Growing Media Europe

Growing Media Environmental Footprint Guideline

V1.0

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Summary

Growing Media Europe (GME) is an international non-profit organisation representing the producers of growing media and soil improvers at European level. As part of its sustainability strategy, GME developed the growing media environmental footprint guideline (GMEFG) providing a detailed and comprehensive technical guidance on how to conduct a life cycle assessment (LCA) study for growing media and itheirconstituents.

This GMEFG provides growing media producers and users guidance on how to assess the environmental performance of growing media in a harmonized and consistent way, allowing for sector wide alignment. The GMEFG also provides additional information necessary for the development of environmental impact assessment of products/processes in which growing media are an intermediate product.

The GMEFG is intended for the provision of life cycle inventory (LCI) information on growing media mixes and constituents in the context of LCA studies of horticultural or floricultural (gardening) studies or any other applicable process where growing media are an intermediate product and the elaboration of cradle to grave LCA studies of growing media for either internal or external communication.

Instructions for LCA practitioners are given regarding the scope definition of GMEFG studies (i.e. functional unit, system boundaries, allocation methodology and impact assessment method).

Information on specific mandatory primary data requirements and data quality evaluation is given. Possible secondary data required to perform GMEFG studies are also identified, however, no GME-specific secondary database has been developed yet and no recommendation is given on a commercial database to be used, leaving this temporarily open in the guidance.

The GMEFG provides specific instructions on data collection and requirements for the development of a life cycle inventory (LCI) for all life cycle stages (cradle to grave) of growing media mixes and single material, including instructions to develop inventories for most relevant growing media constituents and guidance on how to deal with special constituents.

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Acronyms

B2B: business to business

B2C: business to consumer

BoM: bill of materials

CF: characterization factor

CFF: Circular Footprint Formula

DM: dry matter

DQR: Data Quality Rating

EC: European Commission

EF: Environmental Footprint

EI: environmental impact

EoL: End of life

FU: functional unit

GHG: greenhouse gas

GME: Growing Media Europe

GMEFG: Growing Media Environmental Footprint Guideline

GR: geographical representativeness

GWP: global warming potential

IPCC: Intergovernmental Panel on Climate Change

ISO: International Organisation for Standardisation

JRC: Joint Research Centre

LCA: Life Cycle Assessment

LCI: Life Cycle Inventory

LCIA: Life Cycle Impact Assessment

NACE: Nomenclature Générale des Activités Economiques dans les Communautés Européennes

P: precision

PEF: Product Environmental Footprint

PEFCR: Product Environmental Footprint Category Rules

RF: reference flow

RP: representative product

SB: system boundary

TeR: technological representativeness

TiR: time representativeness

TS: Technical Secretariat

UNEP: United Nations Environment Programme

Definitions

Acidification – Impact category that addresses impacts due to acidifying substances in the environment. Emissions of NO_x, NH_3 and SO_x lead to releases of hydrogen ions (H+) when the gases are mineralised. The protons contribute to the acidification of soils and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.

Activity data - This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). The aggregated LCI results of the process chains that represent the activities of a process are each multiplied by the corresponding activity data1 and then combined to derive the environmental footprint associated with that process. Examples of activity data include quantity of kilowatt-hours of electricity used, quantity of fuel used, output of a process (e.g. waste), number of hours equipment is operated, distance travelled, floor area of a building, etc. Synonym of "non-elementary flow.

Additional environmental information – Environmental information outside the impact categories that is calculated and communicated alongside study results.

Additional technical information – Non-environmental information that is calculated and communicated alongside study results.

Afforestation - Afforestation is the process of planting trees, or sowing seeds, in a barren land devoid of any trees to create a forest. The term should not be confused with reforestation, which is the process of specifically planting native trees into a forest that has decreasing numbers of trees. While reforestation is increasing the number of trees of an existing forest, afforestation is the creation of a 'new' forest.

Aggregated dataset - Complete or partial life cycle of a product system that next to the elementary flows (and possibly not relevant amounts of waste flows and radioactive wastes) lists in the input/output list exclusively the product(s) of the process as reference flow(s), but no other goods or services. Aggregated datasets are also called "LCI results" datasets. The aggregated dataset may have been aggregated horizontally and/or vertically.

Allocation – An approach to solving multi-functionality problems. It refers to "partitioning the input or output flows of a process or a product system between the product system under study and one or more other product systems" (ISO 14040:2006)(ISO 2006) .

Average Data – Refers to a production-weighted average of specific data.

Background processes – Refers to those processes in the product life cycle for which no direct access to information is possible. For example, most of the upstream life-cycle processes and generally all processes further downstream will be considered part of the background processes.

Bill of materials – A bill of materials or product structure (sometimes bill of material, BOM or associated list) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture the product in scope of the study. In some sectors it is equivalent to the bill of components.

Bog – Mossy wetlands that accumulate peat obtaining water from rain and snow.

Bulk density – also called apparent density or volumetric density, is a property of powders, granules, and other "divided" solids, especially used in reference to mineral components (soil, gravel), chemical substances, (pharmaceutical) ingredients, foodstuff, or any other masses of corpuscular or particulate matter. It is defined as the mass of many particles of the material divided by the total volume they occupy. The total volume includes particle volume, inter-particle void volume, and internal pore volume.

Business to Business (B2B) – Describes transactions between businesses, such as between a manufacturer and a wholesaler, or between a wholesaler and a retailer.

Business to Consumers (B2C) – Describes transactions between business and consumers, such as between retailers and consumers. According to ISO 14025:2006, a consumer is defined as “an individual member of the general public purchasing or using goods, property or services for private purposes”.

Characterisation – Calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with characterisation factors for each substance and EF impact category of concern. For example, with respect to the EF impact category “climate change”, CO2 is chosen as the reference substance and kg CO2-equivalents as the reference unit.

Characterisation factor – Factor derived from a characterisation model which is applied to convert an assigned life cycle inventory result to the common unit of the EF impact category indicator (based on ISO 14040:2006).

Classification – Assigning the material/energy inputs and outputs tabulated in the life cycle inventory to EF impact categories according to each substance’s potential to contribute to each of the EF impact categories considered.

Climate change - All inputs or outputs that result in greenhouse gas emissions. The consequences include increased average global temperatures and sudden regional climatic changes. Climate change is an impact affecting the environment on a global scale.

Co-function - Any of two or more functions resulting from the same unit process or product system.

Company-specific data – It refers to directly measured or collected data from one or multiple facilities (site-specific data) that are representative for the activities of the company. It is synonymous to “primary data”. To determine the level of representativeness a sampling procedure may be applied.

