Final report

Product Category Rules for Starch Industry Products

Boonen Katrien, Vercalsteren An

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VITO NV
Boeretang 200 - 2400 MOL - BELGIE
Tel. + 32 14 33 55 11 - Fax + 32 14 33 55 99
vito@vito.be - www.vito.be

BTW BE-0244.195.916 RPR (Turnhout)
Bank 375-1117354-90 ING
BE34 3751 1173 5490 - BBRUBEBB

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CHAPTER 1 INTRODUCTION AND SCOPE

1.1. INTRODUCTION

This document describes PCR (Product Category Rules) developed for products produced by the starch industry. They are based on the LCA study on starch industry products published in August 2012 and take into account the ISO 14025 standard, the PEF guide, the Guidance for the PEF pilots and the Envifood Protocol.

The **ISO 14025 standard** “Environmental labels and declarations - Type III environmental declarations - Principles and procedures” is used as a starting point. This document focusses on the guidance related to the development of PCR. As such, the steps for the preparation of a PCR document are followed (see Figure 1). The second step, the LCA, was already performed in the previous study, and is thus a good basis for the PCR development. The LCA study was updated in parallel with the drafting of the PCR. As the PCR also took into account the newly available PEF guide, the LCA study was updated to fully comply with these PCR.

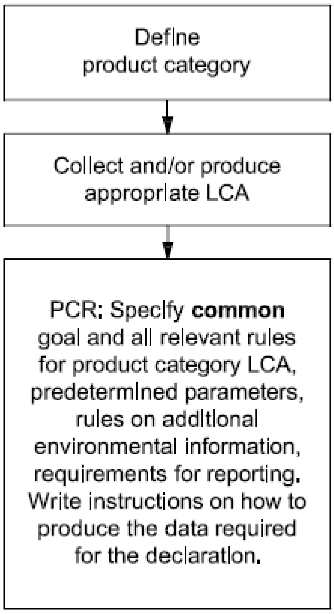

Figure 1: Steps in preparation of a PCR document (ISO 14025)

The content of the PCR is also based on ISO 14025.

The full procedure for developing Type III environmental declaration programmes as described in ISO 14025 will not be followed, and we will not come to Type III environmental declarations (EPDs) within this project. As many decisions were already made during the LCA project, and due to the strict timing for this project, no open participatory consultation with interested parties has been organised nor has a PCR review by a third-party panel been performed.

Although the PCR are not published in the official PEFCR format, the **PEF guide** and its guidance on how to create product category-specific methodological requirements for use in PEFCRs is being followed as much as possible. When methodological aspects of the PCR do not comply with the PEF guide, a justification is included. The PCR will be a good basis for the development of PEFCR when all guidance documents are finalized after the PEF/OEF pilot phase.

The PEF document "**Guidance for the implementation of the EU PEF during the EF pilot phase**" is taken into account when feasible, but it has to be kept in mind that it is only a working document, which will be further elaborated based on the pilots. Only this document's guidance on the content of the PEFCRs will be considered. The process to follow in order to obtain PEFCRs and the guidance on how to organise and coordinate the work will not be taken into account.

The PCR are also compared with the Envifood Protocol (version 1), as this is intended to be a baseline for developing more detailed sectoral guidance and product group/subgroup specific rules (PCRs). The Protocol states that '*PCRs are expected to complement the Envifood Protocol and be either PCRs according to ISO14025 or PEFCRs according to the Commission's PEF. PCRs might be instrumental for Type III Environmental Declarations and environmental footprint programmes, or might be the baseline for detailed assessments enabling the definition of environmental performance indicators and criteria*'.

1.2. SCOPE

This PCR (Product Category Rules) document is considered a position paper of the starch industry that will serve as a background document that summarizes and justifies the decisions taken by the industry with regard to rules relevant for LCA of products produced by the starch industry and that will prepare the industry for upcoming PEFCR rules. This is in line with the Envifood Protocol that states PCRs support the development of consistent environmental assessments of intermediate products in the context of business-to-business and of consumer products in the context of business-to-consumer communication.

The users of this PCR can be producers in the starch industry and other interested parties.

The PCR:

- specifies the products from the starch industry for which this PCR applies;
- identifies and documents the goal and scope of the LCA-based information for the product category;
- defines the parameters to be covered and the way in which they are collated and reported;
- states which stage of a product's life cycle is to be considered and which processes are to be included in the life cycle stages;
- includes the rules for calculating the Life Cycle Inventory and the Life Cycle Impact Assessment, including the specification of the data quality to be applied;
- identifies the rules for producing the additional environmental information for the product category.

The PCR has been commissioned by the European Starch Industry (Starch Europe). The development of this PCR was based on a participatory process which included consultation with the members of Starch Europe.

CHAPTER 2 NORMATIVE REFERENCES

The documents and norms that lay out the basis of the development of this PCR for products from the starch industry are:

- **ISO 14040:2006** – Environmental management – Life Cycle Assessment – Principles and framework;
- **ISO 14044:2006** – Environmental management – Life Cycle Assessment – Requirements and guidelines;
- **ISO 14025:2006** – Environmental labels and declarations – Type III Environmental declarations – Principles and procedures;
- **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;
- European Commission (2013). Annex II: **Product Environmental Footprint (PEF) Guide** to the Commission Recommendation on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations (2013/179/EU);
- European Commission (2014). **Guidance for the implementation** of the EU PEF during the EF pilot phase - Version 4.0. Draft document.

Figure 2 shows the relationship between the different guidelines. The lower the guideline, the higher the level of detail. The **ENVIFOOD Protocol** will be used as complementary guidance during the development of PCR.

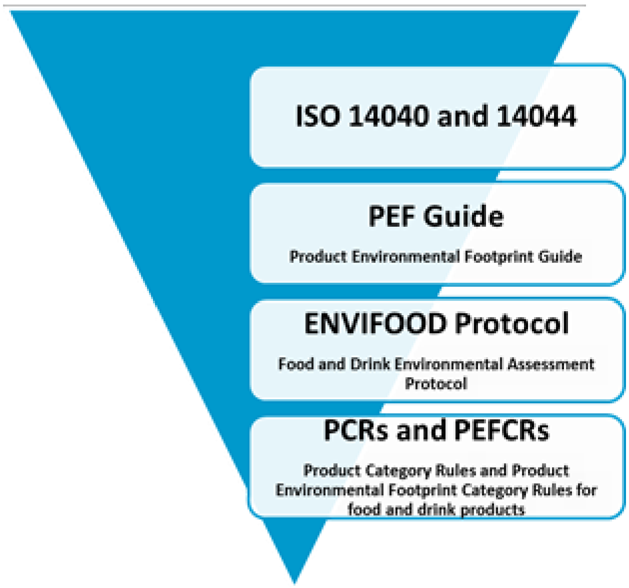

Figure 2: Relationship between different guidelines (Source: ENVIFOOD Protocol)

The PEF guide and PEFCR guidance use a terminology different from ISO terminology to make them more accessible to their target audience, which also includes groups that do not necessarily have strong background knowledge of environmental assessment. As this report develops PCR and not PEFCR, the generally accepted ISO terminology is used.

CHAPTER 3 TERMS AND DEFINITIONS

Allocation
Partitioning the input or output flows of a process or a product system between the product system under study and one or more other products systems [ISO 14044:2006]

Cut-off
Specification of the amount of material flow, energy flow, or the level of environmental significance associated with unit processes or product systems to be excluded from a study [ISO 14044:2006]

Functional unit
Quantified performance of a product system for use as a reference unit
[ISO 14040:2006]

Generic data
Data from literature or databases.
[ISO 14040:2006 and ISO 14044:2006]

Information module
Compilation of data to be used as a basis for a Type III environmental declaration, covering a unit process or a combination of unit processes that are part of the life cycle of a product
[ISO 14025:2006]

Intermediate product
Output from a unit process that is input to other unit processes that require further transformation within the system [ISO 14044:2006]

Life cycle assessment (LCA)
Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle
[ISO 14040:2006 and ISO 14044:2006]

Life cycle impact assessment (LCIA)
Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system
[ISO 14040:2006 and ISO 14044:2006]

Life cycle inventory analysis (LCI)
Phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle
[ISO 14040:2006 and ISO 14044:2006]

Product category
group of goods or services that can fulfil equivalent functions
[ISO 14025:2006]

Product category rules (PCR)
Set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories
[ISO 14025:2006]

System boundary
A set of criteria specifying which **unit processes** are part of a product system
[ISO 14040:2006 and ISO 14044:2006]

Type III environmental declaration
Claim which indicates the environmental aspects of a product or service, providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information
[ISO 14025:2006]

Unit process
Smallest element of a product system for, which data are collected when performing a life cycle Assessment
[ISO 14040:2006 and ISO 14044:2006]

CHAPTER 4 PRODUCT CATEGORY RULES FOR LCA

4.1. Introduction

A PCR shall identify and document the goal and scope of the LCA-based information for the product category and the rules for producing the additional environmental information for the product category. A PCR shall also determine the life cycle stages to be included, the parameters to be covered, and the way in which the parameters shall be collated and reported.
For the sake of completeness and consistency, a PCR shall be based on one or more life cycle assessments (in accordance with the ISO14040 series) and other relevant studies to identify requirements for additional environmental information. These life cycle assessments and other relevant studies shall be referenced in the PCR document.

