Eco-profiles program and methodology
PlasticsEurope
Version 3.1 (September 2022)

PlasticsEurope
Association of Plastics Manufacturers

Version 3.0 (2019)

This updated version of the PlasticsEurope Eco-profile program and methodology document is the successor of version 2.0 of April 2011 and comprises

- Simplifications for a better readability
- Simplification of the specification of the eco-profile reports
- New organisation and role of the Life Cycle Thinking and Sustainability working group of PlasticsEurope
- Management of the program according to PlasticsEurope voluntary commitment
- Specifications of the water inventory
- Specifications of the background chemical datasets and of the steam cracker allocation
- Adaptations to the LCA context evolution

Version 3.1 (2022)

This version updates in section 4 the revision period of eco-profiles.

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1. Introduction

In this document 'shall' means a requirement, 'should' a recommendation and 'may' a possibility.

Since 1993, PlasticsEurope, the association of European plastics manufacturers, has continuously updated and published eco-profiles (Life Cycle Inventories) from assembled data of the process operated by its member companies; producing polymers before their transformation into finished or semi-finished products.

The program management and consistency is ensured by The Life Cycle Thinking and Sustainability working group of PlasticsEurope, composed of experts of its member companies

Eco-profile data and reports are freely available on PlasticsEurope website.

https://www.plasticseurope.org/en/resources/market-data

They generally can be found too in their aggregated form in the most popular databases (for example, Simapro Industrial database, Gabi, Open LCA..) and they can be found, when there is no confidentiality issue, in an adapted disaggregated form in database like Ecoinvent, the European Footprint compliant database.

They are representative of average European production according to the membership of PlasticsEurope.

The declared unit is 1 kg of unpacked polymer resin (or, reactive precursor) »at gate« (production site output).

Comparing eco-profiles (between themselves or with other materials) at the level of 1 kg is meaningless, but they are indispensable building block dataset enabling Life Cycle Assessment of products using polymers.

The objectives of the eco-profile program are to

- enable internal company benchmarking to the eco-profile average in order to foster environmental improvement
- enable polymer value chain users to practice eco-design with plastics
- support the development of Life Cycle Analysis to enable knowledgeable decisions regarding circular economy, sustainable development, waste treatment options…

Additionally, this program is open to associated organisations of downstream users and related industries: feedstocks (fossil or bio-based), additives, compounding, conversion into semi-finished product (sheet, film…), recycled polymers….
The eco-profile methodology strives to adapt to the state of the art practices in LCA. At the same time, the studies and reports strive to differentiate the change in results due to methodology from these due to the process changes, background context, or scope changes (different participating companies…) or others.

2. Roles and Responsibilities in the Eco-profile Program

The identity and contact details of the programme owner, of the data owner (if different form the programme owner), of the LCA practitioner, and of the reviewer **shall** be stated in the Eco profile reports.

Life Cycle Thinking and Sustainability working group of PlasticsEurope

This working group composed of experts from Member Companies of PlasticsEurope manages the eco-profile program, ensures its consistency and a level playing field in full respect of the competition laws.

Data Owner

Regularly, the respective Product Committee (like the Polyolefine group, the PC/BPA group, the PS group…) within PlasticsEurope is the data owner; but another industry association participating in the PlasticsEurope Eco-profile programme may also adopt this role (like CPME for the PET).

It should be carefully noted that the data ownership and the associated responsibility for the accuracy and integrity of the dataset remains with the original data owner, even if the dataset is included in a third-party database or otherwise reproduced, in particular through electronic media. However, the data ownership and the associated responsibility cease where ownership is formally transferred (by contract), or where a third part modifies the dataset in any way, in particular altering the life cycle inventory (LCI) entries.

LCA Practitioner and Dataset Developer

The LCA practitioner and dataset developer is a qualified expert and will usually be an LCA consultant or similar service provider. He is responsible for the data collection under a confidential agreement and procedure with each company involved, and for the preparation of the dataset and all deliverables (report, electronic datasets).

Programme Owner

The programme owner is PlasticsEurope through its Life Cycle Thinking and Sustainability working group and ensure consistency of the eco-profiles, level playing filled and pro-active absolute respect of competition laws.

Reviewer

The reviewer is and expert externally independent from the LCA practitioner and from PlasticsEurope.

3. Purpose of this Document

This document has been prepared in accordance with ISO14040/44

Its purpose is:

- to provide specifications (written as **p**) and information to the LCA practitioner in charge to carry out the eco-profiles for establishing as far as reasonably possible consistancy over the whole program

- to provide infomation to stakeholders for their good and knowledgeable use of eco-profile datasets

4. Program management and update process

The initial creation of a new eco-profile generally comprises a data collection when the manufacturing process are operated by PlasticsEurope members. When it is not the case; like for example the steam cracker operation, primary data (LCI entries) may be based on the LCA practioner own development.

The eco-profile update should be processed every 5 years according to the following steps:

- The LCA practitioner having made the current version of the eco-profile sends to PlasticsEurope the list of companies having participated and the sites involved in the data collection
- PlasticsEurope and the Product group check the possible changes in the scope (company and sites changes, PlasticsEurope membership changes…)
- PlasticsEurope and the Product group check if manufacturing chain has significantly changed (technology, chemical routes, feedstock, efficiency…) to justify a new data collection
- If yes the LCA practitioner sends to all companies their data which was collected three each ago, through peer-to-peer confidential agreement and call for an update of these data.
- If not the LCA practitioner run an update of the eco-profile based on the update of the background dataset (update of datasets of energy, raw materials, and other LCI entry)
- In between a partial data collection may be conducted, for example on water input only to fill a gap (no data collection in the current version) or based on relevance (input having change significantly and having a relevant impact on the eco-profile)

The option of a full new data collection from sites, a partial one, or an update of background data only **shall** be documented in the eco-profile report.

5. Goal & Scope

Eco-profiles (LCIs) from this programme are intended to be used as »cradle-to-gate« building blocks of life cycle assessment (LCA) of defined applications or products using polymers.

It is essential to remind that comparisons cannot be made at the level of the polymer or its precursors.

Comparisons can only be made through LCAs applied at the level of a product using these different materials as different options on the basis of the same functional unit of this product.

Eco-profiles are intended for use by the following target audiences:

- member companies, to support product-orientated environmental management and continuous improvement of production processes (benchmarking);
- downstream users of plastics, as a building block of life cycle assessment (LCA) studies of plastics applications and products; and
- other interested parties, as a source of life cycle information.

Product Description

The product to be declared **shall** be clearly stated, e.g. by polymer family name, and if possible IUPAC name, CAS number. The main production steps **shall** be visualised in a flow diagram. The main applications of the product **shall** be described.

Producer Description

PlasticsEurope Eco-profiles represent European industry average production.

They are generally based on a data collection of the processes operated by participating companies. In that case, to ensure absolute respect of competition law, a minimum of 3 sites is necessary. In some cases, for example when chemical process use different technology and raw material to make the same studied product, the minimum number can be higher.

The participating companies to a data collection **shall** be listed.

The representativeness of the European production **shall** then be estimated and mentioned in the report. The volume of production of the participating sites as well as their total are confidential data only known by the LCA practitioner. Oppositely, the capacity of production is public data although it is difficult to find out and it is generally provided by the data owners. Thus the representativeness of the European production can be estimated by dividing the total production (confidential) or the total capacity of the participating companies (to the data collection) over the total European capacity.

In some cases, Eco-profiles are not based on a data collection from participating companies but from a “representative model”, generally developed by the LCA practitioner, and publicly available average European data (average feedstock, average product mix, average energy consumption or emitted substances). It is for example the case of the steam cracker eco-profile.

