. As a baseline the economical average over the last five years shall be considered.

When assessing publically available PCRs of consumer goods, some PCRs propose a physical allocation key[13] some use energy allocation[14]. Others use mass allocation and sucrose based physical allocation[15]. The PCR for arable products uses economic allocation and provides default allocation factors.

The LEAP sector guideline state that whenever possible allocation should be avoided by dividing unit processes into sub-processes or expanding the product system. If allocation can't be avoided and if a physical relationship cannot be captured in a model, economic allocation is the preferred method. It is described in (FAO, 2014) that for feed the preferred option is economic allocation in many cases of multi-functionality. It is explained that in cultivation as well as processing system expansion will involve unwanted arbitrary choices. Regarding the second option, physical allocation, it is said that in most cases there is not a single physical relationship that can be used to all co-products. The physical characteristics for which co-products are used for feed vary greatly; some products are used for their energy content, others for their protein content or even specific amino acids, etc. [16]

Furthermore FAO [17] states that for external communication or comparison, several alternative allocation options shall be compared as part of a process of sensitivity assessment.

Economic allocation is recognized as a way of systematically executing allocation in LCA. ISO also gives this option within the framework of its allocation procedure (ISO 14041). However, how exactly this economic allocation is to be done still remains rather unspecified, or at least for many practitioners the choices to be made and their consequences are still unclear. A couple of publications tried to work out the principles for economic allocation in a section dedicated to multi-functionality and allocation.

[13] Finkbeiner et.al., 2014a, Berlin Technische Univerität, J. Life Cycle Engineering
[14] Finkbeiner et.al., 2014b, Berlin Technische Univerität, Life Cycle Engineering, 2014b
[15] Ecoinnovazione, 2014
[16] PEF pilot Animal Feed; Draft Scope, Representative Product, Technical Secretatiat for the Animal feed pilot, 2014 (unpublished)
[17] FAO 2014

As one example, an economic allocation can be advised as baseline method for most allocation situations in a detailed LCA. In this method, for example, the share of each product in total sales of a process is considered to indicate its share in the full existence of that process (Economic Allocation: Examples and Derived Decision Tree (Jeroen B. Guinée*, Reinout Heijungs and Gjalt Huppes, Institute of Environmental Sciences (CML), LCA Methodology 2004).

Based on that publication of Guinée et al (2004), a decision tree for handling the multi-functionality problem was proposed, (Figure 3) which seems to be helpful for the present approach. Although this publication focuses on economic allocation, the decision tree can with small changes be used also for more general situations, as the main part of the decision tree is about identifying functional flows and multi-functional processes. One should note that economic criteria are used for identifying functional flows, even when mass- or energy-based allocation is chosen. The decision tree shall be used for identifying and handling multi-functionality situations starting from a defined (product) system. The latter is important as only a defined (product) system will give the opportunity to identify multi-functionality situations and will already supply all inflow related processes upstream and e.g. waste management related processes downstream. There are two types of functional flows: products produced and waste to be treated. Products produced are outflows with economic value higher than or equal to zero, while wastes to be treated are inflows of a (waste managing) process with negative economic value, therefore providing proceeds for that process (Economic Allocation: Examples and Derived Decision Tree (Jeroen B. Guinée*, Reinout Heijungs and Gjalt Huppes, Institute of Environmental Sciences (CML), LCA Methodology 2004).

* Functional flows from a multi-functional process that partially remain within the system studies, e.g. in case of partial closed-loop recycling, are to be handled as normal process calculation after allocation.