4.2. Objective of the PCR for products from the starch industry

This PCR (Product Category Rules) document is considered a position paper of the starch industry that will serve as a background document that summarizes and justifies the decisions taken by the industry with regard to rules relevant for LCA of products produced by the starch industry and that will prepare the industry for upcoming PEFCR rules.
The PCR for products from the starch industry provides additional guidance to perform LCA studies and/or develop type III environmental declarations of starch industry products. General guidance can be found in the ISO 14040/44 standards and the Product Environmental Footprint (PEF) Guide, however, in these guides some options are left open. This PCR contains additional rules, requirements and guidelines, specific to one product category; starch industry products. PEFCR are meant to increase comparability, reproducibility and consistency of LCA studies of products from the starch industry. They also help to focus on the most important parameters of the study, and thus reduce time, efforts and costs (European Commission, 2013).

4.3. Product category definition and description (function, technical performance and use)

This PCR covers products produced by industries under the four-digit NACE code 10.62 “Manufacture of starches and starch products” and underlying classes and sub-classes. Additionally, some products that fall under other NACE codes are included: bran (NACE code 10.61) and sorbitol[1], diols and polyhydric alcohols[2] (NACE code 20.14).

The NACE 10.62 class includes:

- manufacture of starches from rice, potatoes, maize, wheat, pea etc.;
- wet corn milling;
- manufacture of glucose, glucose syrup, maltose (liquid glucose), etc.;
- manufacture of gluten;

[1] Sorbitol or D-glucitol, prodcom code 20.14.23.33
[2] Diols and polyhydric alcohols (excluding ethylene glycol and propylene glycol, D-glucitol), prodcom code 20.14.23.39

- manufacture of corn oil.

The NACE 10.62 class excludes:
- manufacture of lactose (milk sugar);
- production of cane or beet sugar.

In this PCR the following activities are also excluded (although included in the NACE 10.62 code):
- manufacture of tapioca and tapioca substitutes prepared from starch;
- manufacture of inulin.

The underlying LCA-study referred to in this PCR includes all products from the starch industry groups listed in Table 1. Please note that rice is not included in the underlying LCA study as only one dataset on rice was available (only one European producer). Rice is kept in the product definition of this PCR though, as no major differences are expected.

Table 1: Overview of reference and by-products for which environmental impacts are calculated

From wheat	*Application*	From maize	*Application*	From potatoes	*Application*
Starch slurry	*FO, FE, I*	Starch slurry	*FO, FE, I*	Starch slurry	*FO, FE, I*
(Lose) Bran (as such, after grinding)	*FE*	Steep liquor	*FE, I*	Potato proteins	*FE*
Dry wheat feed (bran and solubles mixed, then dried) – pelletilised or not	*FE*	Dry corn feed (steep liquor mixed with fibres, then dried)	*FE*	Fruit juice	*FE, I*
Dry (Solubilised or not) gluten	*FO, FE*	Wet corn fibres	*FE*	Concentrated fruit juice	*FE*
Wet solubilised gluten	*FO, FE*	Dry germs	*FO, FE*	Wet pulp	*FE*
Liquid solubles (as such, after evaporation)	*FE*	Oil	*FO*	Dry pulp (fibres)	*FE*
		Dry proteins	*FE*		
Liquid glucose (including hydrolysates, fructose and glucose syrups)					*FO, I*
Dry crystallized dextrose					*FO, FE*
Maltodextrin					*FO*
Liquid sorbitol					*FO, I*
Dry sorbitol					*FO, I*
Unfermented special polyols					*FO, I*
Native and lightly modified starches (e.g. light or dry modification)					*FO, FE, I*
Modified starch – liquid modification (e.g. PO, esters and ethers)					*FO, FE, I*
Dextrins					*FO, I*
Potable alcohol					*FO*
Broth (by-product from potable alcohol)					*FE*

(FO = Food, FE = Feed, I = Industrial)

The starch industry products are used in a wide range of applications, including food (e.g. drinks, sweets, soups, bread), feed (e.g. pet food, cattle feed, aquafeed) and other industries (e.g. paper, textiles, plastics, pharmaceuticals). The performance depends on the specific product and application.

4.4. Goal and scope definition for the LCA of the product

4.4.1. Functional unit and reference flow

The functional unit is defined as “the production of 1 ton d.s. (dry substance) of starch industry product at the starch plant exit gate”. This can be a reference or a by-product. The functional unit shall be clearly stated in the study.

For products produced by the starch industry, the reference flow is identical to the functional unit. In the case of starch industry products it is not feasible to include a description of the function in the functional unit, as a vast number of functions exist (e.g. sweeten, improve colour, add nutrients, enhance flavour, improve consistency, add strength, bind, stabilize). Even for one specific starch industry product, different applications exist. For this reason, no recommendations on how to include the use phase are given in this PCR and the functional unit is based on mass (and as such identical to the reference flow definition).

In the PEF pilot guidance document (European Commission, 2014) it is stated that a material based approach (e.g. mass based functional unit) might be the best choice in case of intermediate products that can fulfil multiple functions. In that case, the PEFCR becomes a “module” to be used when developing PEFCR for products further down the supply chain(s). The development of “modules” allows for a higher level of consistency among different supply chains that are using such modules as part of their life cycle assessment. Also ISO 14025 allows the use of information modules that represent the whole or a portion of the life cycle, for those materials or parts that are used in the manufacture or assembly of other products. Based on these statements, one PCR document with a mass based functional unit is made for all starch industry products.

4.4.2. System boundary

The cradle-to-gate processes need to be included. If the starch industry product to be analysed has a limited amount of applications that are well known, also the further processing into the final application, the use phase and end-of-life phase can be included. However, no recommendations on the use and end-of-life phase are made in this PCR, as this is not required for intermediate products. The system boundary diagram shown in Figure 3 generically outlines the different life cycle stages and the inputs and outputs that are included in the system boundaries of this PCR.

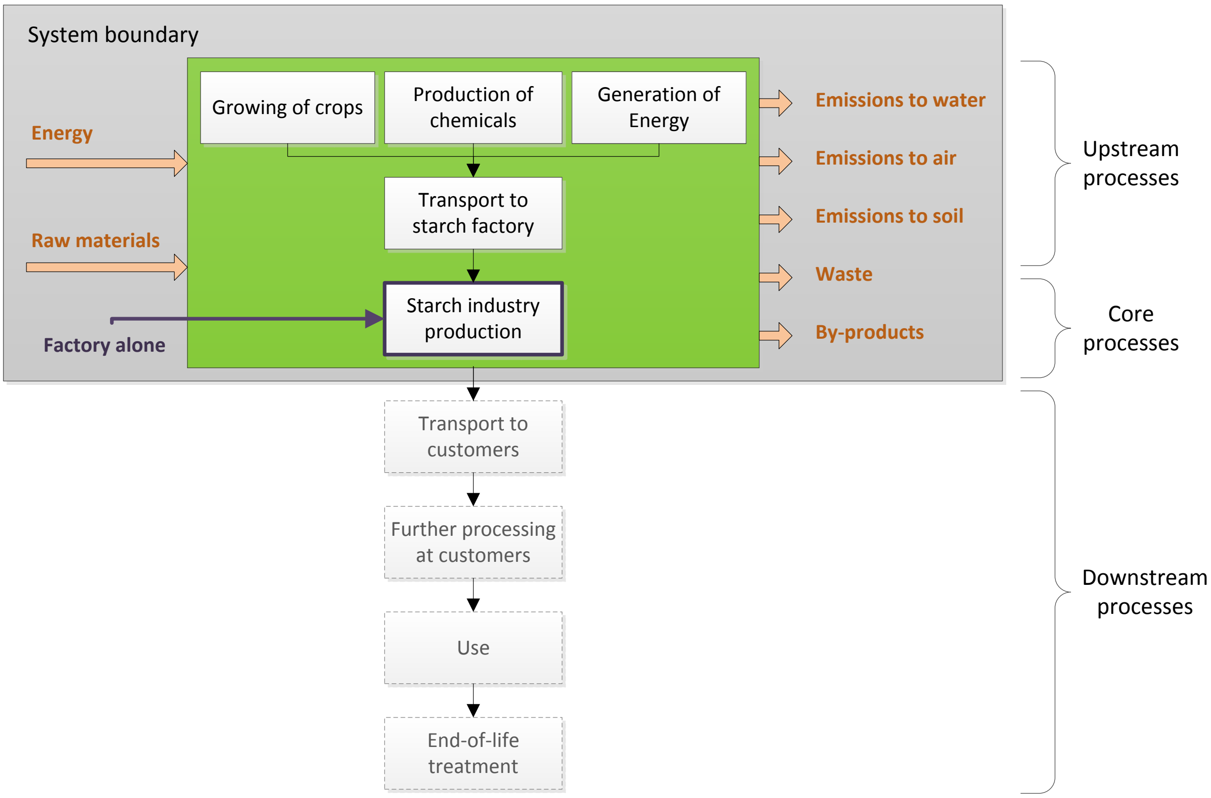

Figure 3: Generic presentation of system boundaries

The following life cycle stages should be included in the analysis:

- ***Cradle-to-raw materials/upstream processes***: These are all the processes upstream of the starch production stage, starting with the resource extraction. This includes:
    - agricultural processes: growing of crops, including soil cultivation, sowing, weed control, fertilisation, pest and pathogen control, harvest and drying (if relevant);
    - the production of energy;
    - the production of chemicals needed for manufacturing starch industry products (caustic soda, hydrochloric acid etc.);
    - Transport steps: Transport of raw materials from the field/plants to the starch plants should be included here.
- ***Factory alone/gate-to-gate/core processes***: This focuses on the production of starch industry products. All relevant processes, starting with the reception of the raw materials need to be included. Depending on the specific starch industry product, these processes can be: reception, dry cleaning, wet cleaning, rasping, steeping, degerminating, grinding/flour milling, dough, separation, sieving, dewatering, washing, refining, mixing & drying, evaporation, drying, solubilizing, pressing, protein separation, conversion, hydrogenation, special polyol process, maltodextrine process, crystallization, fermentation and distillation (non-limitative list). Annex A gives a detailed overview of the starch industry production processes to be included in the analysis.

  If the products are packed when leaving the factory, the packaging should also be included in the analysis. If the packaging is expected to have a negligible contribution to the environmental impact of the product, this can be demonstrated in a sensitivity analysis (this was done in the underlying LCA-study, see Annex B for more information).

The following life cycle stages may be included in the analysis when considered relevant for the goal and scope of the study:

- ***Downstream processes:***
  - Transportation from the starch factory to customers;
  - Further processing of starch industry products into final products at customers;
  - Use of the final products;
  - End-of-life treatment of waste of final product.

To clearly define the system boundaries, some basic principles need to be denoted:

- Inclusion of *infrastructure* (the use of the capital goods and the effects related to this)
  Infrastructure in this respect refers to transportation infrastructure (roads, railways, …) and infrastructure for energy production (electricity plants, pipelines, …).
  Infrastructure related to the starch industry plants may be excluded, the justification can be found in Annex B.
- *Accidental pollutions* are often difficult to distinguish from emissions that occur under normal conditions (accidental pollutions are not measured and reported separately) and therefore do not need to be considered.
- Environmental impacts caused by the *personnel of the production plants* can be neglected, e.g. waste from the cafeteria and sanitary installations or accidental pollution caused by human mistakes, or environmental effects caused by commuter traffic.

4.4.3. DESCRIPTION OF DATA

For all life cycle stages an input-output balance is made:

- ***Input data*** concern the consumption of energy, raw materials and water;
- ***Output data*** are emissions (to air, water, soil) and waste.

The following data sources should be used for the different life cycle phases:

- ***Cradle-to-raw materials/upstream processes***
  - Agricultural processes: ⇒ Primary data if possible, otherwise secondary (generic) data from the Agribalyse database can be used.
    Primary data should be used if possible, since agriculture is responsible for a large part of the environmental impact of products from the starch industry (as shown in the LCA).
    In practice, however, it may be very difficult to obtain primary data since the crops come from many farmers and data availability is limited. The European farmers' associations were contacted, but they do not have EU representative LCA data for agriculture available yet. Therefore, secondary data can be used. It is recommended to select agricultural data from the Agribalyse database (ADEME, 2014). This database contains data on about 30 crops produced in France and some tropical regions (e.g. rice from Thailand). For several products a number of variations exist. The Agribalyse database is deemed to contain data that are representative of the standard conditions of growing, in Europe, of raw materials processed by the starch industry. The allocation methodology follows the ISO recommendations. If allocation can not be avoided, biophysical allocation is used when possible, and otherwise economic allocation is foreseen. For the raw materials used in the LCA-study, 100% of the impacts are allocated to the main product[3]. The Agribalyse database is freely available upon request. It needs to be considered that carbon dioxide

[3] Although economic allocation was meant to be used for straw as a co-product of grain, it could not be applied, as the straw market is currently not very structured.

emissions due to land use changes are not included yet in the Agribalyse database, so a proxy needs to be added in order to be fully compliant to the PEF guide.
In case another database or literature contains more complete data or data more appropriate for the goal and scope for the study, these data can be used, and a justification should be added to the report.

- Production of energy ⇒ Secondary (generic) data from LCA databases
  Many companies in the starch industry generate power in their own Combined Heat Power installations (CHP). For these CHP, specific data should be collected for at least the power to heat ratio and efficiency.
- Production of chemicals needed in the starch industry (caustic soda, hydrochloric acid etc.), ... ⇒ Secondary (generic) data from LCA databases
- Transport from suppliers to the factory ⇒ Secondary (generic) data from LCA databases
  Transport generally has a relatively small contribution to the environmental impact of starch industry products, so it can be justified to use generic data.

- ***Factory alone/core processes***: ⇒ Primary data from starch producing plant(s)
  Since the study focuses on the starch industry processes in the first place, it is important to use specific data for these processes. A list of processes to consider is given in paragraph 4.4.2.

It is recommended to select generic (non-agricultural) data from databases in the following order:

- Ecoinvent database
  Commercial database that contains most of the chemicals relevant for the starch industry.
- ELCD database (JRC, the European Commission's Joint Research Centre)
  The focus of the European reference Life Cycle Database (ELCD) is laid on data quality, consistency, and applicability, furthermore, it supports the Product Environmental Footprint (PEF) standards. The data is available free of charge. However, at the moment this database only contains about 330 datasets. Very few data are available on the production of chemicals, which makes it hard to use for studies on starch industry products.

It is recommended to use one database only as a basis for the study, and convert data from other databases as much as possible to concur with that database. For example, background electricity and transport processes should refer to the same database in order to avoid differences based on inconsistencies between databases.

The data and data sources used should be clearly described in the inventory phase.

4.4.4. CRITERIA FOR THE INCLUSION OF INPUTS AND OUTPUTS

It is often not possible to gather 100% of all inputs and outputs, which pertain to the functional unit in an LCA study. This is because time and resources for projects are limited or data are too difficult to collect. Cut-off criteria (for input & output), allow for exclusion of insignificant contributions. ISO 14044 gives generic guidance for defining cut-off criteria for whether to include or to exclude materials, energy and emissions data (par.4.2.3.3.3):

- ***Mass*** – an appropriate decision would require the inclusion of all inputs that cumulatively contribute more than a defined percentage to the mass input of the product(s);
- ***Energy*** – identical to using mass as a criterion;

- ***Environmental relevance*** – decisions on cut-off criteria should be made to include inputs that contribute more than an additional defined amount of the estimated quantity of individual data of the product system that are specially selected because of environmental relevance.

With these cut-off criteria the importance of omitted flows are minor and the risk that omitted flows will influence the final conclusions is negligible.

For the production of starch industry products, it may be hard to collect data on all chemicals used. Therefore, at least bulk[4] chemicals as input flows should be included (justification is included in Annex B).
The bulk chemicals that should be included are listed in Annex C, also their equivalents should be considered. As the majority of all materials (raw materials and chemicals) are supplied in bulk packaging, packaging of incoming materials is not significant and as such does not need to be taken into consideration.

The chemicals used during manufacture of the products from the starch industry do not all have accurate inventory data. In case no data are available for a certain chemical, an approximation based on the best available data can be used. Data gaps may be filled by conservative assumptions with average or generic data. The assumptions always need to be documented and their effect on the results needs to be assessed.

A number of flows is often excluded in LCA studies, and can be omitted from the system boundaries:

- Lighting, heating, cooling and cleaning of the starch manufacturing plants;
- Burdens related to the administrative department of the production plant;
- Accidental pollutions;
- Environmental impacts caused by the personnel of the production plants;
- Manufacturing, maintenance and end-of-life of the capital goods needed for the starch industry.