6. System Boundaries

General Considerations

As a general rule, the selection of LCI system boundaries **shall** reflect the goal of the production process. This may require careful deliberation because usually polymers and precursors are manufactured in integrated production sites along with a wide variety of other products and co-products. The interdependence of processes and the interchange of substance flows implies a certain complexity (cf. Figure 1).

Two basic cases of system boundaries can occur:

- By default, PlasticsEurope Eco-profiles refer to the **production of polymers or precursors** and are based on a **cradle-to-gate system**. The production stage covers all life cycle processes from extraction of natural resources, up to the point where the product is ready for transportation to the customer. Packaging of the material is not included. The use phase and end-of-life management are not included in the cradle-to-gate information module.
- However, some process may be reported as **gate-to-gate** Eco-profiles, i.e. conversion process may be reported as a module with inputs of monomers/polymers and process energy, among others.

System boundaries generally include:

- Polymer (or monomer) production: named foreground processes, generally included in data collection. The granularity of the foreground process should be as detailed as possible in correspondence to operations for which data are available.
- Raw materials, additives and energy: named background process, generally modelled by using datasets from third-party databases, or preferably if available from PlasticsEurope eco-profiles

Capital, i.e. the construction of plant and equipment as well as the maintenance of plants, vehicles and machinery although irrelevant regarding total energy use and greenhouse gas emission, may be included, for example to get compliant with the requirements of the European environmental footprint database.

The end-of-life management of plastics is outside the LCI system boundaries of Eco-profiles for the production of polymers and precursors.

The system boundaries **shall** be transparently documented in a flowchart of the process, showing the foreground part, corresponding most of the time to the polymer or monomer production, from which the data collection if any takes place, and the background part composed of dataset from commercial databases (like the inventory for electricity, process water, raw materials…).

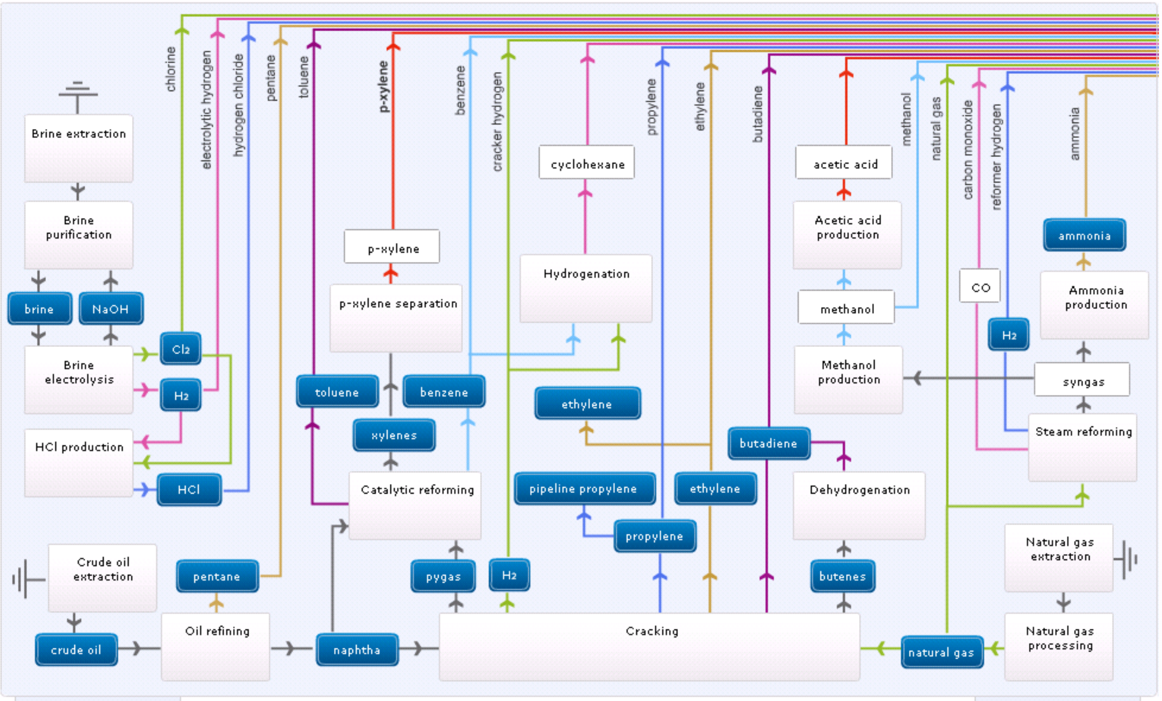


Figure 1: *Sample illustration of system boundaries and interconnected processes in the chemical and plastics industry (source: PlasticsEurope website)*

Technological Reference and Coverage

The LCI data **shall** represent technology in use, and employed by the participating producers.

Time-related Reference and Coverage

The Eco-profile report **shall** state –

- the time period for which the LCI data was collected,
- the reference period, i.e. usually the reference year, and

All LCI data should be collected as 12 month averages; exceptions **shall** be justified.

Geographical Reference and Coverage

Eco-profiles refer to a European average, as defined by the respective locations of sites participating in the LCI data collection. In any other case, the geographic location of the production sites included in the calculation of LCI data **shall** be recorded and justified.

LCI data describing the direct inputs and outputs of foreground processes (resin production) **shall** be representative of the defined production region.

7. Cut-off Rules

The LCI data collection for Eco-profiles **shall** aim for completeness – a closed mass and energy balance – and avoid cut-offs altogether. Where quantitative data are available, they **shall** be included.

However, no undue effort should be spent on developing data of negligible significance concerning environmental effects. Where elementary flows are unknown or no quantitative data are available, the following minimum criteria **shall** guide Eco-profile data collection:

- Include all material inputs that have a cumulative total of at least 98% of the total **mass** inputs to the unit process;
- Include all material inputs that have a cumulative total of at least 98% of total **energy** inputs to the unit process; and
- Include any material, no matter how small its mass or energy contribution, that has significant effects in its extraction, manufacture, use or disposal, is highly toxic, or is classified as hazardous waste (**environmental significance**).

Cut-offs may become necessary in cases where no data are available, where elementary flows are very small (below quantification limit), or where the level of effort required to close data gaps and to achieve an acceptable result becomes prohibitive.

Flows that are cut off, estimated, or substituted **shall** be recorded in qualitative and quantitative terms, and the omission **shall** be examined and justified, if applicable, by a sensitivity analysis considering –

- **Mass**: percentage of total input or output mass flows, respectively;
- **Energy**: percentage of total input or output energy flows, respectively;
- **Cost**: percentage of market value;
- **Environmental significance**: percentage contribution to relevant impact indicators.

8. Data Quality Requirements

Data Sources and Types of Data

Individual plants at each step of the production chain may be supplied with varying feedstocks, depending on production circumstances, geography, etc. Consequently, outputs are often not traceable to single inputs, and material specification typically occurs in general terms and is not supplier specific.

Eco-profiles developed by PlasticsEurope use average data representative of the respective foreground process (usually a polymer resin production), both in terms of technology and market share. The primary data **shall** be derived from site specific information for processes under operational control supplied by the participating member companies of PlasticsEurope. Secondary data may be derived from generic datasets for background processes, or to close data gaps.

In the course of the data collection and research, the type of data (by source) **shall** be noted as follows:

- Primary data –
  - Measured (e.g. accounting or analytical data);
  - Calculated (e.g. using stoichiometric relations or emission factors);
  - Estimated (e.g. expert judgment);
- Secondary data (e.g. literature, third-party database).

Data Quality Indicators

Data quality should be assessed considering the following requirements (Table 1):

- Technological, temporal, and geographical coverage (with regard to goal and scope, see 5);
- Relevance, representativeness and consistency (with regard to goal and scope);
- Completeness (e.g. by noting omitted or substituted flows);
- Precision and accuracy (e.g. by providing a confidence range);
- Data sources, reliability and uncertainty (e.g. ranging from verified measurement to non-qualified estimate).