Company-specific dataset – It refers to a dataset (disaggregated or aggregated) compiled with company-specific data. In most cases the activity data is company-specific while the underlying sub-processes are datasets derived from background databases.

Co-product – Any of two or more products resulting from the same unit process or product system (ISO 14040:2006).

Cradle to Gate – A partial product supply chain, from the extraction of raw materials (cradle) up to the manufacturer’s “gate”. The distribution, storage, use stage and end of life stages of the supply chain are omitted.

Cradle to Grave – A product’s life cycle that includes raw material extraction, processing, distribution, storage, use, and disposal or recycling stages. All relevant inputs and outputs are considered for all of the stages of the life cycle.

Data Quality – Characteristics of data that relate to their ability to satisfy stated requirements (ISO 14040:2006). Data quality covers various aspects, such as technological, geographical and time-related representativeness, as well as completeness and precision of the inventory data.

Data Quality Rating (DQR) - Semi-quantitative assessment of the quality criteria of a dataset based on Technological representativeness, Geographical representativeness, Time-related representativeness, and Precision. The data quality shall be considered as the quality of the dataset as documented.

Direct elementary flows (also named elementary flows) – All output emissions and input resource use that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite.

Downstream – Occurring along a product supply chain after the point of referral.

Ecotoxicity, freshwater – Environmental footprint impact category that addresses the toxic impacts on an ecosystem, which damage individual species and change the structure and function of the ecosystem. Ecotoxicity is *a result of a variety of different toxicological mechanisms caused by the release of substances with a direct effect on the health of the ecosystem.*

Elementary flows – In the life cycle inventory, elementary flows include "material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation" (ISO 14040). Elementary flows include, for example, resources taken from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories.

Eutrophication – Nutrients (mainly nitrogen and phosphorus) from sewage outfalls and fertilised farmland accelerate the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass. Three EF impact categories are used to assess the impacts due to eutrophication: Eutrophication, terrestrial; Eutrophication, freshwater; Eutrophication, marine.

Flow diagram – Schematic representation of the flows occurring during one or more process stages within the life cycle of the product being assessed.

Foreground elementary flows - Direct elementary flows (emissions and resources) for which access to primary data (or company-specific information) is available.

Foreground Processes – Refer to those processes in the product life cycle for which direct access to information is available. For example, the producer's site and other processes operated by the producer or its contractors (e.g. goods transport, head-office services, etc.) belong to the foreground processes.

Functional unit – The functional unit defines the qualitative and quantitative aspects of the function(s) and/or service(s) provided by the product being evaluated. The functional unit definition answers the questions "what?", "how much?", "how well?", and "for how long?".

Gate to Gate – A partial product supply chain that includes only the processes carried out on a product within a specific organisation or site.

Gate to Grave – A partial product supply chain that includes only the distribution, storage, use, and disposal or recycling stages.

Global warming potential – Capacity of a greenhouse gas to influence radiative forcing, expressed in terms of a reference substance (for example, CO2-equivalent units) and specified time horizon (e.g. GWP 20, GWP 100, GWP 500, for 20, 100, and 500 years respectively). It relates to the capacity to influence changes in the global average surface-air temperature and subsequent change in various climate parameters and their effects, such as storm frequency and intensity, rainfall intensity and frequency of flooding, etc.

Growing media: A growing medium is a product other than soil in situ, the function of which is for plants or mushrooms to grow in.

Horticulture – cultivation of plants for food, comfort and beauty both in a professional context and a home setting. Horticulture includes cultivation and processing of soft fruits, vegetables, mushrooms, ornamental plants and trees.

Indirect land use change (iLUC) – It occurs when a demand for a certain land use leads to changes, outside the system boundary, i.e. in other land use types. These indirect effects may be mainly assessed by means of economic modelling of the demand for land or by modelling the relocation of activities on a global scale.

Input flows – Product, material or energy flow that enters a unit process. Products and materials include raw materials, intermediate products and co-products (ISO 14040:2006).

Intermediate product – Output form a unit process that is input to other unit processes that require further transformation within the system (ISO 14040:2006). An intermediate product is a product that requires further processing before it is saleable to the final consumer.

Ionising radiation, human health – EF impact category that accounts for the adverse health effects on human health caused by radioactive releases.

Land use – EF impact category related to use (occupation) and conversion (transformation) of land area by activities such as agriculture, forestry, roads, housing, mining, etc. Land occupation considers the effects of the land use, the amount of area involved and the duration of its occupation (changes in quality multiplied by area and duration). Land transformation considers the extent of changes in land properties and the area affected (changes in quality multiplied by the area).

Lead verifier – Verifier taking part in a verification team with additional responsibilities compared to the other verifiers in the team.

Life cycle – Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal (ISO 14040:2006).

Life cycle approach – Takes into consideration the spectrum of resource flows and environmental interventions associated with a product from a supply-chain perspective, including all stages from raw material acquisition through processing, distribution, use, and end of life processes, and all relevant related environmental impacts (instead of focusing on a single issue).

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).

Life cycle impact assessment (LCIA) – Phase of life cycle assessment that aims at understanding and evaluating the magnitude and significance of the potential environmental impacts for a system throughout the life cycle (ISO 14040:2006). The LCIA methods used provide impact characterisation factors for elementary flows to in order to aggregate the impact to obtain a limited number of midpoint and/or damage indicators.

Life cycle inventory (LCI) - The combined set of exchanges of elementary, waste and product flows in a LCI dataset.

Life cycle inventory (LCI) dataset - A document or file with life cycle information of a specified product or other reference (e.g., site, process), covering descriptive metadata and quantitative life cycle inventory. A LCI dataset could be a unit process dataset, partially aggregated or an aggregated dataset.

Loading rate – Ratio of actual load to the full load or capacity (e.g. mass or volume) that a vehicle carries per trip.

Material-specific – It refers to a generic aspect of a material. For example, the recycling rate of PET.

Multi-functionality – If a process or facility provides more than one function, i.e. it delivers several goods and/or services ("co-products"), then it is "multifunctional". In these situations, all inputs and emissions linked to the process will be partitioned between the product of interest and the other co-products according to clearly stated procedures.

Normalization – After the characterisation step, normalisation is the step in which the life cycle impact assessment results are multiplied by normalisation factors that represent the overall inventory of a reference unit (e.g. a whole country or an average citizen). Normalised life cycle impact assessment results express the relative shares of the impacts of the analysed system in terms of the total contributions to each impact category per reference unit. When displaying the normalised life cycle impact assessment results of the different impact topics next to each other, it becomes evident which impact categories are affected most and least by the analysed system. Normalised life cycle *impact assessment results reflect only the contribution of the analysed system to the total impact potential, not the severity/relevance of the respective total impact. Normalised results are dimensionless, but not additive.*

Ozone depletion – EF impact category that accounts for the degradation of stratospheric ozone due to emissions of ozone-depleting substances, for example long-lived chlorine and bromine containing gases (e.g. CFCs, HCFCs, Halons).