Exclusion of the flows related to infrastructure of the starch industry plants can be justified due to the fact that a huge volume of reference products can be produced during the life span of the infrastructure. Additional justification of this is included in Annex B.
Personnel-related impacts are usually not covered in life-cycle assessments and furthermore, personnel transportation, sanitary effluents etc. are seldom unique for the system under study and differences between alternatives are likely to be small (Nordic guidelines on life-cycle assessment, 1995).

What is included and excluded from the system needs to be clearly specified.

4.4.5. DATA QUALITY REQUIREMENTS

The following aspects of data quality need to be addressed in the report:

- The geographical, time and technological coverage of the data used shall be specified. When using generic data for agricultural processes, the data should refer to a system equivalent to the system under study, with similar agricultural practices and technology, in similar geographical and climatological conditions. If this is not the case, this needs to be stated explicitly and a justification should be given.

[4] Defined as unpacked, not related to specific quantities.

- For the factory-alone analysis (and processes operated or managed by the reporting organisation) as much company-specific data as possible should be used. If no primary data are found, this should be stated and data from literature can be used.
- The primary data collected from starch producing plant(s) should be the most recent good quality data available, unless there is a reason to believe these data are not representative. Primary data should not be more than 5 years old at the moment of the study.
- Primary data sets should be based on (at least) 1 year averaged data; deviations should be justified.
- If this PCR is used to do a sector study (including several companies) or if the same product is produced in different plants, a weighted average dataset per starch industry product should be made, based upon the annual production volumes.
- Secondary data shall be as recent as possible. Data sets used for calculations should have been updated within the last 10 years. In case older data is used, a rationale should be given.
- Data sets shall be complete according to the system boundary within the limits set by the criteria for the inclusion of inputs and outputs.
- The data that are used must be as precise and complete as possible.
- The data used must be consistent and reproducible.
- The origin and representativeness of the data needs to be stated in the reports in the inventory chapter.

4.5. Inventory analysis

4.5.1. Data collection

Data collection shall follow the guidance provided in EN ISO 14044:2006, par. 4.3.2:

Qualitative and quantitative data for inclusion in the inventory shall be collected for each unit process that is included within the system boundaries. The collected data, whether measured, calculated or estimated, are utilized to quantify the inputs and outputs of a unit process.

When data have been collected from public sources, the source shall be referenced. For those data that may be significant for the conclusion of the study, details about the relevant data collection process, the time when data have been collected, and further information about data quality indicators shall be referenced. If such data do not meet the data quality requirements, this shall be stated.

To avoid misunderstanding, it is important to describe each process (input and output flows) and to draw process flow diagrams that outline the unit process and their interrelationships.

4.5.2. CALCULATION PROCEDURES

The calculation procedures described in EN ISO 14044 shall apply. The same calculation procedures shall be applied consistently throughout the study.

4.5.3. ALLOCATION OF MATERIAL AND ENERGY FLOWS AND RELEASES

For processes where allocation is necessary (multiple input or output processes), the allocation procedure described in par. 4.3.4 of the ISO 14044 standard needs to be followed. The allocation procedure as defined in this standard is summarized as follows:

- Step 1: Wherever possible, allocation should be avoided or minimized by detailing multiple processes into two or more sub-processes, some of which can be located outside the system boundaries or by expanding the system boundaries so that inputs/outputs remain inside the system. This is called “avoiding allocation by system expansion”.
- Step 2: Where allocation can not be avoided, it should preferentially be based on causal relationships between the system inputs and outputs. These causal relationships between the flows into and out of the system may be based on physical or economic parameters.
- Step 3: Where causal relationships can not be established, allocation to different products may be based on their economic value.

When performing a study on a specific starch industry products according to this PCR, allocation can usually not be avoided through subdivision or system expansion. Subdivision/disaggregation can (and should) be done up to a certain level, as some processes can be attributed to one product only. However, many production processes in the starch industry are complex and may be considered as a ‘black box’ that cannot be subdivided further (see process trees in annex A).

In that case, mass allocation (dry substance) should be applied. Mass allocation was chosen because it offers the clearest picture throughout the process tree, it relates directly to the functional unit, and is based on the best available data. More detailed information on the allocation procedure is included in Annex B.

Allocation is also important for the correct modelling of Combined Heat Power installations (CHP) that are used by many starch industry companies.
To allocate the environmental burdens caused by the CHP to either heat or electricity, different methods are available. Allocation can be based on i) operational activities (electricity only, heat only), ii) thermodynamic parameters (energy, exergy) or iii) final product prices.
The input- and output flows of the CHP electricity resp. heat output are modelled according to energy allocation. In the LCA study only small differences were found in the total environmental impact calculated for energy and exergy allocation. Therefore, it was decided to base the allocation of the impact of the CHP on energy.

4.6. IMPACT CATEGORY SELECTION AND CALCULATION RULES

Table 2 shows the impact categories and the life cycle impact assessment (LCIA) methods recommended by ILCD (2011) and PEF Guide (European Commission, 2013) to calculate the impacts for each category. The PEF pilot guidance states that “In case of intermediate products, all impact categories shall be included”. It is recommended to include these impact categories and related methods in any LCA study of products from the starch industry.

During the PEF pilots, additional guidance on the life cycle impact assessment methods was given. The LCA study this PCR document is based on took into account the document “Dealing with unexpected results and anomalies of normalised IA figures in the EF screenings”, published on the 21st of November 2014. This document includes guidance on:

- Toxicity categories (human toxicity cancer and non-cancer and freshwater ecotoxicity):
    - The baseline values for the toxicity categories shall be calculated taking into account only impacts due to so called “short term” emissions within 100 years.
    - The baseline values for the toxicity categories shall be calculated making transparent which part of the impacts stems from elementary flows for which the recommendation level according to ILCD Handbook and PEF/OEF guidance is level III (recommended, but to be applied with caution).
- Water depletion
    - The baseline values for the impact category water depletion shall be calculated disregarding impacts from water used for generating hydro-electricity.
    - The baseline values for the impact category water depletion shall include water used for cooling, making transparent which part of the impacts stems from those elementary flows related to water used for cooling.

Table 2: Overview of the default environmental impact categories and impact assessment models for PEF studies (European Commission, 2013)

EF Impact Category	EF Impact Assessment Model	EF Impact Category indicators	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	kg CO 2 equivalent	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon.	kg CFC-11 (*) equivalent	WMO, 1999
Ecotoxicity for aquatic fresh water	USEtox model	CTUe (Comparative Toxic Unit for ecosystems)	Rosenbaum et al., 2008
Human Toxicity - cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Human Toxicity – non-cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	kg PM2,5 (**) equivalent	Humbert, 2009
Ionising Radiation – human health effects	Human Health effect model	kg U 235 equivalent (to air)	Dreicer et al., 1995
Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC (***) equivalent	Van Zelm et al., 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	mol H+ eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – terrestrial	Accumulated Exceedance model	mol N eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – aquatic	EUTREND model	fresh water: kg P equivalent marine: kg N equivalent	Struijs et al., 2009 as implemented in ReCiPe
Resource Depletion – water[5]	Swiss Ecoscarcity model	m 3 water use related to local scarcity of water	Frischknecht et al., 2008
Resource Depletion – mineral, fossil	CML2002 model	kg antimony (Sb) equivalent	van Oers et al., 2002
Land Use/ Transformation	Soil Organic Matter (SOM) model	Kg (deficit)	Milà i Canals et al., 2007
(*) CFC-11 = Trichlorofluoromethane, also called freon-11 or R-11, is a chlorofluorocarbon. (**) PM2,5 = Particulate Matter with a diameter of 2,5 µm or less. (***) NMVOC = Non-Methane Volatile Organic Compounds			

[5] Resource depletion – water: Not conform Envifood Protocol, which recommends the Water stress index model as Impact Assessment model for water use.

According to the Envifood Protocol, water use should be assessed and reported separately given the importance for the food and drink sector.

Some specific points of attention during the impact assessment are summarized below:

- Accounting biogenic CO_2-emissions and CO_2 uptake
  The starch industry's products are not only used for food and feed products, but also for products with a longer service life (e.g. plasterboard, paper, cardboard), where the carbon may be stored for a longer time. The PAS2050:2011 standard indicates that the removal of carbon from the atmosphere (e.g. by plants) must be included in the assessment, except in the case of food or feed products. The ISO/TS 14067:2013 standard states that greenhouse gas emissions and removals arising from biogenic carbon sources and sinks shall be included and documented separately. Therefore, the "carbon credit" related to the CO_2 uptake of the raw materials is reported separately, allowing companies that use starch products in industrial applications to include the "carbon credit" in the carbon footprints of their products when necessary.