In order to assess accuracy, specifically where estimates or substitutes are used, a **sensitivity analysis** should be conducted as follows: each data item is doubled and halved, then checking whether the final impact assessment for the product system being modelled varies by less than 5%, in which case the approximate values can be used – where the variation is greater than 5% further investigation of this parameter **shall** be undertaken.

The LCA practitioner **shall** address each of the requirements as per Table 1 in the Eco-profile report. The electronic ILCD format also requires that these criteria be reported.

These data quality criteria **shall** then be checked and confirmed in the external review of the Eco-profile report and dataset. Based on the outcome, the reviewer can assign data quality indicators (DQI) to the dataset.

Table 1: Requirements for data quality (source: UNEP/SETAC LCA Guidance 2011, in publication)

Requirement	**Description (as per ISO 14040–44 as far as applicable)**
Technological coverage	Specific technology or technology mix for which data was collected
Time-related coverage	Age of data and the minimum length of time over which data was collected; additionally the expected temporal validity of the dataset
Geographical coverage	Geographical area from which data for unit processes was collected
Relevance and representativeness	Qualitative assessment of the degree to which the data set reflects the true population of interest (i.e., geographical coverage, temporal and technology coverage).
Consistency	Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis.
Reproducibility	Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study.
Precision and accuracy	Measure of the variability of the data values for each data expressed (e.g., variance).
Completeness	Percentage of flows measured or estimated.
Data sources	Documentation of the data origins.
Reliability and uncertainty	Uncertainty of the information (e.g. data, models and assumptions).

Nomenclature of Elementary Flows

LCI **Shall** be reported according to the last version of the ICLD format at the publication date.

9. Collection of Primary or Foreground Data

Primary or foreground data comprises all data concerning processes under operational control of the respective producer. They are strictly confidential information and hence subject to the non-disclosure agreement between the data provider (company) and the dataset developer.

The dataset developer is required to keep these records for a minimum of ten (10) years.

Upon request, the dataset developer **shall** make the anonymised records available to the reviewer.

Most of the information can be derived from existing plant records. Few companies have the resources available to carry out new measurements on their plants, but usually the monitoring of plants is sufficiently detailed. There may yet be cases where data are from different sources (e.g. calculated as opposed to measured) or data gaps need to be closed by estimates.

Data Collection Conventions

The following conventions apply to data collection:

- **Units** — SI units are used throughout the Eco-profiles and EPD (or any report submitted to the verifier). Hence, data should be collected in SI units if at all possible, keeping unit conversions and the associated error potentials to a minimum.

- **Calorific values** — Gaseous fuels are commonly recorded in terms of their energy content – indeed natural gas fuel is sold by energy content rather than mass. Similarly exchanges of fuels internally are often recorded by energy content. Eco-profiles should record gross calorific values (upper heating value); alternatively, the net calorific value (lower heating value) of the water-free resource could be specified. In any case, the reference **shall** be clearly stated because the difference between gross and net calorific value can cause substantial errors in calculation. Additionally, the mass flow should be provided as well, if at all possible.

Data Collection for Waste Streams

It should be noted that, in accordance with the rules in the *ILCD* handbook, the final LCI dataset must not include any waste streams for treatment, but only final deposits released into the environment. Therefore, for all waste streams recorded during data collection the intended waste treatment **shall** be mentioned. In the course of the LCI modelling, all waste streams **shall** be assigned to the applicable waste treatment systems accordingly.

Data Collection in Practice

In preparation of the LCI data collection, a meeting should be held with participating companies including a knowledge-building session in order to raise awareness about the procedures and success factors of the exercise.

The LCA practitioner will usually employ a spreadsheet-based questionnaire which is distributed to the participating member companies. To this aim, a generic questionnaire template could be developed which should contain default substance flow names as per the ILCD handbook, accommodate data entry in varying units (drop-down to select unit), offer automatic conversion to metric standard units (e.g. tonnes to kg), and ensure a base-level plausibility by restricting numerical entries to reasonable ranges.

The following requirements for data quality should guide the data collection:

- Direct measured data should be preferred over inferred or estimated data;

- Locally appropriate data should be preferred over data from remote sources;
- Data for identical processes should be preferred over data from analogous processes;
- Recent data should be preferred over older data;
- At last resort estimated data should be used until the mass and energy balance for the process is complete.

Any deviation should be documented.

Data Gaps and Overseas Production

Gaps in primary datasets may occur, for instance, because of –

- Lack of emission data for a given unit process;
- Use of imported materials (overseas production);
- Use of third-party waste management or wastewater treatment processes, or;
- Products or processes otherwise outside the operational control of the data provider.

In such cases, the data gap should be addressed by secondary data. This substitution **shall** be recorded and commented upon.

In cases where region-appropriate LCI data for imported materials and non-domestic processes (overseas production) would not be available they could be modelled as a proxy, by adapting data representative of the European production. For example, by adjusting transportation distances and modes, electricity generation fuel mix, calorific value and emission profile of solid fuel resources etc. Where such adaptations are undertaken it **shall** be clearly recorded that the inventories are based on European production data and are not actual inventories for imported production.

10. Use of Secondary or Background Data

Secondary or background data concern processes either outside the operational control of the respective producer or for which primary data are not available at a feasible effort (like LCI datasets representative of the used raw materials, the used grid electricity mix transport, the used transport, infrastructure, on-site wastewater…)

Such generic datasets can be derived from publicly available or commercial LCI databases should comply with quality requirements set out in the ILCD handbook

The selected generic dataset needs **shall** be recorded and reported.

Background chemical datasets harmonisation along the eco-profile program

The LCA practitioner **shall** identify the relevant background chemical datasets and check with the program owner if these are also used and relevant for another eco-profile. (See annex 1).

If this is the case, the possibilities of harmonisation will be considered to the extent of a reasonable feasibility.

In case these relevant background chemicals are issued from the steam cracker, the allocation as recommended by PlasticsEurope for the sake of comparability will be applied (See annex 2)

Modelling Intermediates and Ancillary Polymer Production Processes

Data for intermediates and ancillary polymer production processes should be taken from the PlasticsEurope Eco-profile database, where available.

Note that the use of generic datasets is an option, not an obligation: indeed there may be reasons to use proprietary datasets, for example, for intermediates like syn-gas or chlorine which are specific to a production site. As above, where possible, a comparison with the respective benchmarks should be conducted.

Modelling Energy Supply

The energy supply **shall** be modelled on a site-specific basis. If direct energy supply is derived from one source, then this should be used, and where energy is taken from a national or regional grid, then this **shall** be modelled specifically for the specified geographic region.

Generic data for energy can be obtained from the database of the *International Energy Agency IEA*[1].

When accounting for renewable energy or carbon offsets, appropriate quality standards **shall** be taken into consideration. In any case, credits must be reported as distinct line items, and off-set emissions must not be included in the LCI datasets.

[1] IEA Website: www.iea.org (energy information centre).

11. Calculation Rules

Vertical Averaging aggregated datasets

When modelling and calculating average Eco-profiles from the collected individual LCI datasets, vertical averages **shall** be calculated (**Error! Reference source not found.**). Vertical averaging involves combining a sequence of Unit Process Inventories (UPI), or sometimes aggregated processes, which are linked by a reference flows (see definition in ISO14040/4), e.g. precursors or intermediates. Vertical aggregation also means that data are first calculated separately for each production chain, and only then an average is calculated, weighted by the production tonnage of each chain.