Particulate Matter – EF impact category that accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NOx, SOx, NH3).

Photochemical ozone formation – EF impact category that accounts for the formation of ozone at the ground level of the troposphere caused by photochemical oxidation of volatile organic compounds (VOCs) and carbon monoxide (CO) in the presence of nitrogen oxides (NOx) and sunlight. High concentrations of ground-level tropospheric ozone damage vegetation, human respiratory tracts and manmade materials through reaction with organic materials.

Primary data - This term refers to data from specific processes within the supply chain of the practitioner of the LCA methodology. Such data may take the form of activity data, or foreground elementary flows (life cycle inventory). Primary data are site-specific, company-specific (if multiple sites for the same product) or supply chain specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material/product balances, stoichiometry, or other methods for obtaining data from specific processes in the value chain of the user of the LCA practitioner. In this method, primary data is synonym of "company-specific data" or "supply-chain specific data".

Product – Any goods or services (ISO 14040:2006).

Raw material – Primary or secondary material that is used to produce a product (ISO 14040:2006).

Reference flow – Measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit (based on ISO 14040:2006).

Representative product (model) - The RP may be a real or a virtual (non-existing) product. The virtual product should be calculated based on average European market sales-weighted characteristics of all existing technologies/materials covered by the product category or sub-category. Other weighting sets may be used, if justified, for example weighted average based on mass (ton of material) or weighted average based on product units (pieces).

Representative sample – A representative sample with respect to one or more variables is a sample in which the distribution of these variables is exactly the same (or similar) as in the population from which the sample is a subset.

Resource use, fossil – EF impact category that addresses the use of non-renewable fossil natural resources (e.g. natural gas, coal, oil).

Resource use, minerals and metals – EF impact category that addresses the use of non-renewable abiotic natural resources (minerals and metals).

Sample – A sample is a subset containing the characteristics of a larger population. Samples are used in statistical testing when population sizes are too large for the test to include all possible members or observations. A sample should represent the whole population and not reflect bias toward a specific attribute.

Secondary data - It refers to data not from a specific process within the supply-chain of the company performing a LCA study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third party LCI database or other sources. Secondary data includes industry average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies *and patents, and may also be based on financial data, and contain proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data.*

Sensitivity analysis – Systematic procedures for estimating the effects of the choices made regarding methods and data on the results of a LCA study (based on ISO 14040: 2006).

Site-specific data – It refers to directly measured or collected data from one facility (production site). It is synonymous to "primary data".

Specific Data – Refers to directly measured or collected data representative of activities at a specific facility or set of facilities. Synonymous with "primary data."

Supply chain – It refers to all of the upstream and downstream activities associated with the operations of the study practitioner, including the use of sold products by consumers and the end of life treatment of sold products after consumer use.

Supply chain specific – It refers to a specific aspect of the specific supply chain of a company. For example the recycled content value of an aluminium may be produced by a specific company.

System boundary – Definition of aspects included or excluded from the study. For example, for a "cradle-to-grave" EF analysis, the system boundary includes all activities from the extraction of raw materials through the processing, distribution, storage, use, and disposal or recycling stages.

System boundary diagram – Graphic representation of the system boundary defined for the LCA study.

Temporary carbon storage - happens when a product reduces the GHGs in the atmosphere or creates negative emissions, by removing and storing carbon for a limited amount of time.

Unit process – Smallest element considered in the LCI for which input and output data are quantified (based on ISO 14040:2006).

Upstream – Occurring along the supply chain of purchased goods/ services prior to entering the system boundary.

Waste – Substances or objects which the holder intends or is required to dispose of (ISO 14040:2006).

Water use – It represents the relative available water remaining per area in a watershed, after the demand of humans and aquatic ecosystems has been met. It assesses the potential of water deprivation, to either humans or ecosystems, building on the assumption that the less water remaining available per area, the more likely another user will be deprived (see also http://www.wulca-waterlca.org/aware.html).

Weighting – Weighting is a step that supports the interpretation and communication of the results of the analysis. LCI results are multiplied by a set of weighting factors, which reflect the perceived relative importance of the impact categories considered. Weighted EF results may be directly compared across impact categories, and also summed across impact categories to obtain a single overall score.

1.Introduction

Growing Media Europe (GME) is an international non-profit organisation representing the producers of growing media and soil improvers at European level. Growing Media Europe is committed to the highest environmental standards, to the sustainable use of natural resources and to contributing to the competitiveness of the European horticultural sector by providing high quality growing media products.

As part of its sustainability strategy, GME developed the growing media environmental footprint guideline (GMEFG) providing a detailed and comprehensive technical guidance on how to conduct a life cycle assessment (LCA) study for growing media and its constituents.

The GMEFG follows the latest international life cycle assessment guidelines relevant to the sector, and have been developed (unless specified in the document) in alignment to the European Commission (EC) Product Environmental Footprint Category Rules (PEFCR) guidance document "Suggestions for updating the Product Environmental Footprint (PEF) method" (Zampori and Pant 2019)

This GMEFG provides growing media producers and users guidance on how to assess the environmental performance of growing media in a harmonized and consistent way, allowing for sector-wide alignment. The GMEFG also provides additional information necessary for the development of environmental impact assessment of products/processes where growing media are an intermediate product.

2.General Information

2.1 Guideline purpose and use

This GMEFG supports the following purposes:

1) Provision of life cycle inventory (LCI) information on growing media mixes and constituents in the context of LCA studies of horticultural, floricultural studies or any other applicable process where growing media are an intermediate product;

2) To provide guidance on how to perform cradle to grave LCA studies of growing media for either internal or external use.

Basic LCA concepts and theory are not elaborated upon on this guideline as basic LCA understanding and a certain degree of expertise in LCA area is therefore required by the practitioner.

In alignment with PEFCR JRC 2019 (Zampori and Pant 2019), this GMEFG uses precise terminology to indicate the requirements, the recommendations and options that could be chosen when a study is conducted.

• The term "shall" is used to indicate what is required in order for a study to be in conformance with this GMEFG.

• The term "should" is used to indicate a recommendation rather than a requirement. Any deviation from a "should" requirement has to be justified when developing the study and made transparent.