  The carbon uptake of the plants during the cultivation is taken into account as an uptake (a minus) of CO_2 emissions. This minus is allocated over the reference and by-products of the starch industry processes (according to different rules as discussed in this document) and may only be included in the carbon footprint figure when starch industry products are used in non-food applications. The carbon uptake shall be reported as a separate figure that is complementary to the carbon footprint for non-food applications.
- Impact of land use change on climate change
  The impact of land use change on climate change should be included. A tool that allows calculating the greenhouse gas emissions from land use change is the "Direct Land Use Change Assessment Tool (Version 2014.1 - 21 January 2014)" developed by Blonk Consultants.

4.7. Predetermined parameters for reporting of LCA data

In addition to the impact categories discussed in the previous paragraph, inventory data can provide relevant information about a product's environmental performance, e.g. 'non-treated final waste flow for landfill and incineration' expressed in kg waste, water use expressed in m^3 and land use expressed in m^2year.

4.8. Requirement for additional environmental information

No additional environmental information is relevant and required.

4.9. Materials and substances to be declared

There are no materials and substances that can adversely affect human health and environment relevant to be declared.

4.10. Information on which stages are not considered

No recommendations on the use and end-of-life phase are made in this PCR, as this is not required for intermediate products.

4.11. Period of validity

This PCR is valid for a 5 year period from the date of issue, after which it shall be reviewed and verified.

REFERENCES

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ISO 14040:2006 – Environmental management – Life Cycle Assessment – Principles and framework

ISO 14044:2006 – Environmental management – Life Cycle Assessment – Requirements and guidelines

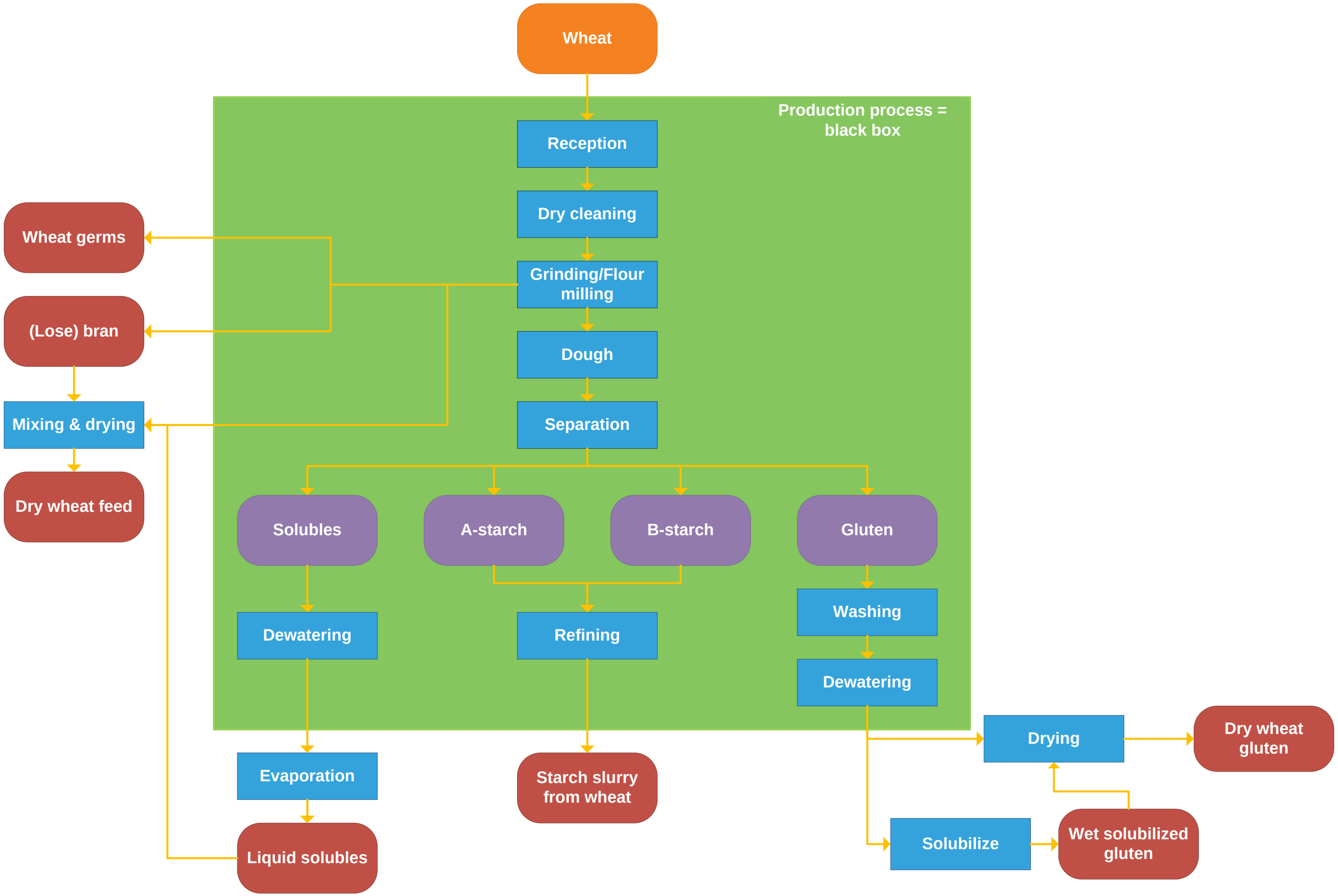
ISO 14025:2006 – Environmental labels and declarations – Type III Environmental declarations – Principles and procedures

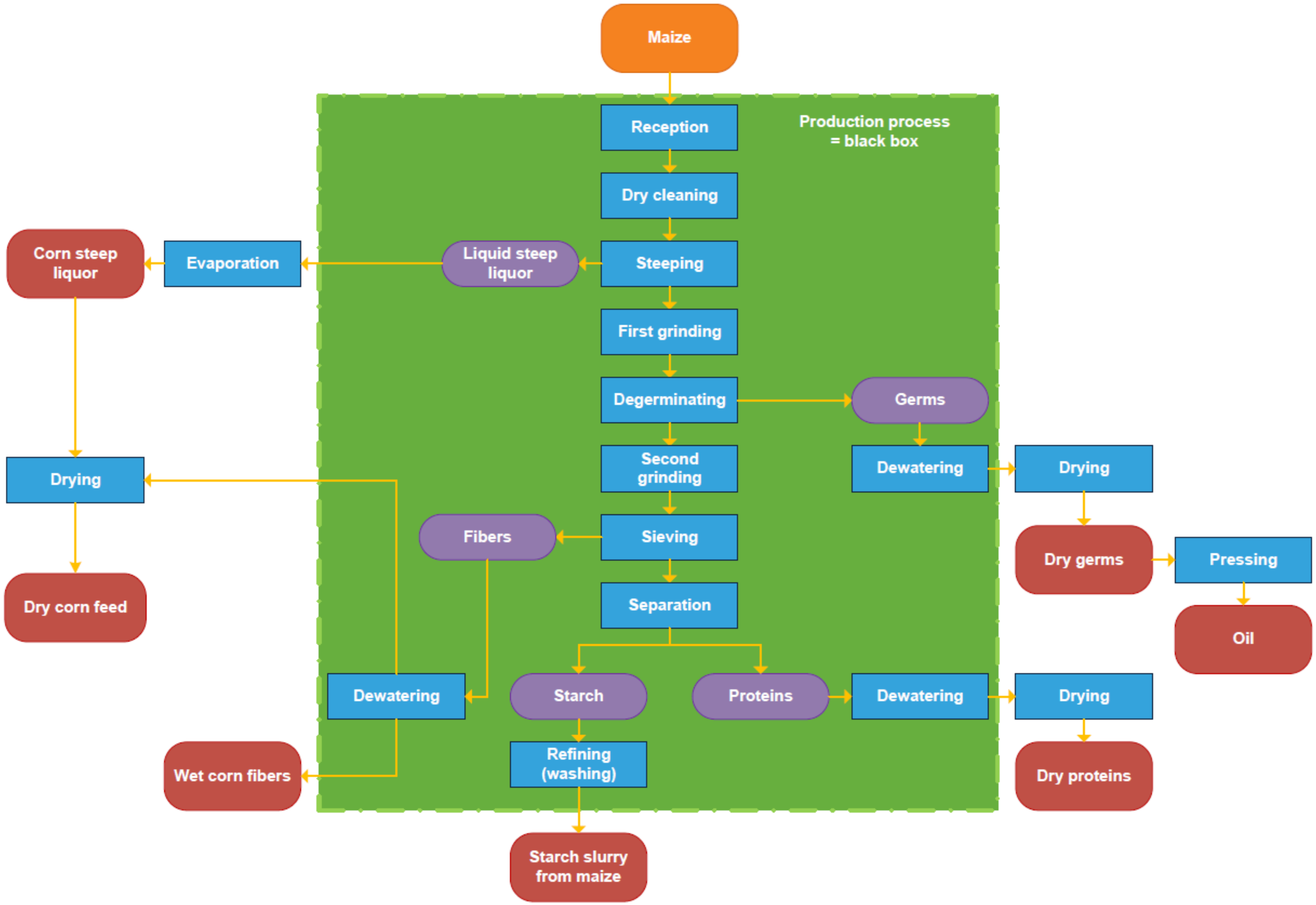
Koch P. and Salou T.. 2013. AGRIBALYSE®: Rapport Méthodologique – Version 1.0. Ed ADEME. Angers. France. 384 p.