By contrast, horizontal averaging (**Error! Reference source not found.**) implies aggregating multiple UPI or aggregated processes each supplying the same reference flow. Horizontal averages may in some cases be useful to handle data gaps or for benchmarking purposes. However, utmost care needs to be taken that the operations thus included in the average are indeed consistent; further, the horizontally averaged performance may not represent a real system due to interdependencies between operations.

The sub-system boundaries for the production chains to be vertically averaged should be set in such way as to avoid allocation as far as possible. They **shall** take into account a sufficient number of representative site-specific production routes. The datasets obtained by vertical averaging aim at being the most faithful representation of the industrial reality reflecting the integration within production sites and industrial networks as captured at the time of the eco-profile study,

In practice, Eco-profiles will often use a hybrid of vertical and horizontal averages in that intermediates may constitute a reasonable sub-system boundary. Therefore, wherever possible and useful, meaningful intermediates can also be reported as »partial-chain«, or modular, Eco-profiles.

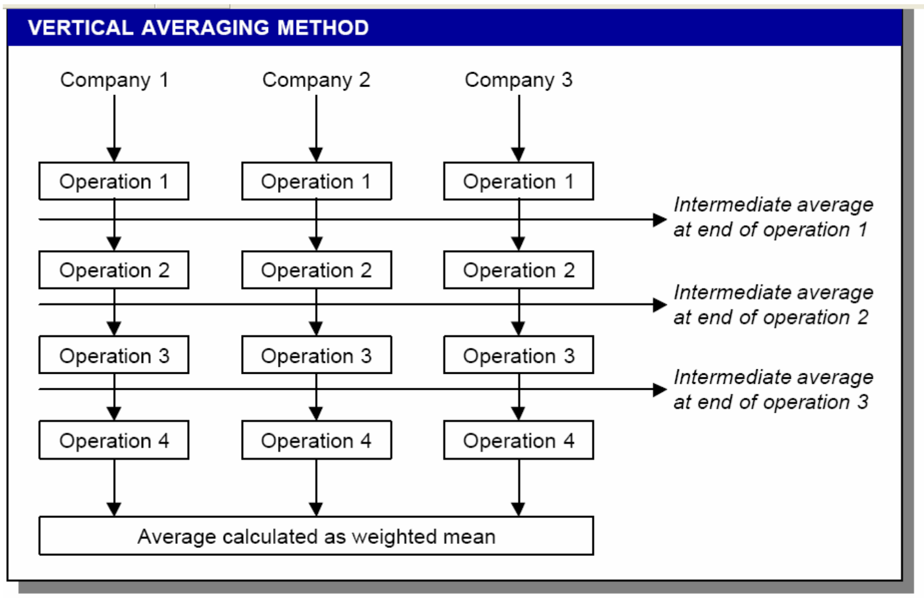
Disaggregated information

In order to adapt the eco-profiles based on data collection of participating companies, to database like the European Environmental Footprint compliant database, or the Ecoinvent database, average inputs and outputs to the foreground system (raw material, energy, direct emissions **shall** be delivered to the data owner and programme owner), on the strict condition that they are calculated from a minimum of 3 companies,. In some cases, this minimum can be decided higher, as a precaution to ensure full respect for competition laws. This may be an impediment to disaggregation for example for technical polymers which do not have enough participating sites, or use different technologies with different inputs/outputs. Even for commodity polymers comprising many plants, it may be an impediment to regionalize some of the inputs like water, electricity. On the top of that, averaging inputs implies that small chemicals, often specific to each site or company, are turned into a generic chemical input or neglected.

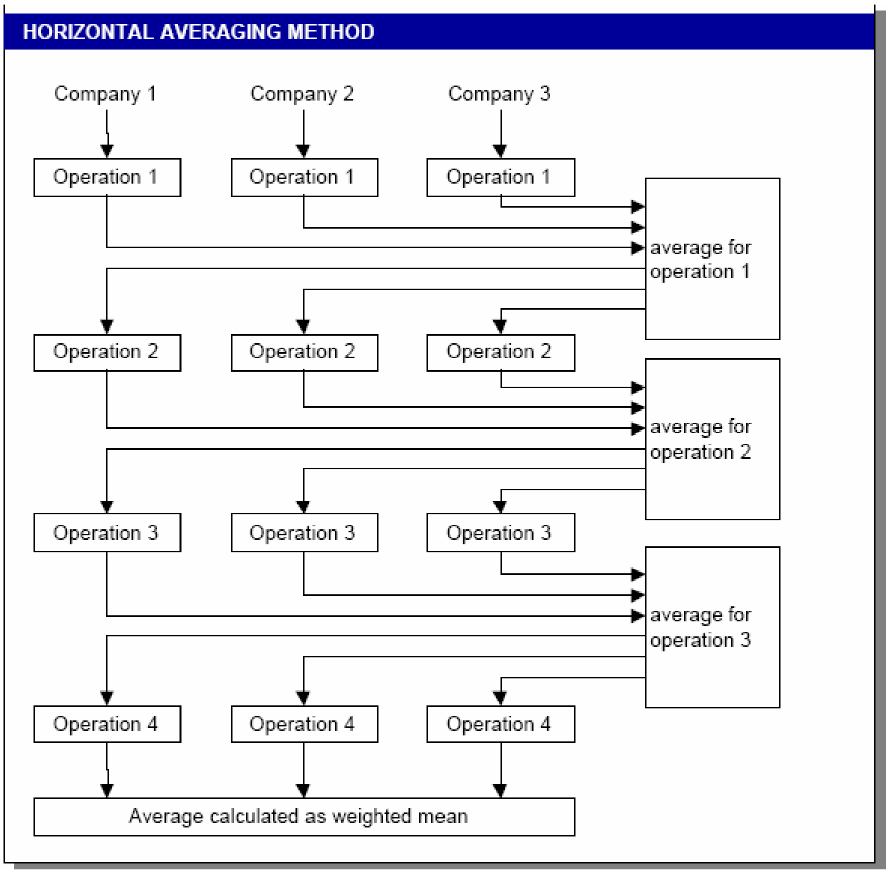
Due to these adaptations, and to the fact that the foreground process will be most likely connected to different secondary datasets used in the new host database than the one used in the aggregated eco-profile published by PlasticsEurope, the result of LCI will be per se different, which could have a strong effect on some indicators.

When getting disaggregated data, LCA practitioners, as a current practice, may on purpose change input and output values, change they representativeness (geographical, temporal, technological), for example to adapt the original dataset as a proxy to other situations, or to test some different background context. These changes are operated under the responsibility of LCA practitioners, and should be documented, particularly when the new changed datasets are published.

In all cases, academic researchers and practitioners are welcomed to contact PlasticsEurope in case of further needs, to consider the possibility and conditions for delivering more information.



Vertical Averaging



Horizontal Averaging

Interchange of Hydrocarbon Fuels

Frequently waste hydrocarbon products from one process are exported for use as fuels to another, but totally unrelated, process elsewhere on the site. Often, the chemical composition of these fuels is unknown, as is their calorific value, which may, in any case, vary with time depending on the types of waste produced. In such cases, the following procedure **shall** be used:

- When the precise calorific value of the »unknown« hydrocarbon is not known, it is assigned an arbitrary value of 40 MJ/kg. It is therefore necessary to examine the sensitivity of the final result to this value.
- When such by-product fuels are subsequently burned, the combustion emissions are assumed as for heavy fuel oil combustion.

12. Allocation Rules

Production processes in chemical and plastics industry are usually multi-functional systems, i.e. they have not one, but several valuable product and co-product outputs. Wherever possible, allocation should be avoided by expanding the system to include the additional functions related to the co-products. To this aim, a generic process with the same function (product) can be introduced, and the examined system receives credits for the associated burdens avoided elsewhere (»avoidance allocation«, avoided burden). System expansion should only be used where there is a dominant, identifiable displaced product, and if there is a dominant, identifiable production path for the displaced product

Often, however, avoiding allocation is not feasible. In such cases, the aim of allocation is to find a suitable partitioning parameter so that the inputs and outputs of the system can be assigned to the specific product sub-system under consideration.