• The term “may” is used to indicate an option that is permissible. Whenever options are available, the GMEFG compliant study shall include adequate argumentation to justify the chosen option.

2.2 Technical secretariat

The technical secretariat of the GMEFG is made up by the following GME members and industry experts:

- Jan Köbbing (Klasmann-Deilmann GmbH)
- Cecilia Luetgebrune (GME)
- Nele Ameloot (GME)
- Hein Boon (RPP)
- Folkert Moll (Kekkilä-BVB)
- Laurent Largant (AFAIA)
- Arne Hückstädt (Industrieverband Garten)
- Paul Alexander (Pindstrup)
- Cédric Abriat (Agaris)
- Sander Golberdinge (Grodan)
- Henri van Beerndonk (Jiffy)

2.3 Consultation and stakeholders

Pending: For the open consultation, the following information shall be provided:

Open consultation scheduled to begin 14-11-2020

- Opening and closing date
- Number of comments received
- Names of organizations providing comments
- GME only (link to APPENDIX consultation)

2.4 Geographic validity

The GMEFG is valid for growing media products sold or consumed in the European Union + EFTA.

Each study performed under this guidance document shall identify its geographical validity listing all the countries where the growing media is consumed/sold with the relative market share. In case the information on the market for the specific product object of the study is not available, Europe +EFTA shall be considered as the default market, with an equal market share for each country.

2.5 Language

The GMEFG is written in English. It is not foreseen at this stage to make this document available in other languages. The original in English supersedes translated versions in case of conflicts.

2.6 Conformance to other documents and methodology

This GMEFG has been developed in conformity with the following documents under the umbrella of the Product Environmental Footprint (PEF) method (Suggestions for updating the Product Environmental Footprint (PEF) method (Zampori and Pant 2019)):

- PAS2050-1:2012
- PAS2050:2011
- IPCC Guidance on National Greenhouse Gas Inventories 2006
- 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands
- ISO 14040:2006
- ISO 14044:2006

3.Scope

The scope of the GMEFG is growing media made up of a single constituent or a mix of constituents, to be used in the professional or hobby markets to allow plant growth.

3.1 Product classification

A growing medium is a product other than soil in situ, the function of which is for plants or mushrooms to grow in. Growing media are mixes or single components of organic and/or mineral materials which allow plant growth. They provide a rooting environment for physical stability, storage of air for the roots, water absorption and retention and nutrient supply. Growing media are used by the horticulture industry as well as by private consumers to support healthy plant development (GME 2019).

Growing media can be used in a wide variety of growth applications.

3.1.1 Common applications

A representative growing media product or mix can vary widely depending on its end application and user needs.

Examples of applications and representative growing media mixes are presented in Table 3-1. No aggregated representative product has been defined for this guideline.[1]

Table 3-1 Typical examples of growing media applications and mix compositions

Application	Constituent	% vol/vol
Potting plants & ornamentals	White peat (milled)	35%
	Black peat	20%
	White peat (sod)	20%
	Coconut coir	15%

[1] PEFCR 2019 indicates that a single representative product shall be modelled in a PEFCR based on the European market situation at the time of the development of the study. This has not been done in the GMEFG given the high variability of mixes depending on the end application, no single representative product modelled will encompass all possible applications or deliver any significant additional information as benchmark.

	Perlite	10%
	Additive	**kg/m^3**
	Dolocal	3
	Fertilizer-mix	0.6
	Calcium nitrate	0.2
Application	**Constituent**	**% vol/vol**
Soft fruits or tree nursery	White peat fibres	25%
	White peat (sod) (different fractions)	40%
	Perlite	10%
	Wood fibre	25%
	Additive	**kg/m^3**
	Fertilizer-mix	3.5
	Limestone	2
Application	**Constituent**	**% vol/vol**
Hobby market	White peat (different fractions)	30%
	Black peat	20%
	Coconut coir	20%
	Green waste compost	10%
	Composted bark	10%
	Fine bark fraction	10%
	Additive	**kg/m^3**
	Clay	5
	Dolocal	2.5
	Organic fertilizer	4
Application	**Constituent**	**%vol/vol**
Tomatoes & fruity vegetables	Stone wool	100%

In each GMEFG study, users shall clearly state the specific application and exact material constituent and additive composition of the growing media. Section 5 details the development of the life cycle inventory for growing media, and the steps to model the production of different material constituents.

3.1.2 *Growing media constituents*

Depending on the application, growing media can be made of only one constituent (mono-material) or made up from a mix of different organic and/or mineral constituents. A description of different common growing media constituents is given in Table 3-2 (Bos et al. 2003). This list is non exhaustive and for informative purposes only.

Table 3-2 Placeholder constituent description.

Constituent name	Description
White Peat	Type of moss or raised bog peat, which mainly consists of various types of sphagnum, Cotton grass, Rannoch-rush, wood fragments. Low decomposed up to 20% (<4H von Post scale), acidity (pH) ranges from 3.0 to 4.0. acidic. The main

	characteristic of White Peat is its high air and water absorption and distribution capacity.
Black Peat	Fen type or grass peat, consists of different types of herbaceous plants, reeds, sedges, wood fragments, etc. well decomposed >35% (>6H von Post scale), acidity (pH) ranges from 5,5 to 7.0. Black peat comes from the lower, highly decomposed peat layer.
Bark	Bark from coniferous (softwood) trees, that is either fresh, aged or composted for the use in growing media, soil improvers and mulches.
Coir pith	Coir products are originating from the mesocarp of the coconut (Cocos nucifera) which consists of the fibres und the pith. The fibres and the spongy tissue between are separated. The coir pith is a side product of the fibre extraction and contains a certain amount of short fibres (< 20 m) depending on the intensity of the combing and sieving between 2 and 20% (v/v). However, specially assembled mixtures of fi-bres and pith are also available.
Perlite	Glassy volcanic rock, crushed, sieved, and then 'popped' at about 1000°C. In horticulture perlite is used as additive in potting soil mixtures and as pure substrate.
Wood fibres	Wood fibres are mechanically and thermally frayed wood for horticultural purposes. If necessary, conditioning agents are added during the production process to stabilize the nitrogen balance.
Stone wool	Stone wool is produced by melting basalt and limestone after addition of coke at elevated temperatures. Rock wool is mainly used as mat in vegetable and flower production.

3.1.3 *Growing media additives*

Additives are materials apart from substrate constituents conveying diverse physical and/or chemical properties to the growing media mixes. Common additives are nutrients (fertilizers), added for plant growth.

3.2 Growing media product types

Two types of growing media products are identified in this guideline: growing media as intermediate or as final product.