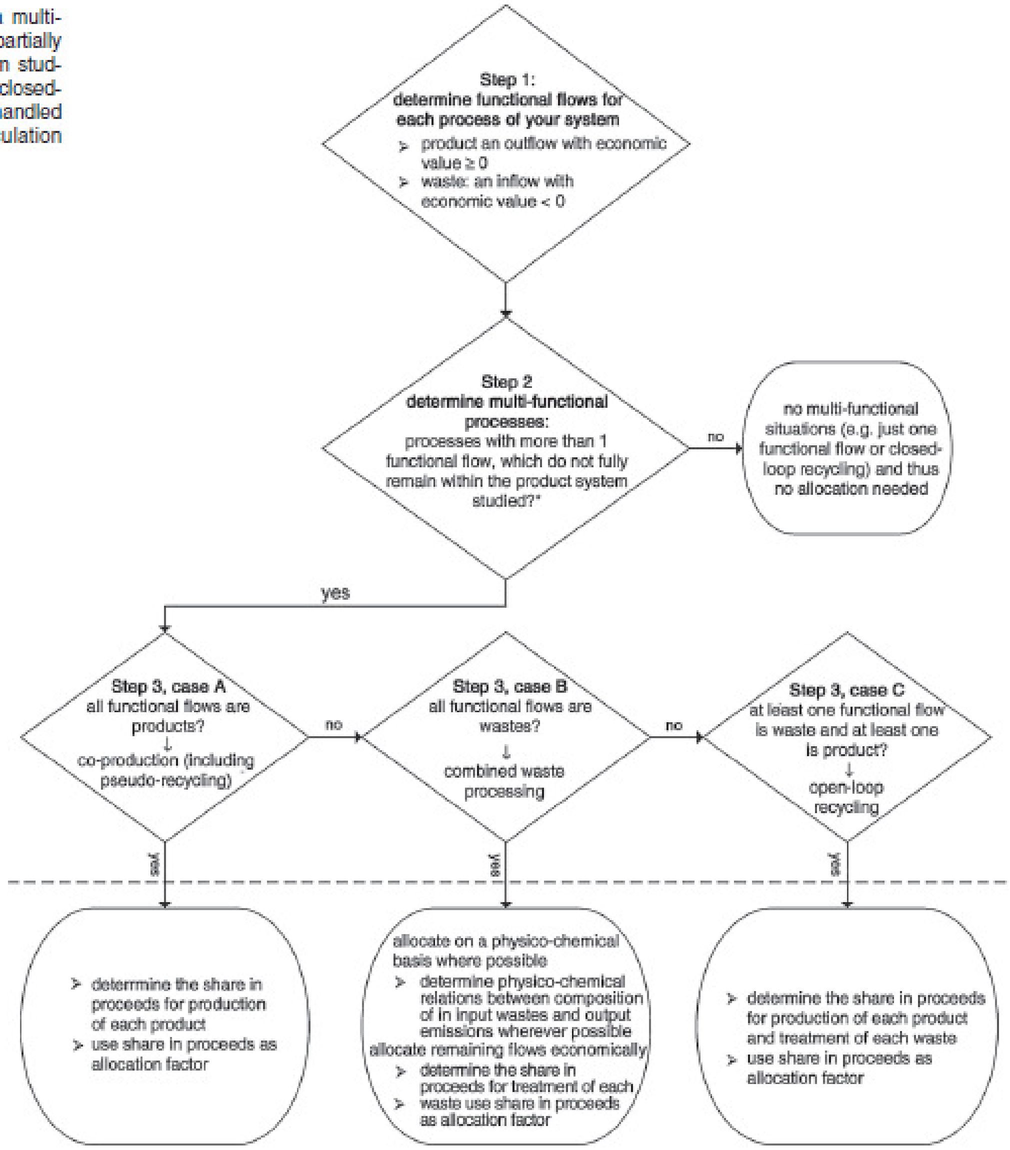

Figure 3: **Decision tree for identifying and handling multi-functionality situations (according to Economic Allocation: Examples and Derived Decision Tree (Jeroen B. Guinée*, Reinout Heijungs and Gjalt Huppes, Institute of Environmental Sciences (CML), LCA Methodology 2004).**

Following that publication in combination to the experience of the pilot study (FEFANA IFIF Joint Report 2014). The economic allocation method shall be the favored approach for allocating ecological burdens or benefits to different multi-functional systems. Within the scientific world more methodological solutions to the multi-functionality are possible and defensible. By focusing on economic allocation these other methods shall not be excluded automatically. But the economic allocation seems to be the best generally applicable and consistent approach currently available and fitting within modelling principles of LCA studies (Economic Allocation: Examples and Derived Decision Tree (Jeroen B. Guinée*, Reinout

Heijungs and Gjalt Huppes, Institute of Environmental Sciences (CML), LCA Methodology 2004).