Since production systems are controlled by different strategies and allocation is always a value judgment, PlasticsEurope's stipulates the following »allocation philosophy«: from the following allocation methods the practitioner **shall** select the one most appropriate to the goal of the production system and transparently record the justification of this choice; the chosen allocation method **shall** also be noted in the meta-data

The following allocation methods are eligible options:

- **Mass or energy allocation** aims at a close representation of physical causality, i.e. the causal relationships between the inputs and outputs. The choice of partitioning parameter is meant to reflect the physical behaviour of the system as shown by mass or energy flows.

- **Stoichiometric allocation** aims at a close representation of physical causality in case of chemical transformation processes, i.e. as shown by molecular flows.

For example, in order to produce 1 kg of chlorine from an electrolytic cell, a total of 1.648 kg of rock salt (NaCl) must be fed into the cell, assuming stoichiometric performance. However, there would also be a co-product of sodium hydroxide (NaOH). Thus of the 1.648 kg of NaCl, 1.000 kg is chloride (Cl^-) which goes to produce the chlorine and 0.648 kg of sodium (Na^+) which goes to produce NaOH. Therefore the quantity of NaCl that is attributable to the chlorine product is 1 kg and not 1.648 kg.

- **Economic allocation** aims at a close representation of the economic purpose of production systems, i.e. as indicated by prices or costs.

In particular, stoichiometric and economic allocation should be considered in order to avoid inappropriate results where these are an upshot of mass allocation. In case of substantial deviation, i.e. more than 20%, between the resulting LCI or impact indicator from mass allocation and an alternative method, the influence of the choice of allocation method **shall** be addressed by a sensitivity analysis.

In principle, allocation rules should reflect the goal of the production process. Furthermore, it should be noted that allocation not only affects calculated results, but also the primary data collection in that certain elementary flows might be dropped from the outset. The same allocation method **shall** be applied consistently throughout all datasets contributing to an average.

The chosen allocation method and its rationale **shall** be recorded in the Eco-profile report. Where possible, a sensitivity analysis should be carried out to illustrate the variability in results for alternative allocation methods.

13. LCI Results

Delivery and Formats of LCI Dataset

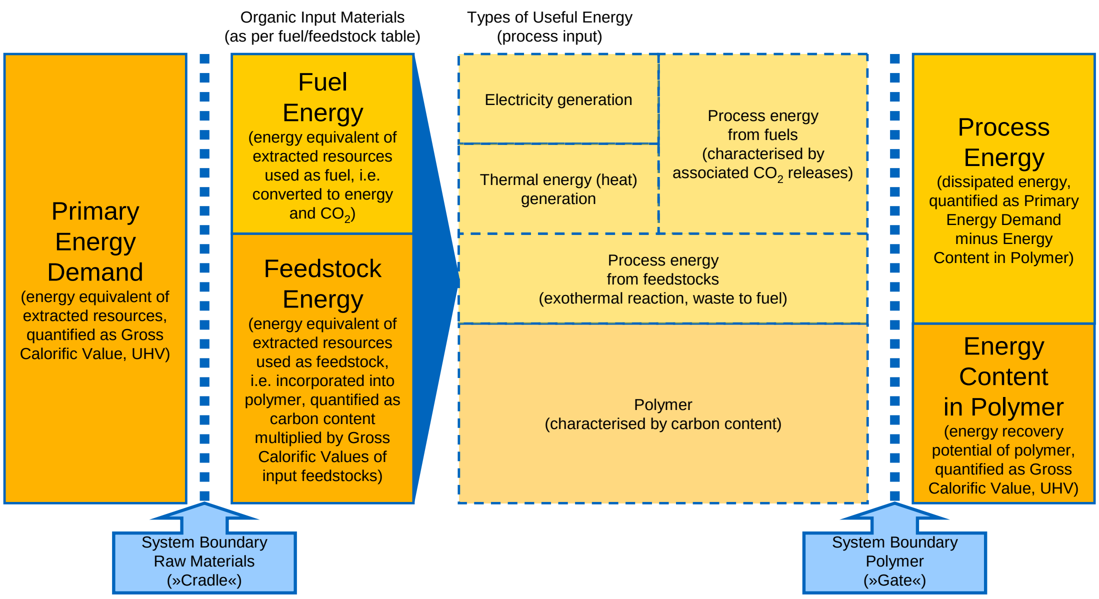
LCA practitioner **shall** deliver

- An aggregated dataset in ILCD format (https://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml) according to the last version at the date of publication of the eco-profile and including the reviewer (internal and external) input. The delivered dataset must pass the ILCD verification set up by JRC or implement by the European Commission in the frame of the Environmental Footprint.
- In case the eco-profile is based on a data collection of participating companies, average inputs and outputs to the foreground system in order to enable partial disaggregation and further adaptation of the dataset. This only (see Section 11)

  - on the strict condition that they are calculated from a minimum of 3 sites

  - on confirmation by data owner and programme owner in consideration of full respect of competition laws
- a report according to the document "eco-profile report framework V3" in a format enabling text edition

Energy Demand



Energy flow diagram showing how primary energy demand (system input) is disproportioned into fuel and feedstock energy (within system), and process energy and energy content in polymer (system output)

The above figures gives a theoretical view of the energy in chemical process.

The feedstock energy represents the share of the primary energy demand which is incorporated into the polymer, as opposed to being used as a fuel for process energy. Hence, the feedstock energy is a measure of the stoichiometric contributions to the polymer, quantified as energy resource equivalents on the input level. It is different from the energy content in the polymer, which depends only the chemical composition of the output.

Energy and mass balances can be complex. too keep it simple and useful, the LCA practitioner **shall** report:

- As a key indicator on the inventory level, the **primary energy demand** (system input) of XX MJ/kg indicating the cumulative energy requirements at the resource level, accrued along the entire process chain (system boundaries), quantified as gross calorific value (upper heating value, UHV).

- As a measure of the share of primary energy incorporated in the product, and hence indicating a recovery potential, the **energy content in the polymer** (system output, instead of feedstock energy,), quantified as gross calorific value (UHV), is XX MJ/kg,

- the difference (∆) between primary energy input and energy content in polymer output as a measure of **process energy** which may be either dissipated as waste heat or recovered for use within the system boundaries.(Useful energy flows leaving the system boundaries were removed during allocation).

Primary energy demand (system boundary level) per 1kg Polymer

Primary Energy Demand	**Value [MJ]**
Energy content in polymer (energy recovery potential, quantified as gross calorific value of polymer)	
Process energy (quantified as difference between primary energy demand and energy content of polymer)	
Total primary energy demand	

Water Consumption

In a chemical plant, for a good management of water, it is interesting to identify all the water flow inputs, their origin (lake, river, public supply, underground…), their treatment (process water), how and where the water is employed, all the outputs and their treatment if any (back to the river, evaporated, in the public sewage network, in the product…). Improvement action plans base on this knowledge.

Here is a list of possible water flows that can be found in a plant. Most of the time, cooling towers (item 2 of the list below) dominates water use and consumption inventory. But it is not always the case, and sometimes, for example, the relative amount of water entering with raw materials (item 6 of the list below) may reveal surprisingly high.