Growing media as intermediate product, or business to business (B2B) is growing media as an input to other economic activity. Intermediate products should be investigated from cradle to gate, and as per (Zampori and Pant 2019); the use and end of life (EoL) stage should be excluded from analysis.

The second type is growing media as a final product (B2C); where growing media is the main product. In this case, the product environmental impact shall be evaluated from cradle to grave, including the use and EoL.

3.3 Reference flow

The reference flow for growing media (both as intermediate and final product, see section 3.2) is defined in this GMEFG as 1m^3 of fresh growing media mix or mono material fit for purpose, as delivered (packed) to user. Changes in volume during use shall not be taken into account. All considerations necessary to deliver $1m^3$ of fresh product to user shall be made.

What?	*Growing media mix or mono-material for a specific growing application.*
How much?	*1 m^3 of fresh growing media as delivered to the professional or hobby user. (Bulk density to be determined following EN12580)*
How long?	*Growing media is consumed in a short period after delivery; no extended storage time or warehousing considered.*
How well?	*Fit for purpose in line with GME's code of practice (in development).*

The specific application of the growing media shall always be indicated along with the definition of the reference flow in a GMEFG study. Comparative assertions between growing media mixes, shall only be made for growing media mixes intended for the same application and in the context of the same study.

3.4 System boundary

The system boundary that should be applied is illustrated in Figure 1. Please note that the system boundary will change depending on the product type of the growing media mix or mono-material under study. Table 3-3 provides a short description of the life cycle stages that should be considered from the perspective of the growing media producer.

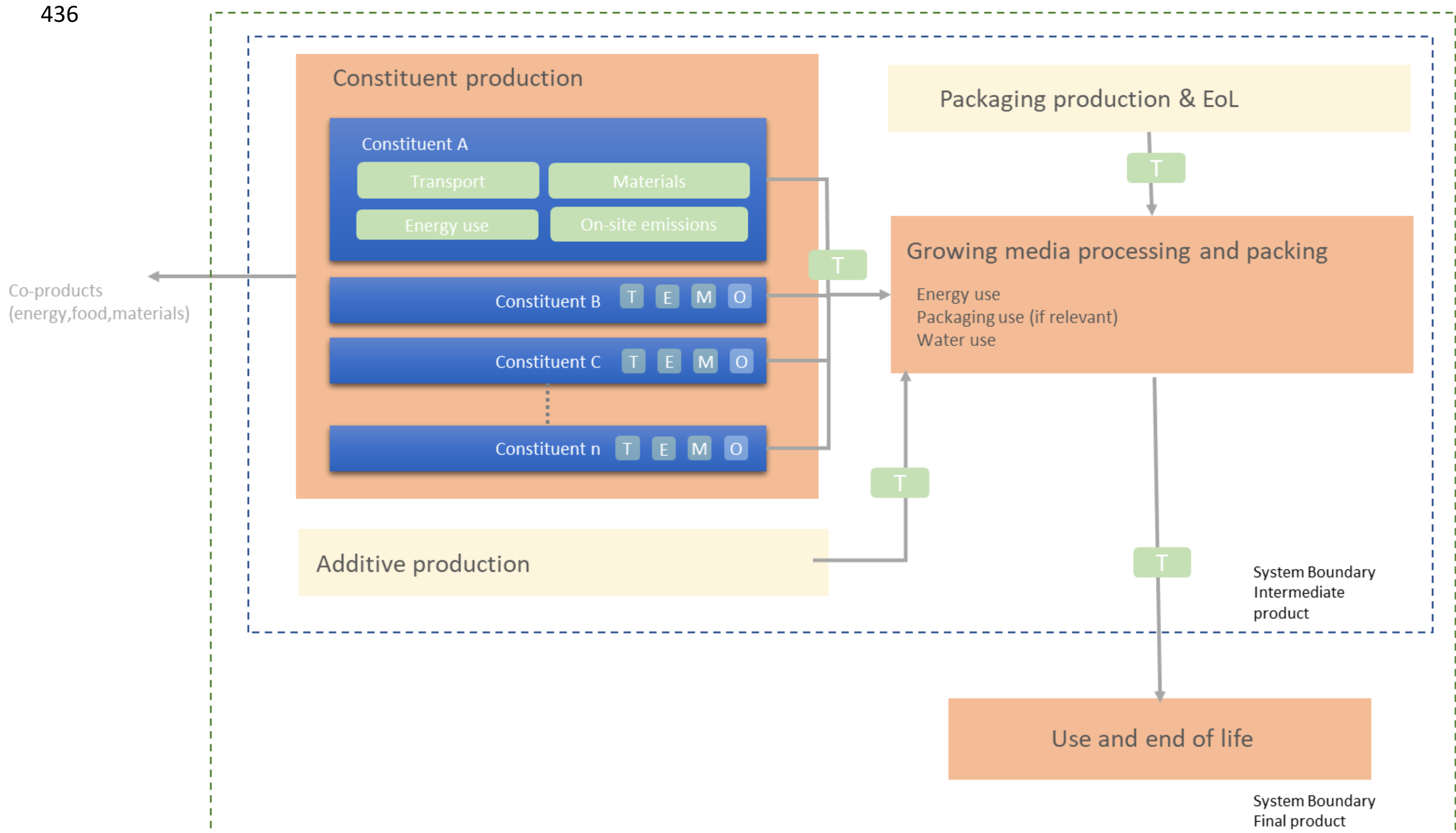

Figure 1 Simplified system boundary for a GMEFG study

Table 3-3 Description of life cycle stages of growing media production

Life cycle stage	Description of the process included
Processing and packing of growing media	Step in which one or more constituents (including additives, if any) are further processed if needed and then mixed together and packed.
Packaging production	Refers to the production of packaging primary, secondary and tertiary material for growing media to consumer. In this guideline, as further explained in section 5.1.3 both production and end of life of the packaging material are encompassed in the same life cycle stage.
Transport of materials to production plant (inbound distribution)	Transport steps related to the delivery of individual constituents, additives, or packaging material at plant for processing and packing of growing media. Different transport modes can be included in this step.
Growing media delivery to final user (outbound distribution)	Delivery of packed growing media to final user. This can take place by different modes of transportation.
Production of individual (organic and/or mineral) constituents and additives	The production stage considers energy and material inputs and associated emissions to the production of individual constituents and additives. Growing media constituents vary in source and type. Depending on the type of constituent, production process varies in kind and complexity. Production of peat, for example, includes all processes and emissions related to peat harvesting throughout the life of a peat bog. Coconut coir considers the impacts of coconut farming, de-husking, fibre and coir production as well as cleaning and buffering of coir. Details of required inventory for different constituents can be found in section 5.2.
Use and end of life	The use/end of life refer to the emissions related to the decomposition of organic components in growing media and N related emissions derived from the fertilizer content (additives) of the growing media mix. This stage considers, if applicable, re- use or recycling of growing media.