Description of the rules

According to the explanations given in the introduction above, multi-functional production systems for all elementary flows should be assessed using the economic model described in Figure 3. This should be valid for all the different flows already described under the chapter for the determination of the system boundaries:

- Base feed ingredients (Co-products)
  Allocation shall follow the rules of economical allocation on the basis of average prices of the different co-products within the last 5 years (i.e. soybean meal and soybean oil, rapeseed meal and rapeseed oil, wheat grains and wheat straw for other uses, etc.)
- By- products from other production processes (i.e. from food production)
- Transportation within the boundary
- Manure Management (manure replacing artificial fertilizer)

If any ingredient used in a feed formulation, that will not have an economical value, it has to treat as waste and no ecological burden can be allocated to that elementary mass flow. But the author of the study must reflect the likelihood of any further contribution to the different impact categories through the disposal phase.

PRODUCT CATEGORY RULE:

All products used in the feed formulations either coming from agricultural processes, feed mixing processes or manufacturing processes of other SFIs must be assessed through economical allocation, if they significantly contribute to any of the given impact categories. The same approach shall be seen as valid for all other by-products of any other production process such like food production for example. If the author of the study sees clear reasons not to follow these rules for allocation, he explains the reasons and should give full transparency on the alternative allocation procedures. Otherwise, the outcoming results will not be comparable to other studies.

2.5 Land use Change (LUC)

Definition:

In agriculture, the topic of land conversions is of major interest as fertile land is a scarce resource. With a land use change also different impacts on the environment occur, for example release of greenhouse gases, changes in biodiversity and soil quality, and the reduction of the carbon sink.

Table 3 shows the GWP impacts from LUC of the different crops in the respective regions under investigation calculated according to the PAS 2050-1:2012 methodology and the ENVIFOOD Protocol[18]. The values represent weighted average emissions calculated with the GHG LUC calculator from Blonk Consultants (Blonk LUC Tool) for the scenarios where data was available.

Table 3: GWP impacts from LUC for EU, NA and SA scenarios in kg CO_2-eq per 1 kg of crop (based on values from Blonk LUC Tool). n.a. refers to the fact that these crops are not part of the diets in these regions.

Emissions in t CO_2-eq / t crop	EU (Germany)	NA (USA)	SA (Brazil)
Wheat	0.03	0.00	0.00
Maize	0.04	0.00	0.12
Barley	0.00	n.a.	n.a.
Rapeseed	0.10	n.a.	n.a.
Soybean	n.a.	0.01	3.72

In general LUC emissions per kg crop for the EU are significantly lower than in SA (see Table 3). The emissions from NA are even less significant. These emissions contribute (in most cases) significantly, with some percentage points to overall GWP results of the crops. In contrast, LUC emissions for soybean cultivated in South America are very high and dominate overall GWP results.

Description of the rules

The calculation method applied in this study is compliant with ILCD and follows the WRI GHG protocol calculation approach. The methodology to calculate direct land-use change

18 ENVIFOOD Protocol, Food SCP RT (2013), ENVIFOOD Protocol, Environmental Assessment of Food and Drink Protocol, European Food Sustainable Consumption and Production Round Table (SCP RT), Working Group 1, Brussels, Belgium

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(dLUC) emissions according to ILCD is described below (ILCD Handbook: Provision 7.4.4.1. Modelling agro- and forestry systems):

- CO_2 emissions shall be calculated using the most recent Intergovernmental Panel for Climate Change (IPCC) factors per default, unless more accurate, specific data are available.

- The land transformation related direct and indirect inventory shall be allocated to the following crops by used/ occupied land area and duration of cropping, as follows. Two cases are to be differentiated:

  # Firstly, inventory items that occur over a longer period than one year, exponentially reaching a new quasi-equilibrium (e.g. CO2 emissions from loss of soil organic carbon due to biodegradation of e.g. humus). In this case the entire inventory is allocated to the total amount of the crop, independently of the specific year when the crop has been harvested; i.e. each kg has the same inventory.