1. Water used for open loop cooling system is withdrawn from the sea or rivers having a sufficient flow (to avoid significant perturbation). It is not treated, go once through the heat exchange system, does not enter into contact with any product, and get back to the same basin as such, with just a few degrees of temperature more. In that case, water use flows are important but the consumption according to ISO 14046 is null in normal conditions, apart from leaks and purge operations which may be negligible. Flow is often not metered but may be known thanks to the design data of the cooling system or thanks to the pump capacity. In any case, this water use flow must not be confused with the water consumption of closed looped system (see next point), which are around 10 to 20 times lower. This confusion seems to be frequent, and when using LCA dataset of similar processes but from different sources it is important to bear this order of magnitude in mind to detect possible inconsistencies.

2. Water used in closed loop cooling system, getting in open contact with air, with evaporation ensuring the removal of calories. They typically have the form of cooling towers. In these systems, the circulation flows are high (similarly to case 1 above) but the input to the plant corresponds in fact only to the top-up of the recirculating water, compensating the evaporation and the purge. The evaporated water is considered as consumption according to ISO 14046. It is in general the dominant consumption when there are cooling towers. The amount consumed could be calculated from the water treatment, generally demineralization and biocide to avoid the development of Legionellose.

3. Water used for closed loop cooling system without contact to air. As there is no evaporation the top-up of the system is much lower than in the previous case, limiting to the purge of the water held up that may be necessary to maintain operational conditions of the treated cooling water. This could be for example a secondary cooling loop, linked to a primary cooling loop (which could be of type 1 or 2 as above) The water purged out from the cooling system goes through a collection network/water treatment station (internal, external) back to the environment. It is considered consumption if the final destination basin is different from where the water was withdrawn. The amount could be calculated from the water treatment, generally demineralization and biocide to avoid the development of Legionellose, although the risk is much lower than in the open air cooling system.

4. Water used to produce steam, may be employed to heat the pipes and drums containing a product, or to enter in contact with the product like in steam cracking (see type 5). In the first case it is likely that the condensed water out from the steam trap goes through a collection network/water treatment station (internal, external) back to the environment. It is considered consumption if the destination basin is different from where the water was withdrawn. The amount can be calculated from the steam purchasing data or from the steam production facilities, taking into account the steam condensate that could be recycled.

5. Steam or water entering in contact with the product, may be separated or stay with the product put on the market (as diluter, solvent like for some paints …). In the former case, the separated water goes through a collection network/water treatment station (internal, external) back to the environment. It is considered consumption if the destination basin is different from where the water was withdrawn. The amount can be calculated from the process working conditions, from the Bill of Material, and/or from the steam purchasing data or from the steam production facilities. In the latter case, the water put on the market with the product is to be considered by default as consumption (unless it can be demonstrated that it ends up in the same basin). The amount can be calculated from the volume of production multiplied by the water content of the product

6. Water brought by raw materials, may be separated or stay with the product put on the market. In the former case, the separated water goes through a collection network/water treatment station (internal, external) back to the environment in a basin. It is a negative consumption for that basin. In the latter case, the water put on the market with the product is to be considered as ending in a different basin (unless it can be demonstrated that it ends up in the same basin). So the impact on the local basin consumption is null. The amount can be calculated from the amount of raw material purchased and its water content.

7. Water produced by a chemical reaction, may be separated or stay with the product put on the market. In the former case, the separated water goes through a collection network/water treatment station (internal, external) back to the environment in a basin. It is a negative consumption for that basin. In the

latter case, the water put on the market with the product is to be considered as ending in a different basin (unless it can be demonstrated that it ends up in the same basin). So the impact on the local basin consumption is null. The amount can be calculated from the stoichiometry of the reaction and the production volume.

8. Raining water collected by the plant area goes through a collection network/water treatment station (internal, external) back to the environment in a basin. It is interesting to know for the sake of water inventory balance, and for good management of the waste water treatment. The consumption is considered null. The amount can be estimated from local meteorological data.

9. Water for cleaning, sanitary… comes from the supply network or is part of the process water. It is a consumption if it ends up in a different basin as the one from where it was withdrawn. The amount is likely relatively small and already included in the global purchasing or production data of process water and does not need a specific calculation.

The ISO 14046 standard (1) on water footprint differentiates

- water use (2) which includes any withdrawal (abstraction as a synonymous) from any source, and corresponds to the total input water flows of the studied system (a plant, a site..)
- water consumption (2) which is the part of this withdrawal which is not returned back to the same drainage basin it is sourced from, with a level of quality enabling its further use. It may be water evaporated in cooling towers, incorporated in the product, evapo-transpirated by plants (only the water from irrigation, 4), non-sea water ending up in the sea. Note that water sourced from the sea is not part of the consumption, as it is considered unlimited.

The notion of "drainage basin" (basin in this paper) as defined in ISO 14046 (3) corresponds to large portion of territory in proportion to the surrounding of a chemical site. Thus, in most cases water input coming from river, lake, ground which is not evaporated in the atmosphere by cooling towers (or incorporated in products, or rejected in sea, which are rarely significant) will end up after use in the same basin and will not correspond to a net consumption.

This net water consumption is the input necessary to assess the water impact according to the last consensual model being developed: AWaRE (http://www.wulca-waterlca.org/); taking into account human and ecosystem needs.

It is important to bear in mind that this net water consumption according to ISO 14046 anf AWaRE is most often different from the water consumption as we use to consider it as a plant manager, or as a consumer at home, generally linked to a cost. Again, the most part of this "user consumed" water often ends up in the same basin from where it was originated and thus the ISO 14046 consumption may be null (apart from possible losses and quality degradation)

In LCA, lake and river inputs are elementary flows but public supply, underground, process water are not elementary flows but intermediate flows corresponding to more or less regionalized LCA datasets, available in databases.

Consistency of datasets form different sources regarding water is a bit challenging and one the works the LCA community strive to address.

In PlasticsEurope Eco-profiles program, we aim at collecting consistently the primary data of the foreground part:

- Total water use and the part of Total water use for cooling
- Total water consumption, and the part of total water consumed for cooling
- If meaningful, the water content in raw materials and final products

Most of the time, cooling towers (item 2 in the above list) dominates water consumption inventory. But as it is not always the case, the LCA practitioner should first screen the different flows listed above (from 1 to 9) to estimate whether they could be relatively significant. Then focus on the dominant(s) one(s) to refine their measurements.

In any case the LCA practitioner **shall** ensure to not mix the recirculating flow of item 1 (which is many a use and not a consumption apart from losses to the air) with the consumption of item 2. This has been a frequent source of inconsistency and reporting in the past, before the clarification by the ISO 14046.

(1) ISO 14046 "Environmental management — Water footprint — Principles, requirements and guide-lines "

(2) Definition according to ISO:
3.2.1
water use
use of water by human activity
Note 1 to entry: Use includes, but is not limited to, any *water withdrawal* (3.2.2), water release or other human
activities within the *drainage basin* (3.1.8) impacting water flows and/or quality, including in-stream uses such as fishing, recreation, transportation.
Note 2 to entry: The term **"water consumption"** is often used to describe water removed from, but not returned to, the same drainage basin. Water consumption can be because of evaporation, transpiration, integration into a product, or release into a different drainage basin or the sea. Change in evaporation caused by land-use change is considered water consumption (e.g. reservoir). The temporal and geographical coverage of the *water footprint assessment* (3.3.2) should be defined in the goal and scope.

(3) Definition according to ISO
3.1.8
drainage basin
area from which direct surface runoff from precipitation drains by gravity into a stream or other *water body* (3.1.7)
Note 1 to entry: The terms "watershed", "drainage area", "catchment", "catchment area" or "river basin" are
sometimes used for the concept of "drainage basin".
Note 2 to entry: Groundwater drainage basin does not necessarily correspond in area to surface drainage basin.
Note 3 to entry: The geographical resolution of a drainage basin should be determined at the goal and scope stage:

(4) Rain water. Excerpt from "Introduction to Water Assessment in GaBi Software", Thinkstep.