In all studies, the following processes may be excluded (cut-off): all capital goods over all life cycle stages of growing media production.

3.5 Allocation

When necessary, allocation of environmental impacts shall be conducted as per Table 3-4. Details on when to apply allocation in the different growing media life cycle stages or exceptions depending on product specifications are available in section 5.

Table 3-4 Allocation rules for activity data and elementary flows

Process	Allocation Rule	Modelling Instructions

Transport (inbound and outbound)	Physical allocation	Allocation of transport emissions to transported products shall be done on the basis of physical causality, such as mass share. If the mass of a full freight is lower than the maximum load capacity of the truck (low density products), the transport shall be considered volume-limited and the allocation shall be modelled as in section 4.4.3 (Zampori and Pant 2019). When using primary activity data, practitioners may modify the utilization ratio (kg load/kg payload) in EF compliant datasets, including empty returns (if applicable). If no primary information is available, a utilization ratio of 50% for bulk transport and 64% for any other mass-limited transport shall be assumed (both ratios already include empty returns). Practitioners shall clearly indicate the chosen utilization ratios. Further information on this approach can be found in section 4.4.3 (Zampori and Pant 2019).
Co-products in constituent and additive production	Economic allocation	Economic allocation refers to allocating inputs and outputs associated with multi-functional processes to the co-product outputs in proportion to their relative market values. The market price of the co-functions should refer to the specific condition and point at which the co-products are produced (Zampori and Pant 2019).
Growing media plant operations	Two situations shall be distinguished for mixing/processing and packing operations at growing media facility: a) Specific facility data are available: no need to allocate b) Average facility data are available: physical allocation shall be used (average utility consumption per m^3 of growing media mix produced)	

3.6 Impact assessment

The impact assessment method groups the collected activity data from the life cycle inventory (LCI) according to their contribution to specific environmental impact categories. For this GMEFG, the recommended default impact assessment method to be utilized is the latest EF impact category, which at the moment of releasing this GMEFG is EF 3.0., developed by the European Commission (EC) in the context of the PEF/PEFCR projects.

Each study carried out in compliance with this GMEFG, shall calculate the environmental profile of growing media including all impact categories listed in Table 3-5, or corresponding to the most recent EF impact assessment method.

Table 3-5 impact categories with respective impact category indicators and characterization models to be used in the GMEFG as reported in (Zampori and Pant 2019).

Impact category	Impact category Indicator	Unit	Characteri-zation model	Robustness[2]
Climate change, total	Radiative forcing as global warming potential (GWP100)	kg CO2 eq	Baseline model of 100 years of the IPCC (based on IPCC 2013)	I
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 eq	Steady-state ODPs as in (WMO 2014 + integrations)	I
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model 2.1 (Fankte et al, 2017)	III
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model 2.1 (Fankte et al, 2017)	III
Particulate matter	Impact on human health	disease incidence	PM method recomended by UNEP (UNEP 2016)	I
Ionising radiation, human health	Human exposure efficiency relative to U235	kBq U235 eq	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	II
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC eq	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe 2008	II
Acidification	Accumulated Exceedance (AE)	mol H+ eq	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N eq	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P eq	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II
Eutrophication, marine	Fraction of nutrients reaching marine end	kg N eq	EUTREND model (Struijs et al, 2009) as implemented in	II

[2] The differences of robustness have been taken into account by the European Commission to determine the weighting factors, when weighted results are calculated. I indicates most robust while III least robust method (Zampori and Pant 2019).

	compartment (N)		ReCiPe	
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTUe)	CTUe	USEtox model 2.1 (Fankte et al, 2017)	III
Land use	- Soil quality index - Biotic production - Erosion resistance - Mechanical filtration - Groundwater replenishment	-Dimensionless (pt) - kg biotic production - kg soil - m^3 water - m^3 groundwater	Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)	III
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 world eq	Available WAter REmaining (AWARE) as recommended by UNEP, 2016	III
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb eq	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.	III
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)26	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002	III

The impact category score for ‘climate change’ shall be broken down in three subcategories:

- Climate change – fossil
- Climate change – biogenic methane emissions
- Climate change – land use and land transformation

No biogenic CO_2 uptake and capture shall be accounted, following the simplified approach for biogenic carbon reporting of the PEF guidance (Zampori and Pant 2019).

Following the steps of classification and characterisation, the impact assessment shall be complemented with normalization and weighting. Normalization and weighing factors provided in the EF 3.0 method are available in Appendix III[3].

3.7 Additional environmental information

Additional environmental information shall be provided and properly documented based on company-specific data.

[3] According to the ISO 14044 standard on life cycle assessment (LCA), normalization is defined as “calculating the magnitude of category indicator results relative to reference information” and weighting as “converting and possibly aggregating indicator results across impact categories using numerical factors based on value-choices”.

This information includes bulk density of the final growing media mix, moisture content of the mix, the carbon content of the peat-based constituents in the growing media mix (kg C/kg peat dm) as delivered to client and nutrient (NPK) and limestone content supplemented to the growing media mix in each additive (section 5.1.1). This information shall be clearly communicated to the downstream partner involved in LCA modelling.

Downstream partners performing LCA using growing media as intermediate products, can obtain guidance on how to use this additional environmental information to model the use and EoL of growing media (section 5.4).

Practitioner may also include (when available) any certification scheme or production program to which their constituent production is subject (e.g. RPP). This aims at disclosing any additional information to the downstream partner that cannot be captured by the LCA results.

3.8 Limitations

- In the use phase of the life cycle of growing media, this guideline focuses exclusively on the oxidation of C from peat constituents. As this is clearly the most relevant contribution to the environmental impact of growing media to climate change, and climate change is the most relevant impact category contributing to a weighted single score, no effort was made to reconcile different approaches and the limited information acquired on asserting other emissions attributed to the use phase. This is acknowledged as a limitation to the study and can be brought up as a point for further research in coming versions on the GMEFG.
- Default emission factors for soil emissions of peat harvesting are limited to the deemed best available source IPCC wetland supplement (IPCC 2014). It is acknowledged that experts on the field have mixed opinions on these emission factors, but developers of the guideline consider these as the best available at the time of development, and as the guideline allows and encourages the use of direct measurements or country specific emission factors for soil emissions of peat production, no other sources are available for default values.
- Information on emissions from stockpiling in peat harvesting is scattered and not case-specific, hence a limitation for the default value given in this guideline. Direct measurements are encouraged.
- Default emission factors for composting were wide ranging in literature, and each available source had different details to the emissions reported. In this guideline, two sets of default emissions are given (open and enclosed composting) aiming at better reflecting the practitioner's actual situation. The poor availability of good default emissions for composting is acknowledged and direct emissions are encouraged whenever available.
- Full carbon oxidation of peat containing growing media in the use phase is assumed in this guideline. This is modelled after guidance given in section 8.2.3.2 of PAS 2050:1 2012 (BSI 2012), where no integration into the soil organic matter is considered. This is a conservative approach, due to limited knowledge and unpredictability with regards to complex environmental relations and parameters that may affect the level of peat oxidation, such climate and soil type. This can be a subject of improvement in later versions of this guideline.