  # Secondly, inventory items that occur in direct context of the transformation and not longer than one year afterwards (e.g. machine use during conversion and peak emissions e.g. from biomass burning). Additionally, the total amount of uses over which the production inventory of the land transformation is to be shared, shall be 20 years or in case the minimum use is longer, one plantation cycle shall be used.

- For both cases if the natural goods from the converted land are also at least partly used (e.g. harvested primary forest wood), they shall be considered as one function as part of the multifunctional system.

According to the WRI GHG protocol, direct land-use change (dLUC) has to be assessed if the carbon extraction (e.g. harvesting) of a biogenic product or product component, whichever timeframe is longer.

Please note that “indirect land use change” is not part of the analysis in this study, because it is not required by the relevant international accounting standards and also not consistent with attributional LCA modelling (Finkbeiner 2014).

The WRI GHG protocol standard defines that reports shall quantify and report the total inventory results in CO2eq per unit of analysis, which includes all emissions and removals included in the boundary from biogenic sources, non-biogenic sources, and land-use change impacts. Land-use change impacts have to be reported separately. The calculation approaches have to be reported and are distinguished by whether the specific land on which the cultivation occurs is known or unknown (FEFANA IFIF Joint Report 2014).

PRODUCT CATEGORY RULE:

Land use change (LUC) shall be considered for those base feed ingredients, where an impact on the environment linked to the conversion of land from forest/permanent grasslands to crop production is expected. If land use change is considered, all assessments shall be conducted only for the direct land use change (dLUC).

Comment:

Before there will be no common and harmonized approach on evaluation of the impacts and dimensions of indirect land use change (iLUC), that should not be further considered in any approach. As long as there are still intensive discussion by science any consideration of iLUC would increase complexity of the assessment (Finkbeiner, 2014).

2.6 Other Recommendations

2.6.1 Biogenic Carbon

During growth of plants, carbon is stored via photosynthesis. This biogenic carbon is stored in different animal feed and is fed to the animals. The carbon stored in this biomass will be released or stored at different life cycle stages: Either directly during processing of animal feed or as carbon dioxide from respiration of the animals. A share of this biogenic carbon remains in the final product animal live weight. Another share is excreted and ends up as manure. Carbon in manure is either released as carbon dioxide or as methane. If biogenic carbon is released as methane it is taken into account as emission. Methane has a different characterization factor than carbon dioxide and is not taken up by plants anymore. This means that there is a net addition of greenhouse gases. The release of biogenic carbon dioxide does not add to the greenhouse gas effect if the uptake and release are within a short time frame, as the carbon dioxide was taken up by the plants beforehand.

This carbon cycle can be analyzed, but it is not mandatory according to the currently used standards, as all bound carbon is released within rather short time frames. The uptake of carbon is distributed amongst the carbon stored in the product and the release of carbon and methane. An analysis at which life cycle stage the release occurs is normally not of importance for this type of studies.

Consequently, if biogenic carbon emissions are modelled in the intended study, it should be clearly indicated to keep the different approaches transparent and comparable. The best option will be to display the modelling results with and without counting of the biogenic carbon.

2.6.2 Data Quality Requirements

The data used to create the inventory model shall be as precise, complete, consistent, and representative as possible with regards to the goal and scope of the intended study under given time and budget constraints.

- Measured primary data is considered to be of the highest precision, followed by calculated and estimated data. In this study primary data was collected for the feed composition. Besides primary data, publically available literature which is mostly based on primary data as well as expert knowledge has been used.
- Completeness is judged based on the completeness of the inputs and outputs per unit process and the completeness of the unit processes themselves. There is some cut-off applied in this study. Wherever data were available on material and energy flows, these were included in the model. Where data were not available, proxy datasets were used (see chapter 2.5 and chapter 2.9).
- Consistency refers to modelling choices and data sources. The goal is to ensure that differences in results occur due to actual differences between product systems, and not due to inconsistencies in modelling choices, data sources or emission factors.
- Representativeness expresses the degree to which the data matches the geographical, temporal, and technological requirements defined in the study's goal and scope.