Rain water "refers to use of natural precipitation (green water). Typical examples are rain water use by crops or rain water harvesting plants."

The LCA practitioner **shall** report the **Foreground (gate-to-gate) water use and consumption** as below

The following table shows the weighted average values for water use of the foreground production process. For each of the typical water applications the water sources are shown.

Water use and source per 1kg of polymer

Source	Process water [kg]	Cooling water [kg]	Steam Water [kg]	Water in Raw Materials [kg]	Total [kg]
Deionized					
From River					
Relooped					
Totals					

The following table shows the further handling/processing of the water output of the PC production process.

Treatment of Water Output per 1kg of polymer

Treatment	Water Output [kg]
To WWTP	
To Sea (after WWTP)	
To River (untreated)	
Reloop to process	
Water Vapour	
Formed in reaction (to WWTP)	
Totals	

Based on the water use and output figures above the water consumption can be calculated as:

Consumtion = (water vapour + water most to the sea) – (water generated by using containing raw materials + water generated by the reactor)

The LCA practitioner **shall** report the **cradle to gate water consumption** and if possible, water use.

Dominance Analysis

The LCA Practitioner **shall** elaborate and report on the main contributors to impact, differentiating clearly the foreground and the background part.

Table : Dominance analysis of impacts per 1kg Polymer

	Total Primary Energy [MJ]	**ADP Elements [kg Sb eq.]**	**ADP Fossil [MJ]**	**GWP [kg CO_2 eq.]**	**AP [g SO_2 eq.]**	**EP [g PO_4^{3-} eq]**	**OTHER**
BACKGROUND							
Main Raw Material 1							
Main Raw material n							
Other chemicals							
FOREGROUND							
Production							
Utilities							
Electricity							
Thermal Energy							
Process was treatment							
Other as relevant							
Total	100%	100%	100%	100%	100%	100%	100%

Comparison of the present Eco-profile with its previous version

LCA practitioner **shall** elaborate and report on the main contributors differentiating clearly foreground, background, scope and methodology influence.

What are the causes of the significant differences in impacts?

- Changes in scopes (different panel of participating companies/plants)
- Changes in foreground process (different energy and/or raw material specific consumption, different feedstock and/or product mix, technology changes, abatement measures for emissions to the environment…)
- Changes in background process (changes in the energy and/or raw material profiles…)
- Changes in methodology (different allocation, different characterisation methods, …)

Cause effect will be

Explanations **shall** relates to the average only and in consideration of respect of confidentiality..

Table : *Comparison of the present Eco-profile with its previous version*

Environmental Impact Categories	**Eco-profile PC Previous (Date)**	**Eco-profile PC New**	**Difference (%)**
Gross primary energy from resources [MJ]			
Abiotic Depletion Potential (ADP), elements [kg Sb eq.]			
Abiotic Depletion Potential (ADP), fossil fuels [MJ]			
Global Warming Potential (GWP) [kg CO_2 eq.]			
Acidification Potential (AP) [g SO_2 eq.]			
Eutrophication Potential (EP) [g PO_4^{3-} eq.]			
Ozone Depletion Potential (ODP) [g CFC-11 eq.]			
Photochemical Ozone Creation Potential [g Ethene eq.]			
Others impact as relevant			

14. REVIEW

Internal Review and Plausibility Checks

First, the LCA practitioner and dataset developer **shall** conduct an internal review. This can be included in on-going quality assurance procedures. In particular, the LCA practitioner **shall** conduct plausibility checks as per ISO 14040–44, e.g. checks on units and dimensions, completeness, consistency, and sensitivity analysis etc. For further details about such checks, reference is made to the *ILCD* handbook.

Second, after submitting the preliminary Eco-profile report and calculations to the commissioner, the results of the calculations (i.e. the respective industry averages) will be discussed for further cross-checking. These measures are meant to eliminate possible errors of the primary data and data collection procedures.

Third, the LCA practitioner **shall** compare the final results with the previous version of the Eco-profile, if available, and comment on any significant changes. Interpretations and explanations **shall** be included in the Eco-profile report. This will be part of a benchmarking approach and will also provide invaluable feed-back to the member companies. The LCA practitioner should mention any known reason for significant changes between updates in order to facilitate plausibility checks and interpretation.

ISO Compliance, External Review and Critical Review

All procedures, methods and assumptions **shall** comply with the requirements set forth in ISO 14040–44.

In particular, the Eco-profile reports (LCI data collection and calculations) **shall** be prepared in an auditable way.

Before publication of the dataset an external review **should** be conducted. In particular, the reviewer should check and confirm whether the data quality requirements are met and, optionally, assign data quality indica-tors accordingly

While not mandatory as per ISO 14040–44 for non-comparative cradle-to-gate LCI datasets, the external review enhances the acceptance of PlasticsEurope Eco-profiles as best-quality datasets, may be a precon-dition for inclusion into third-party databases.

ANNEX 1

MONOMERS AND PRECURSORS TO UPSTREAM OIL AND GAS EXTRACTION

Chlorine			
Ethylene Propylene Butadiene Pygas E Oxyde MEG DEG TEG Benzene from SC Toluene from SC Xylene from SC Butene, Hydrogen	Steam Cracker	Naphta Ethane	Crude oil Natural gas
Benzene from Reformate Toluene from Reformate Xylene from Reformate	Catalytic Reformate		

POLYMERS ARBORESCENCE TO UPSTREAM MONOMERS AND PRECURSORS

LDPE	Ethylene Fuels Electricity Transport Small chemicals
LLDPE	Ethylene Butene Hexene Octene Fuels Electricity Transport Natural gas (for catalyst) Small chemicals
HDPE	Ethylene Butene Fuels

	Electricity			
	Transport			
	Natural gas (for catalyst)			
	Small chemicals			
PP	Propylene			
	Ethylene			
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
PVC	VCM			
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
VCM	Chlorine			
	Ethylene			
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
PTA	P-Xylene from SC			
	P-Xylene from Ref			
	Acetic Acid	methanol	Natural gas	
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
PET	PTA	Xylene from SC		
		Xylene from Ref		
	Ethylene Glycol	Ethylene		
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
GPPS	Styrene	Styrene EBSM	Ethylbenzene	Benzene from Ref
				Benzene from

				SC
		Styrene POSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
HIPS	Styrene	Styrene EBSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
		Styrene POSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
	Polybutadiene	butadiene		
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
SAN	Styrene	Styrene EBSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
		Styrene POSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
	AMStyrene			
	Acrylonitrile	Ammonia	Natural Gas	
		Propylene		
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
ABS	Styrene	Styrene EBSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
		Styrene POSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
	Butadiene			
	AMStyrene			
	Acrylonitrile	Ammonia	Natural Gas	
		Propylene		

	Fuels			
	Electricity			
	Transport			
	Small chemicals			
EPS	Styrene	Styrene EBSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
		Styrene POSM	Ethylbenzene	Benzene from Ref
				Benzene from SC
	Pentane			
	Graphite			
	Flame retardants			
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
PC	Bisphenol A	Acetone	Cumene	Propylene
				Benzene from Ref
				Benzene from SC
		Phenol	Cumene	Propylene
				Benzene from Ref
				Benzene from SC
	Diphenyl Carbonate	Phenol	Cumene	Propylene
				Benzene from Ref
				Benzene from SC
	Phosgene	Chlorine		
		CO from Natural gas		
	Fuels			
	Electricity			
	Transport			
	Small chemicals			
POM	Formaldehyde	Methanol	Natural gas	
	Fuels			
	Electricity			