4. Data requirements

Data used to model the different life cycle stages of growing media can be either company / supplier specific data (primary) or secondary data. Primary data refers to data directly measured or collected at a specific facility or set of facilities, and representative of one or more activities or processes in the system boundary. Secondary data refers to data that are not based on direct measurements or calculation of the respective processes in the system boundary.

Primary data shall be collected for all processes referenced in section 4.1. This is mandatory in order for a study to be considered compliant to this GMEFG. For all processes not included in section 4.1, secondary data may be used as they are non- mandatory for primary data. Practitioner may, however, make use of primary data whenever accessible and shall communicate which processes are modelled using primary data and which are modelled using secondary data.

Primary data collection is recommended in all cases where the practitioner is the owner of the life cycle process, however, at this moment the TS consensus is that collection of primary data shall not be mandatory for processes not listed in section 4.1. this decision may be revised in future versions of the GMEFG. In all cases, practitioner shall indicate which data is coming from primary data sources and which data is modelled using secondary data.

For primary data collection, there is option for sampling. Based on PEFCR guidance (Zampori and Pant 2019), in some cases, a sampling procedure is needed by the practitioner in order to limit the data collection only to a representative sample of plants/processes etc. Examples of cases when the sampling procedure may be needed are in case multiple production sites are involved in the production of the same product unit. e.g., in case the same raw material/input material comes from multiple sites or in case the same process is outsourced to more than one subcontractor/supplier. If needed, sampling in this GMEFG shall be performed in compliance with section 4.4.6 of PEFCR guidance (Zampori and Pant 2019).

4.1 Mandatory Primary data collection

For a study to be compliant to this guideline, the required mandatory primary company specific data are described in the three sub-sections below.

4.1.1 Growing media composition

Use of company specific data is required for the list of different constituent components/bill of materials for the growing media mix or mono-material. Not using primary data for this composition, means the study is not compliant with this GMEFG. The constituent list should add up to 100% of the volume composition for 1m^3 of growing media as delivered to used excluding additives (See section 5.1.1). All additives (if applicable) shall be included and reported separately based on their use in mass per m^3 of growing media delivered to user.

Rules on LCI modelling for growing media constituents are provided in section 5.2.

4.1.2 Utility consumption in mixing, processing and packing

Primary activity data for utilities (i.e. energy and water consumption) in the growing media production plant shall be collected. Utilities used should not consider operational activities such as office lighting or employee transport. Data is to be recorded according to details provided in the life cycle inventory section (5.1.2).

Data can be derived on different levels of accurateness:

- The minimum level of accurateness shall be average facility data determined for 1 year of normal activity (normal activity is defined as data corrected for outstanding events, which need to be properly documented) and reported per m^3 of final mix produced. In this case, utility use for the production of a specific constituent (e.g. wood fibre) on site shall be separated from the utility use of the plant operations.

- Specific facility data collected related to specific mix or mono-material mixing/processing and packing. This shall preferably be done based on measurements or if measurements are not possible on the basis of an analysis where use of energy and auxiliary material is derived from technical specifications for the equipment.

Utility consumption measurements shall be allocated per m^3 of final growing media mix delivered to user, as per indication in section 3.5 , Table 3-4.

4.1.3 Outbound transport

Primary data shall be collected for outbound transport. The outbound transport is defined as the transport from the growing media production plant to the final user (e.g. growing media delivery to greenhouse). This may be done with different levels of accuracy and should follow the steps described in section 5.1.5.

4.2 Data quality requirements

The data quality of each new dataset and of the total study shall be calculated and reported. Data quality for this GMEFG shall be evaluated in alignment to the data quality rating (DQR) calculations and requirements described in the latest PEFCR guidance (Zampori and Pant 2019) as described below.

The calculation of the DQR shall be based on four data quality criteria as expressed on Equation 1:

$$\mathrm{DQR} = \frac{\mathrm{TeR} + \mathrm{GeR} + \mathrm{TiR} + \mathrm{P}}{4}$$

Equation 1

Where TeR is the Technological-Representativeness, GeR is the Geographical-Representativeness, TiR is the Time-Representativeness, and P is Precision. The representativeness (technological, geographical and time-related) characterises to what degree the processes and products selected are depicting the system analysed, while the precision indicates the way the data is derived and related level of uncertainty.

Five quality levels (from excellent to poor) can be achieved according to the Data Quality Rating (DQR). These are summarized in Table 4-1.

Table 4-1 Overall data quality level of datasets according to the achieved data quality rating

Overall data quality rating (DQR)	**Overall data quality level**
DQR ≤ 1.5	Excellent quality
1.5 < DQR ≤ 2.0	Very good quality
2.0 < DQR ≤ 3.0	Good quality
3 < DQR ≤ 4.0	Fair quality
DQR >4	Poor quality

4.2.1 DQR calculation of company specific data

The DQR of each process in the life cycle inventory of a GMEFG study is either provided by default in secondary data or shall be calculated for each process created for the study based on company-specific primary activity data.

When creating a company-specific dataset, the data quality of i) the company-specific activity data and ii) the company-specific direct elementary flows (e.g. emission data) shall be assessed.