To demonstrate the applicability, this concept have been used in the pilot study for the assessment of amino acids and phytases (FEFANA IFIF Joint Report 2014).

Inventory data quality shall be judged by its precision (measured, calculated or estimated), completeness (e.g. unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source) and representativeness (geographical, temporal, and technological). LCA information i.e. from the GaBi database 2012 can be used, but also all other accessible databases will be applicable as well. In any case transparency of data sourcing and documentation must be guaranteed.

Since the LCI data sets from the GaBi database 2012 are widely distributed and used with the GaBi 6 Software, the authors of the present document propose to all applicants to use this database. The datasets have been used in LCA models worldwide in industrial and scientific applications in internal as well as in many critically reviewed and published studies. In the process of providing these datasets they are cross-checked with other databases and values from industry and science. GaBi databases 2012 are critically reviewed by the verification company DEKRA. If the applicant decides to use another database he has to ensure that at least the above listed criteria on data quality will be applicable.

2.6.3 Phase feeding

In general, the aim and prerequisite of an efficient and sustainable animal feed composition is to guarantee an optimal animal performance over all stages of life. Since each phase of the animal´s life stage (phase) demands different nutritional conditions, the diets need to be adapted accordingly. Furthermore the feed diet should also display regionally typical and representative feed compositions. To safeguard transparency and comparability of LCA studies for SFIS, the present document on PCRs should give also some advice how to consider these specific recommendations of phase feeding for farm animals. The minimum set of production phases is given in the Tables 4 and 5 below. The share of the specific phase or production stage of the total production cycle shall be indicated. All stages in sum should yield up to 100%. The average over all stages (phases) of production will be tabled as the representative feed per option, which shall be compared within the LCA assessment.

Table 4: Proposed production phases for pigs

Phase	Sub-phase
Sow	Gestating Phase
	Lactating Phase
Weaned Piglets	Pre-Starter
	Starter
Fattening Pigs	Grower
	Finisher

Table 5: Proposed production phases for broilers

Phase	Description
Starter	
Grower	
Finisher	
Growing / Finishing	(optional, depending on the region)
Withdrawal	(optional, depending on the region)

Specific examples for pigs and broilers are also given in Annex IV of this PCR document.

The present document is based on the pilot study conducted for the sustainable use of amino acids and phytase in pig and poultry production. Therefore the PCRs are also only addressed to pigs and poultry so far.

But generally, the concept and the methodology behind is also applicable for all other food producing animal species. If necessary, the authors will adapt the present document to the possible specific recommendations of other production systems.

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4. .Annex I:

Template for LCA (PCR short)

This Annex shall give a short guidance for the template of a LCA study for the use of SFIs in livestock production. The structure and content fulfils all recommendations of the ISO standard 14040 to 14044 inclusively the elements of the ILCD handbook, Pas 2050 band the Greenhouse Gas Protocol. The elements have been applied and tested through the industry consortium study (FEFANA IIFIF Joint Report 2014).

1 GOAL OF THE STUDY

2 SCOPE OF THE STUDY

2.1 System Description
- 2.1.1 Production of Base Feed Ingredients (BFI)
- 2.1.2 Production of Specialty Feed Ingredients (SFI)
- 2.1.3 Preparation of Feed
- 2.1.4 Animal Husbandry
- 2.1.5 Manure Management

2.2 Product Functions, Functional Unit and Reference Flows
- 2.2.1 Function
- 2.2.2 Functional Unit

2.3 System Boundaries
- 2.3.1 Time Coverage
- 2.3.2 Technology Coverage
- 2.3.3 Geographical Coverage

2.4 Co-product treatment and general allocation principles

2.5 Cut-Off Criteria

2.6 Biogenic Carbon

2.7 Selection of Life Cycle Impact Assessment (LCIA) Methodology and Types of Impacts

2.8 Data Quality Requirements
- 2.8.1 Technological Coverage and representativeness
- 2.8.2 Geographical Coverage and representativeness
- 2.8.3 Time Coverage and representativeness
- 2.8.4 Completeness
- 2.8.5 Precision and uncertainty
- 2.8.6 Methodological appropriateness and consistency