LEAP (2014). Environmental performance of animal feeds supply chains - DRAFT FOR PUBLIC REVIEW. LEAP, FAO, Rome, Italy.

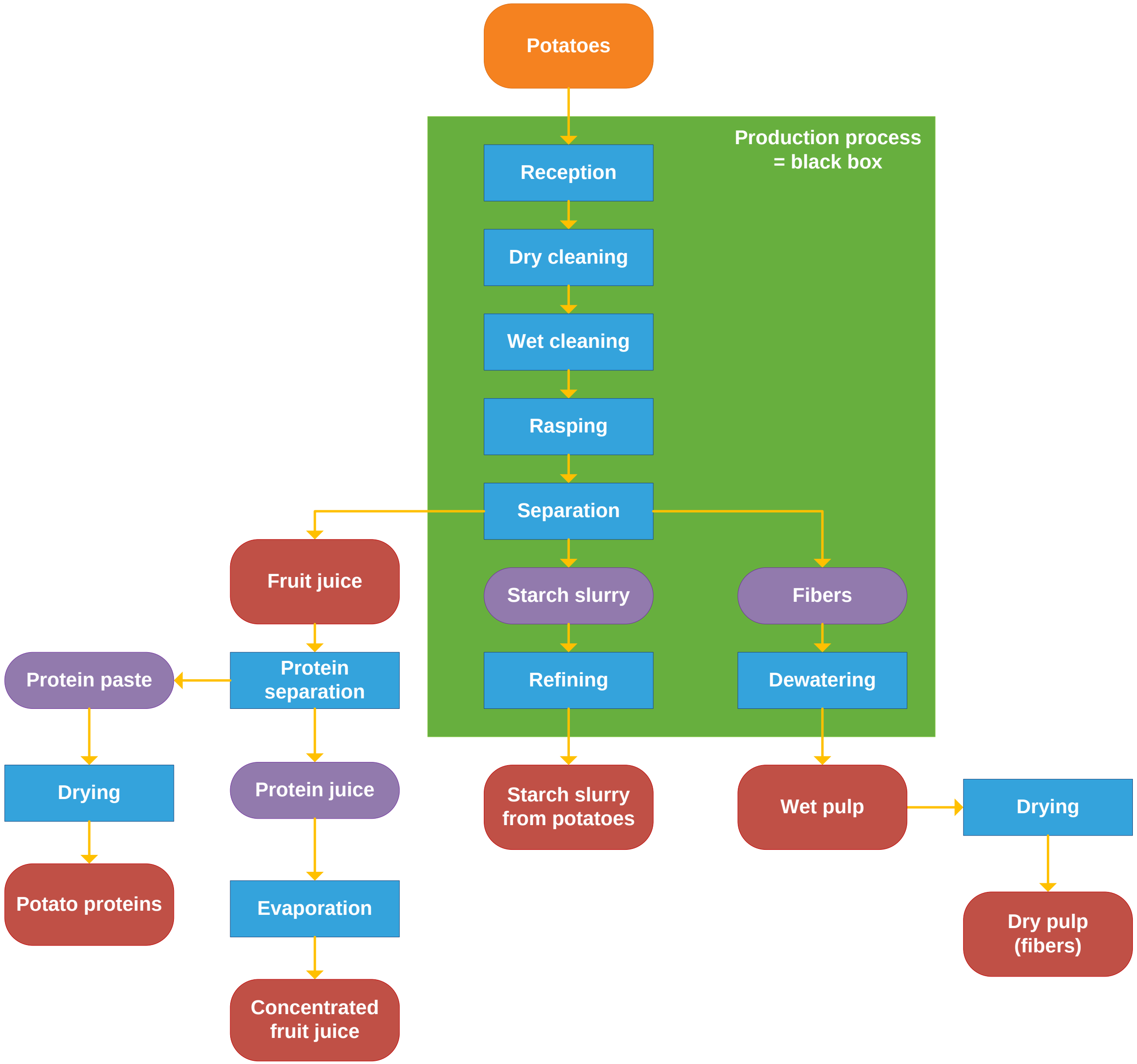
Lindfors, L.-G., K. Christiansen, L. Hoffman, Y. Virtanen, V. Juntilla, O.-J. Hansen, A. Rønning, T. Ekvall & G. Finnveden (1995). Nordic guidelines on life-cycle assessment. Nordic Council of Ministers, Copenhagen, Denmark.