	Transport				
	Small chemi-cals				
PA6	Caprolactame	Sulfuric Acid			
		Oxime	Cyclohexanone		
			Hydroxylamin	Cyclohexane	Benzene from Ref
					Benzene from SC
					Hydrogen
	Fuels				
	Electricity				
	Transport				
	Small chemi-cals				
PA66	Adipic Acid	Nitric Acid	Ammonia	Natural gas	
		Cyclohexanol	Cyclohexane	Benzene from Ref	
				Benzene from SC	
				Hydrogen	
	Hexamethylene Diamine	Adiponitrile	Butadiene		
			Ammonia	Natural gas	
			Methane		
		Hydrogen			
	Fuels				
	Electricity				
	Transport				
	Small chemi-cals				
MMA	Acetone Cya-nohydrin	HCN	Ammonia	Natural gas	
		Acetone	(Cumene cata-lyst)	Propylene	
				Benzene from Ref	
				Benzene from SC	
	Methanol	Natural gas			
	Fuels				
	Electricity				
	Transport				
	Small chemi-cals				
PMMA	MMA				
	Fuels				
	Electricity				

	Transport Small chemicals			
PU	TDI	Toluene from Ref		
		Toluene from SC		
		Nitric acid		
		Phosgene	Chlorine	
			CO from Natural gas	
	MDI	Benzene from Ref		
		Benzene from SC		
		Nitric acid		
		Formaldehyde		
		Phosgene	Chlorine	
			CO from Natural gas	
	Aliphatic Isocyanate	(Complex processes)	Butadiene	
			Phosgene	Chlorine
				CO from Natural gas
			Benzene from Ref	
			Benzene from SC	
	Aromatic Polyester Polyol	ethylene oxyde	Ethylene	
		propylene oxyde	Propylene	

ANNEX 2

PlasticsEurope recommendation on

Steam Cracker allocation

Life Cycle and Sustainability working group of PlasticsEurope,

14 September 2017

1. Goal and scope of this paper

LCA data for products, especially information on the carbon footprint (global warming potential) gained more interest through the last years in B2B as well as in B2C communication. LCA data of products comprise the environmental impact of such products from cradle-to-gate. LCA data of steam cracker products directly influence a huge amount of further downstream products, hence they will become even more important. It is therefore important that LCA data for steam cracker products are modelled consistently by LCA experts as a basis for further use in LCA studies. Practitioners need to be enabled to facilitate a comparison of LCA information of downstream products based on sound LCA data of steam cracker products.
For multi-output processes, such as a steam cracker, ISO 14040 and 14044 standards define a hierarchy of several options to tackle that. Following these rules and due to the nature of steam cracker processes allocation is the preferred option of the assessment.
The goal of this paper is to give a recommendation for the allocation of steam cracker processes.

2. Steam cracker product system

2.1 General

The steam cracker process turns fossil hydrocarbon feedstocks (predominantly ethane, LPG, naphtha, or gas oil) into several different main products, like ethylene and propylene, benzene, butadiene and hydrogen. The process yields additional further chemicals like, acetylene, butene, toluene and xylene. This product spectrum is fairly independent from steam cracker´s feedstock, however the ratio of the produced products changes with the feedstock. Some of the products, like toluene and xylene are considered as “side-catch” compared to the main objectives of a steam cracker. Toluene and xylene bulk production predominately originates from reformate, a refinery intermediate product rather than from pyrolysis gas, a steam cracker effluent. This is described in the report “Benzene, Toluene and Xylenes – Aromatics, BTX”, published by PlasticsEurope in February 2013.

The environmental footprint of the steam cracker products depends on:

- the feedstock composition and its environmental profile

- the energy demand of the steam cracker process.
- the proportion of products and by-products produced
- the treatment of steam cracker waste streams prior to their final disposal

2.2 Influence on LCA data

2.2.1 Feedstock

The major impact on the environmental profile of a single product is the product mix produced in the steam cracker. The feedstock used is influencing the environmental profile in two ways, one, as described is the product mix produced, the other is the impact of the feedstock itself, whose environmental profile is differing due to origin (natural gas or oil), location and refinery characteristics, in case of oil.

2.2.2 Energy demand and related emissions

Another relevant factor is the energy demand for the process operation. Most of the energy demand is needed to heat up the feedstocks to cracking temperature and for the cracking process itself. The heat from the process is recovered by steam production which is used amongst others for heat input into separation processes and as motive fluid for steam turbines driving various compressors in the process. Depending on the process configuration and steam cracker´s efficiency these values can vary. The energy demand needs to be allocated in the preparation of LCI as well.

3. Allocation of steam cracker processes

3.1 General

Due to ISO 14040 and 14044, the allocation should be done between the different products or functions in a way that reflects the underlying physical relationships between them. Where physical relationships (e.g. mass, heating value, C-content etc.) alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way that reflects other relationships between them on another basis. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.

In relation to these ISO standards it is recommended to define the **“main products (MP)”** for the steam cracker process. Co-products, others than on “main products” will be defined as **“additional products (AP)”**.

For steam crackers the “main products” are:

- Ethylene
- Propylene
- Benzene (*)
- Butadiene (*)
- Hydrogen
- Toluene (*)
- Xylene (*)
- Butenes

(*) if separated from mix

independently which cracker technology or which feedstock is used.

The allocation scheme for “main products” and “additional products” is defined in the following section. This regulation enables practitioners to consistently create LCA data for steam cracker processes.

3.2 Allocation of feedstock

Feedstock **shall** be allocated on mass basis to all steam cracker products. It is recommended for a better understanding to report the relative share of “main products” and “additional products”.

3.3 Allocation of s energy demand and emissions

Energy demand and emissions **shall** be exclusively allocated on a mass basis to the “main products”. “Additional products” **shall** not take an environmental burden from energy demand and emissions.

4. Summary

The concept of defining a main “products” fixed list in combination with a mass-based allocation for steam crackers leads to a consistent LCA approach, independently from market prices, technological changes or market driven adaptions of steam cracker outputs. It gives practitioners a clear guidance for the allocation process. This results in less differing environmental data for steam cracker products and will lead to a higher comparability. The results are much more stable, although the same product will have slightly different LCI results depending on different amounts of products derived from the steam cracker.

Questions and Answers

How was this recommendation established?

It was built through a consensual 5 years long process by The Life Cycle Thinking and Sustainability working group of PlasticsEurope, composed of experts from its member companies, plus some experts of the Chemical Sector of the World Business Council for Sustainable Development, and LCA consultants.

Why is there a need for such a recommendation?

Allocation is a key aspect of LCA of steam crackers. Different assumptions can be made and all of them are somehow right and also wrong. To avoid influencing the results by different understanding of companies of the allocation scheme, it is needed to agree on the basic principles of the allocation without knowing the details of specific processes. Different allocation and different lists of “main products” and ‘co-products” may be absolutely relevant in function of the situations and configurations of different steam-crackers and in function of the goal and scope of the studies.
But the purpose here is to ensure the comparability of petrochemical datasets.
As full transparency is not an option, given the confidentiality of business and to respect the competition laws, the only way to enable comparability is to fix an allocation method,
Then it makes sense that this allocation method is built through a consensual approach, aiming at being as much representative as possible of the steam-cracker population.

Why not allocating to all products, whatever “main products” or “co-products”?

Some co-products are used as fuel or get back as feedstock so they do not carry more values than the steam-cracker feedstock,

Why not having an open list of “main products” and “co-products”?

All products, but particularly those being a small part of the total production, like for example, acetylene, toluene, xylene, may undergo a huge environmental profile difference between being in one list or the other. As said before, for the sake of comparability, the list must be the same for all, limited and clear, even if it could be detrimental to the representativeness of some steam-crackers. By going through a consensual work, we have tried to minimize this consequence.