The Review Process
The Review Results
The Conclusion

5. Annex II:

List of Abbreviations

ADP	Abiotic Depletion Potential
AP	Acidification Potential
EF	Emission Factor
ELCD	European Life Cycle Database
EP	Eutrophication Potential
EPD	Environmental Product Declaration
FCR	Feed Conversion Ratio
FEFANA	EU Association of Specialty Feed Ingredients and their Mixtures
FU	Functional Unit
GaBi	Ganzheitliche Bilanzierung (German for holistic balancing); LCA software developed by PE INTERNATIONAL AG.
GHG	Greenhouse Gas
GWP	Global Warming Potential
IFIF	International Feed Industry Federation
ILCD	International Life Cycle Data System
iLUC	indirect Land Use Change
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LEAP	Livestock Environmental Assessment and Performance

LUC Land Use Change

PCRs Product Category Rules

PE PE INTERNATIONAL AG

SFI Specialty Feed Ingredients

UBA Umweltbundesamt (Environmental Agency of Germany)

6. Annex III:

List of available and compared PCRs- PCR – Arable crops (Sessa et al., 2014)

- PCR – Oilseed processing services (Berlin Technische Universität, FEDIOL, & S.r.l. Ambiente Italia, 2014b)
- PCR – Crude vegetable oil refining services (Berlin Technische Universität, FEDIOL, & S.r.l. Ambiente Italia, 2014a)
- PCR – Grain mill products (Life Cycle Engineering, 2014)
- PCR – Refined sugar from sugar beet (Ecoinnovazione, 2014)
- LEAP Guidelines Environmental performance of animal feeds supply chains – draft for public review- (FAO, 2014)

7. Annex IV:

Source: IFIF - International Feed Industry Federation and FEFANA – EU Association of Specialty Feed Ingredients and their Mixtures (2014), REPORT LCA on the role of Specialty Feed Ingredients on livestock production's environmental sustainability, PE INTERNATIONAL AG

(A) Diets Pigs

All animal development phases applied in that study which imply different feeding regimes have been taken into account to set up the overall feed composition for pig production. Regional differences in the amount of feeding phases were considered and transferred/translated into the following feeding phases (as default the European feeding regime was used). The considered phases are (all values given in brackets refer to the values applied in the alternatives and are related to feed intake for the production of 1000 kg LW):

Table 6: Example for production phases for pigs

Phase	Sub-phase	Share [%]		
		EU	**NA**	**SA**
Sow*		16	13	13
	Gestating Phase**	70	65	65
	Lactating Phase**	30	35	35
Weaned Piglets*		11 *[7.3-28.0 kg]*	9 *[7.5-25.0 kg]*	9 *[7.5-25.0 kg]*
	Pre-Starter**	14	24	24
	Starter**	86	76	76
Fattening Pigs*		73	78	78
	Grower**	40	42	42
	Finisher**	60	58	58

* Share of the overall cycle, ** share of the specific sub-phase to the phase

Based on the given diets and phases, an average feed composition was calculated for each region which was used for LCA modelling. The average feed composition of 1 ton of feed for the different regions and different alternatives.

(A) Diets Broiler

The feed diet is intended to display regionally typical and representative feed compositions. The calculation of the feed composition was validated by the scientific council based on regionally typical feed ingredients and the net energy. For South America the calculation was done based on metabolic energy.

All animal development phases which imply different feeding regimes were taken into account to set up the overall feed composition for broiler production.

Table 7: Example for production phases for pigs

Phase	Share [%]		
	EU	**NA**	**SA**
Pre-Starter	5		5
Starter	25	5	25
Grower	70	25	
Grower - Finisher			70
Finisher		35	
Withdrawal		35	

Based on the given diets and phases, an average feed composition was calculated. The average feed composition of 1 ton of feed for the different regions and different alternatives.