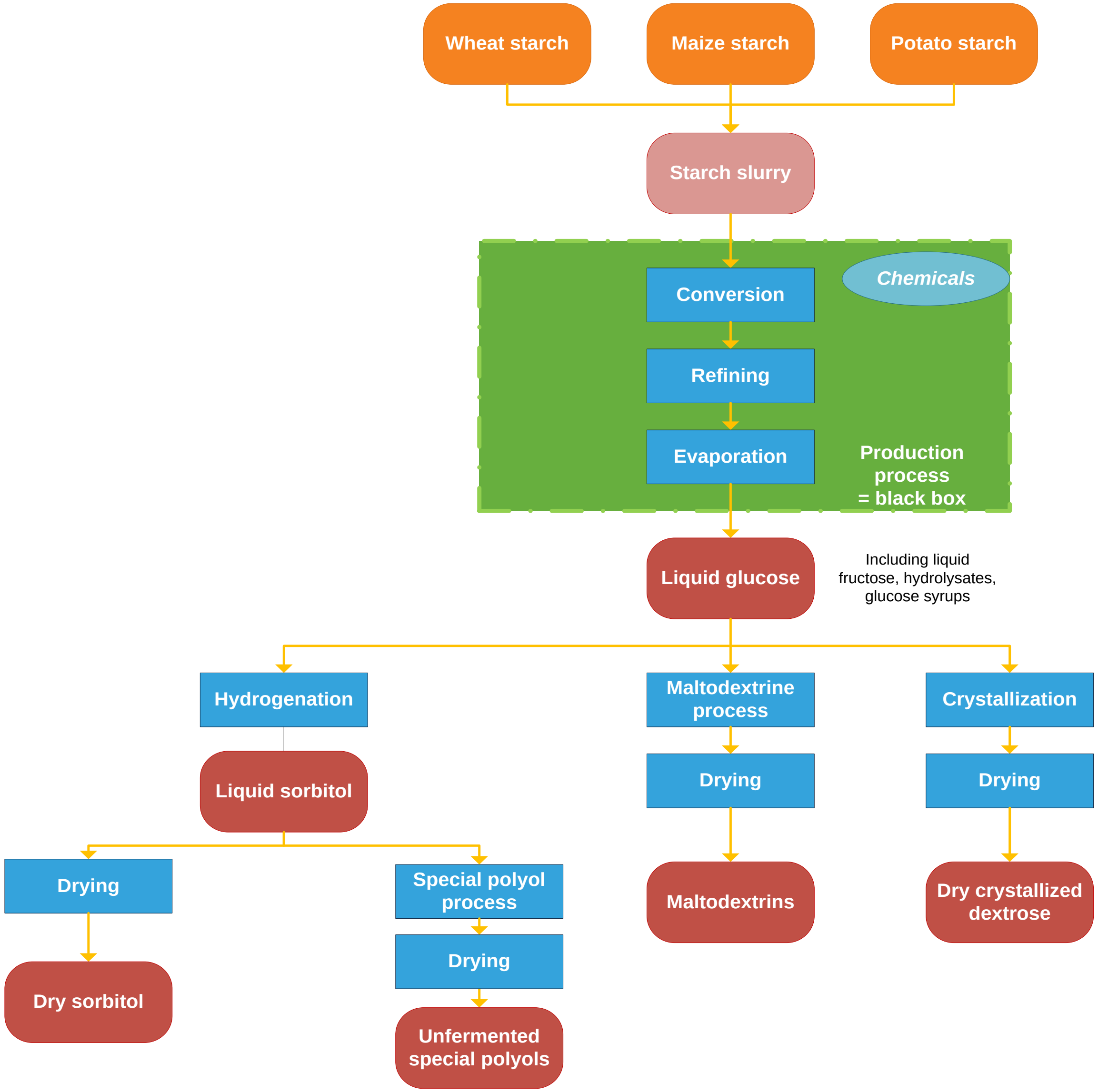
ANNEX A: PROCESS TREES

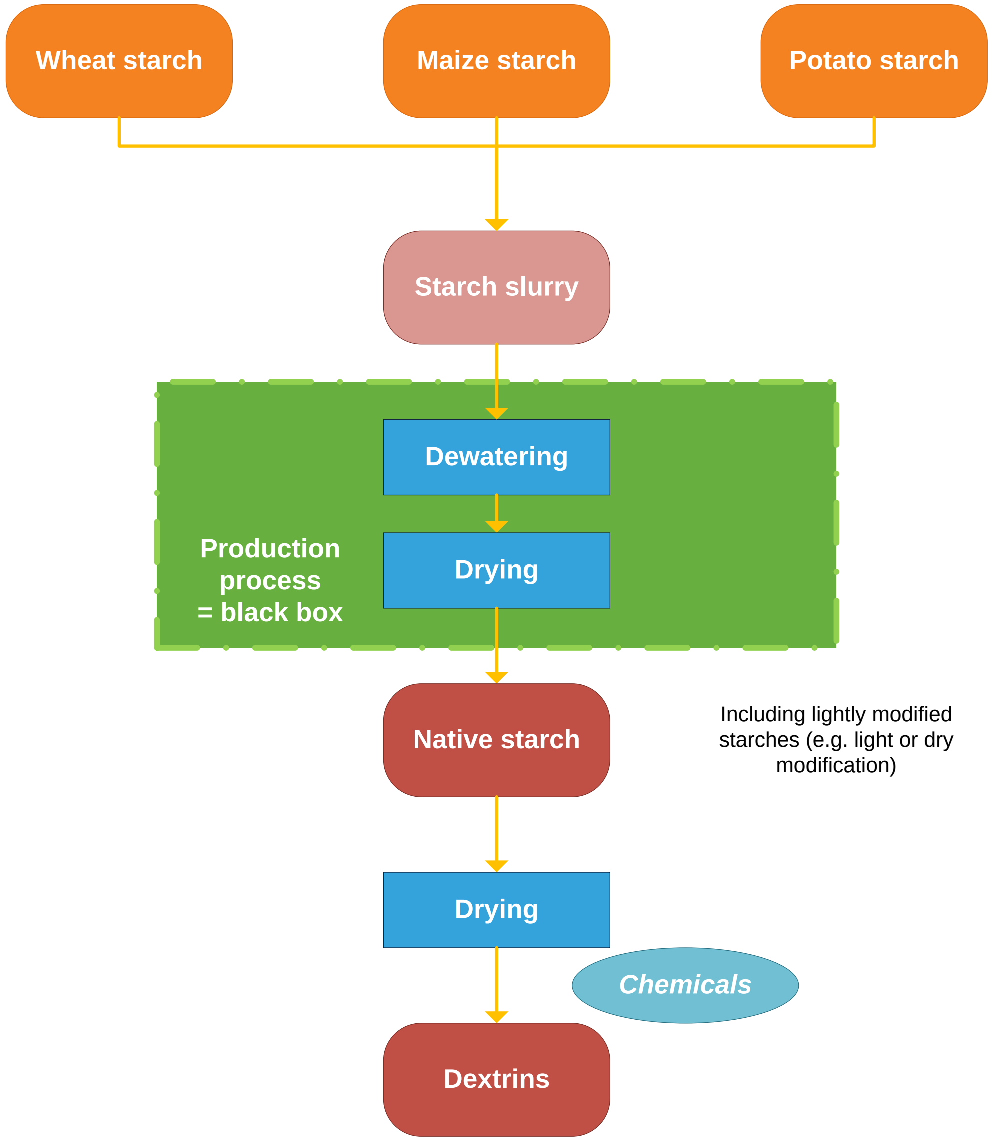


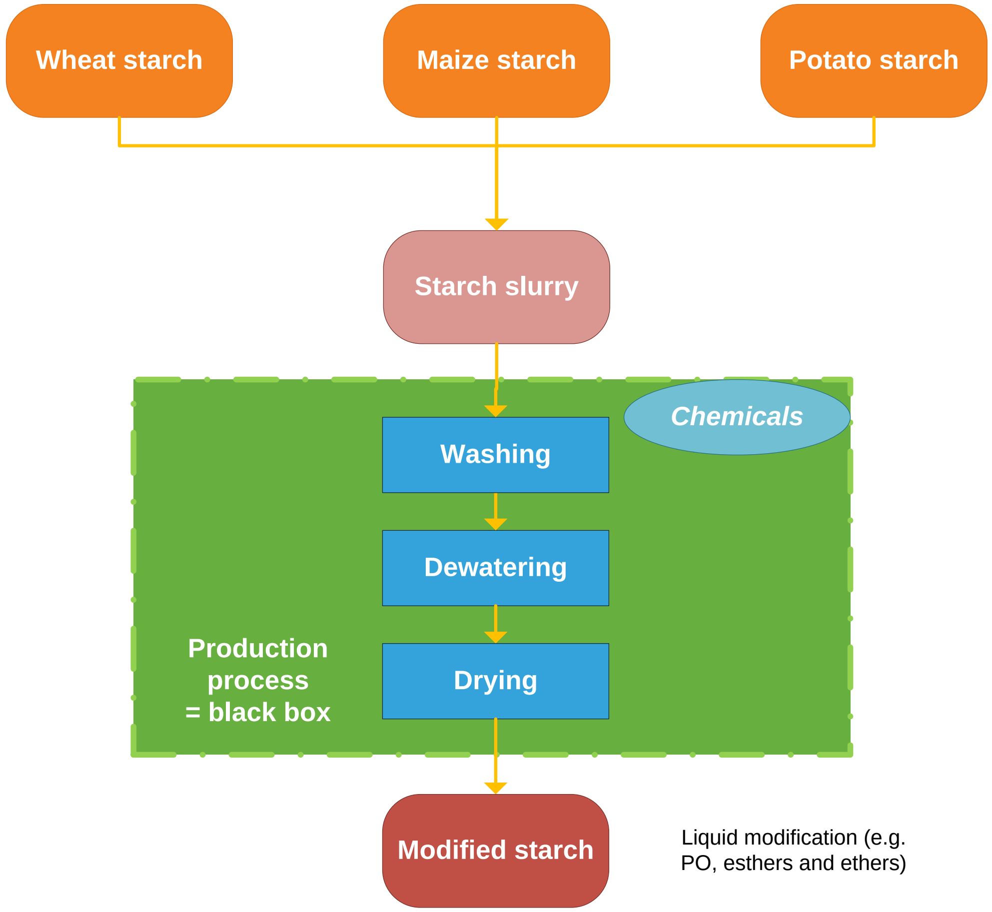


Maize
Reception
Production process
= black box
Dry cleaning
Corn steep
liquor
Evaporation
Liquid steep
liquor
Steeping
First grinding
Degerminating
Germs
Second
grinding
Dewatering
Drying
Drying
Fibers
Sieving
Dry germs
Pressing
Dry corn feed
Separation
Oil
Dewatering
Starch
Proteins
Dewatering
Drying
Refining
(washing)
Wet corn fibers
Dry proteins
Starch slurry
from maize

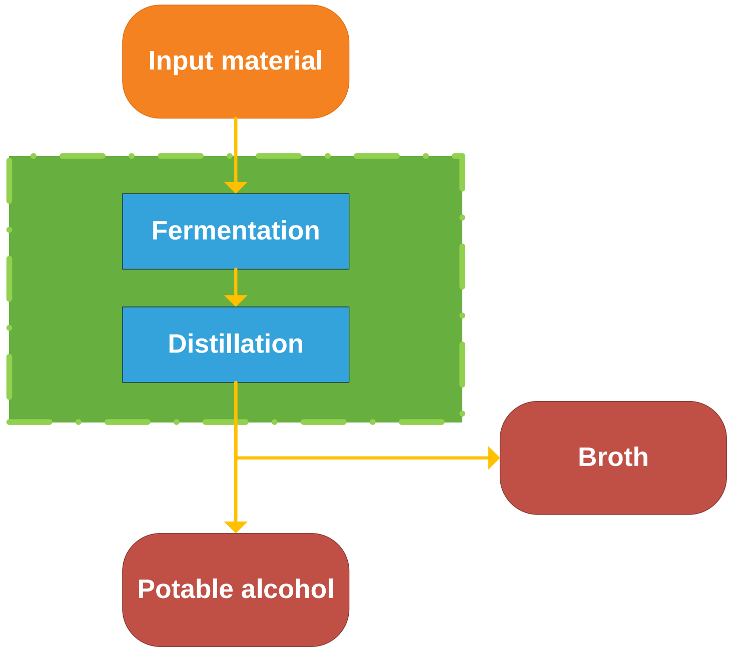

Potatoes
Production process
= black box
Reception
Dry cleaning
Wet cleaning
Rasping
Separation
Fruit juice
Starch slurry
Fibers
Protein paste
Protein separation
Refining
Dewatering
Drying
Protein juice
Starch slurry from potatoes
Wet pulp
Drying
Potato proteins
Evaporation
Dry pulp (fibers)
Concentrated fruit juice


Wheat starch
Maize starch
Potato starch
Starch slurry
Conversion
Chemicals
Refining
Evaporation
Production process = black box
Liquid glucose
Including liquid fructose, hydrolysates, glucose syrups
Hydrogenation
Maltodextrine process
Crystallization
Liquid sorbitol
Drying
Drying
Maltodextrins
Dry crystallized dextrose
Drying
Special polyol process
Drying
Dry sorbitol
Unfermented special polyols


Wheat starch
Maize starch
Potato starch
Starch slurry
Dewatering
Production process = black box
Drying
Native starch
Including lightly modified starches (e.g. light or dry modification)
Drying
Chemicals
Dextrins



Liquid modification (e.g. PO, esthers and ethers)


Input material
Fermentation
Distillation
Broth
Potable alcohol

ANNEX B: ADDITIONAL DOCUMENTATION AND JUSTIFICATION

4.4.2. SYSTEM BOUNDARY

In the underlying LCA-study, it was demonstrated that the environmental impact of the packaging of starch industry products considered is negligible in comparison to the full environmental impact of the starch industry product itself. One of the sensitivity analyses focussed on packaging of starch. Native starch was selected for this sensitivity analysis, as it may be packed in small quantities and the impact of native starch itself is relatively small, so the packaging is likely to have a larger contribution to the environmental impact. Two different types of packaging were considered: polypropylene big bags (500 kg of starch per bag) and kraft paper bags with polyethylene film (25 kg of starch per bag). The PP big bags contributed less than 1% to the impact of native starch, the contribution of the paper bags was below 3% for all impact categories considered.

Many LCA studies exclude the impact of infrastructure/capital goods, assuming that their impact on the functional unit is small because they are used for a large time, to make a large amount of products.

Frischknecht et al. (2007) indicate that in some cases, capital goods have a large influence on the results and should be included. The systems for which capital goods should be included, when studying climate change and/or non-renewable cumulative energy demand, are: non-fossil electricity, agricultural products and processes, wooden products, transport services and waste management services. In the starch products LCA, the infrastructure related to energy production, agricultural production, transport and waste water treatment is included. For the assessment of toxic effects, Frischknecht et al. (2007) recommend that capital goods are included in any sector.

Therefore, in the LCA of the starch industry products a sensitivity analysis was done, using an approximation for the starch plant infrastructure: the sugar refinery included in the Ecoinvent v2.2 database. The contribution of this infrastructure to the total impact of the AAF starch industry products is smaller than 0,5% for all impact categories (including toxicity categories), except for resource depletion, where the impact is smaller than 3%. The Ecoinvent sugar refinery has a production capacity of 200 kt sugar per year, while the average starch plant production capacity is much higher, so the actual impact of the starch production plants may be even smaller. In the case of starch industry products, it is thus justifiable to exclude the impact of the infrastructure needed for the starch production from the analysis.

4.4.4. CRITERIA FOR THE INCLUSION OF INPUTS AND OUTPUTS

At least bulk chemicals as input flows should be included. For the LCA study, two of the participating companies provided a complete list of the chemicals they use. The total volume of bulk chemicals covered about 94% of the list (depending on the company looked at). The non-bulk chemicals can thus be excluded because: i) their volume is marginal, ii) even bulk chemicals have a relatively small impact on the environmental profiles and iii) correct info on their composition is hard to get.

4.5.3. ALLOCATION OF MATERIAL AND ENERGY FLOWS AND RELEASES

For processes where allocation is necessary (multiple input or output processes), the allocation procedure described in par. 4.3.4 of the ISO 14044 standard needs to be followed. The allocation procedure as defined in this standard is summarized as follows:

- Step 1: Wherever possible, allocation should be avoided or minimized by detailing multiple processes into two or more sub-processes, some of which can be located outside the system boundaries or by expanding the system boundaries so that inputs/outputs remain inside the system. This is called “avoiding allocation by system expansion”.
- Step 2: Where allocation can not be avoided, it should preferentially be based on causal relationships between the system inputs and outputs. These causal relationships between the flows into and out of the system may be based on physical or economic parameters.
- Step 3: Where causal relationships can not be established, allocation to different products should reflect other relationships between them. For example, it may be based on their economic value.

When performing a study on a specific starch industry product according to this PCR, allocation can usually not be avoided through subdivision or system expansion. Subdivision/disaggregation can (and should) be done up to a certain level, as some processes can be attributed to one product only. However, many production processes in the starch industry are complex and may be considered as a ‘black box’ that cannot be subdivided further (see process trees in annex A). System expansion is not useful either, as the goal of the LCA is to determine the environmental impacts per co-product, to allow companies that use only one specific starch industry product to use the results as an input for the LCA of their products. Allocation can thus not be avoided.

There has been continuous discussion amongst LCA practitioners about the choice of allocation methods. Both physical and economic allocation have benefits and drawbacks. For starch industry products, mass allocation (dry substance) was chosen as a preferred method, because it offers the clearest picture throughout the process tree, it relates directly to the functional unit, and is based on the best available data. This corresponds to the recommendation of the ISO 14040/44 standards and the ILCD Handbook, which both prefer allocation based on physical relationships.

In theory, allocation should be done based on the product characteristics at the point of allocation. Since many production processes in the starch industry are complex and considered as a ‘black box’, it is impossible to give data on that level of detail (each step in the production process). Since the physical characteristics that are relevant for the function differ per starch industry product, mass (dry substance) is considered to be the best option.
The impact of the starch slurry process is caused mainly by energy use and transport. As the impact of transport and energy use for cleaning, milling, grinding, rasping,… is directly related to the mass of the process inputs, it is logical to distribute these impacts to the outputs by mass allocation also.
Also USIPA (Union des Syndicats des Industries des Produits Amylacés et de leurs dérivés) prefers mass allocation for allocating environmental impacts over reference and by-products of the starch industry.

In case allocation can not be avoided and allocation based on an underlying physical relationship can not be done, the Envifood Protocol (version 1) and the draft LEAP guidelines state that economic allocation shall be used. However, economic allocation has some drawbacks:

- In many cases, intermediate products that come from a multi-functional process do not have a price/market value as such.
- Variability of prices does not allow monitoring of process improvements over a certain period of time. The impact of a product may vary over time without any physical changes taking place in the system. Moreover, fluctuations of market prices over time may affect the credibility of the results of the LCA study (Marvuglia et al., 2010).
- Economic values and other market signals do not adequately reflect the environmental impacts (Pelletier and Tyedmers, 2011). These authors recommend using biophysical variables as a basis for the attribution of causality. They state LCA is a biophysical accounting framework, and therefore the modeling parameters should maintain the biophysical relationships, or otherwise the resulting outcomes will lose their biophysical meaning/coherence and instead reflect existing market relationships.
- Prices can be influenced by factors other than free market mechanisms (e.g. limited supply, government interventions such as subsidies or compulsory requirements) and hence do not represent the causal relationship between customer preferences and the investigated system.
- According to the ILCD handbook, a general disadvantage of using market prices in allocation is that this assumes a positive correlation of impacts with the market price, disregarding that environmental measures such as emission reduction technologies in fact increase the production cost while reducing the environmental burden. Using the market price for allocation also leads to some degree of correlation of the environmental impact with the price of the product, what limits the meaningfulness of such environmental impact data in eco-efficiency analysis.

References

Marvuglia, A., Cellura, M. and Heijungs, R. Toward a solution of allocation in life cycle inventories: the use of least-squares techniques. International Journal of Life Cycle Assessment 15:9 (2010), 1020-1040

Pelletier, N. and Tyedmers, P. (2011). An ecological economic critique of the use of market information in life cycle assessment research. Journal of Industrial Ecology. 15(3): 342-354

Annex C: List of bulk chemicals

Acetic anhydride
Adipic acid
Ammonia
Antifoam
Biocide
Calcium chloride
Calcium hydroxide
Cationic reagent
CIP detergent
Diatomaceous earth
Dichloropropanol
Enzymes
Food-grade silicone emulsion
Hydrochloric acid
Hydrogen peroxide
Hypochloric acid
Ionex resins
Liquid hydrogen
Liquid nitrogen
Nitric acid
n-octenyl succinic anhydride
Peracetic acid
Phosphoric acid
Phosphoroxychloride
Potash soda
Potassium permanganate
Preservative (organic acid)
Propionic acid
Propylene oxide
Salts, buffers
Sodium bisulphate
Sodium bisulphite
Sodium carbonate
Sodium chloride
Sodium hydroxide
Sodium hypochlorite
Sodium metabisulphite
Sodium sulphate
Sulphur dioxide
Sulphuric acid
Vegetable oil