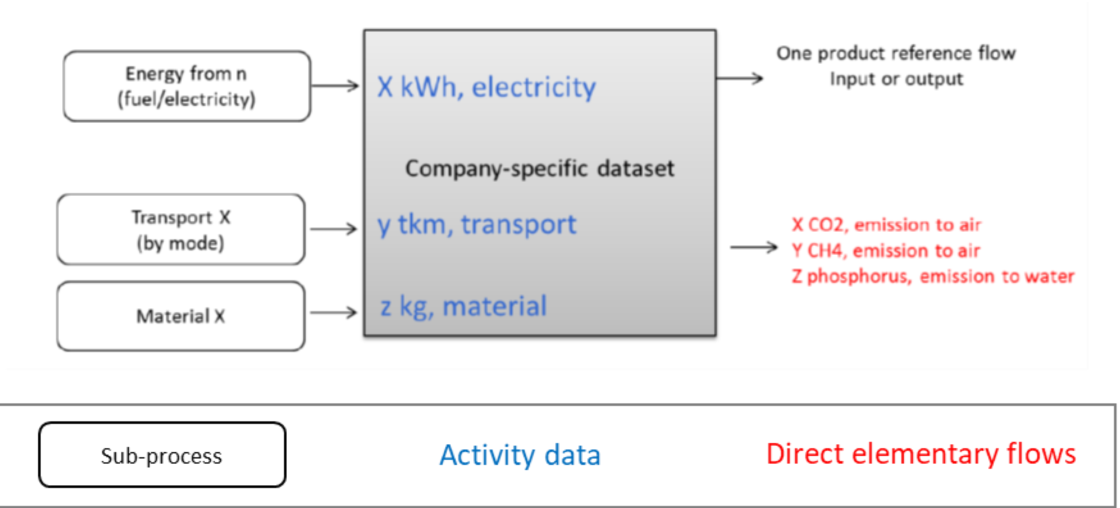

Figure 2 Representation of company specific data set for a process, extracted from (Zampori and Pant 2019).

The DQR for processes modelled using company specific data shall be calculated as follows:

1) Select the most relevant activity data and direct elementary flows of the process: most relevant activity data are the ones linked to sub-processes (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset for a specific process, listing them from the most contributing to the least contributing one to a single score (Pt). This means the practitioner shall run the weighted results of each new dataset and order all activity data and elementary flows from highest to lowest contribution to the total weighted score of the newly created process in order to determine those contributing to at least 80% of the total score.

2) For each most relevant activity data and each most relevant direct elementary flow, calculate the DQR criteria TeR, TiR, GeR and P using Table 4-2.

Table 4-2 How to assess the value of the DQR criteria for datasets with company-specific information (general process)

Rating	PEF and PAD	TiR-EF and TiR-AD	TeR-EF and TeR-AD	GR-EF and GR-AD
1	Measured/calculated and externally verified	The data refers to the most recent annual administration period with respect to the GMEFG report publication date	The elementary flows and the activity data reflect exactly the technology of the newly developed dataset	The activity data and elementary flows reflects the exact geography where the process modelled in the newly created dataset takes place
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the EF report publication date	The elementary flows and the activity data is a proxy of the technology of the newly developed dataset	The activity data and elementary flows) partly reflects the geography where the process modelled in the newly created dataset takes place

3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the GMEFG report publication date	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

3) To define the weight of the activity data and elementary flows to the total DQR, calculate the environmental contribution of each most-relevant activity data (through linking to the appropriate sub-process) and direct elementary flow to the total sum of the environmental impact of all most relevant activity data and direct elementary flows, in % (weighted, using all impact categories). For example, the newly developed dataset has only two most relevant activity data, contributing in total to 80% of the total environmental impact of the dataset:

- Activity data 1 carries 30% of the total dataset environmental impact. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).
- Activity data 2 carries 50% of the total dataset environmental impact. The contribution of this process to the total of 80% is 62.5% (the latter is the weight to be used).

4) Calculate the TeR, TiR, GeR and P criteria of the newly developed dataset as the weighted average of each criteria of the most relevant activity data and direct elementary flows. The weight is the relative contribution (in %) of each most relevant activity data and direct elementary flow calculated in step 3.

5) The practitioner shall calculate the total DQR of the newly developed dataset using the equation below, where $\overline{TeR}$,$\overline{GR}$,$\overline{TiR}$,$\overline{P}$ are the weighted average calculated as specified in point (4).

$$DQR = \frac{\overline{TeR} + \overline{GeR} + \overline{TiR} + \overline{P}}{4}$$ *Equation 2*

Guidance to calculate DQR values for the mandatory company specific data in this GMEFG, is given in section 5.6.

4.2.2 DQR of secondary datasets

The secondary datasets to be used or developed for this guideline will be further discussed and developed after the open consultation. The DQR value for each process in the background datasets developed for the GMEFG shall be calculated and provided to all practitioners as supplementary information to this guideline.

4.2.3 Calculating average DQR of the study

The DQR of the study shall be calculated as the weighted average of the DQR scores of all most relevant processes (primary and secondary) in the entire life cycle in the scope of the study, based on their relative environmental contribution to the single overall score.

The minimum DQR score for the study shall be *DQR ≤3.*

4.3 Which data to use?

Primary activity data shall be collected for all processes described in section 4.1 and may be collected for all processes directly run by the company practicing the study, which in turn will be reflected in the overall study DQR (e.g. lower DQR). In all other instances, secondary datasets shall be used to model the life cycle of the growing media under study.

At this moment, the exact source of secondary data or development of a GME specific database is to be discussed with the TS. If no secondary data is developed specifically for the GMEFG, practitioners are free to choose any commercially available LCI database.

Secondary data is identified to be required for the following processes:

- Secondary data energy and transport
- Secondary data packaging materials
- Secondary data growing media constituent production
- Secondary data additive production
- Secondary data waste management

In some cases, no data is available in databases. In that case, proxies (regional or global average for the constituent at stake or product group average) need to be used. Using proxies always triggers lower data quality (i.e. higher DQR).

5.Modelling Life Cycle Inventory Data

This section gives details on the different activity data needed to model each life cycle stage for growing media.

5.1 Processing and packing of growing media

5.1.1 Growing media composition

Growing media can be a mix or mono-material. All components of $1m^3$ (functional unit) of growing media shall be compiled. Details on composition per m^3 and additional ingredients shall be enlisted as per Table 5-1 , Table 5-2 and Table 5-3 depending on which applies. The composition of growing media is mandatory company specific data. All constituents shall add to 100% vol/vol for a fresh mix and shall include the fresh bulk density and moisture content as delivered to client Table 5-1.

Constituents used shall be expressed in volume using product specific fresh bulk density measured according to the European Standard specifies methods for the determination of a number of soil improvers and growing media in bulk and in packages EN 12580.

Total volumes of each constituent used for the mix shall account for product losses when mixing. When modelling the growing media mix, practitioners shall be mindful of using correct moisture content and density of all constituents to avoid inadvertent over -or- under estimations of material input when integrating the mix for calculation. When the moisture content and/or density of a constituent at production changes before the final mix, this shall be registered and considered before calculating the amount of material required for the final GM mix.

Table 5-1 List of constituents for growing media mix, all constituents shall sum up to 100% in volume

Constituent	vol/vol [%]	Density fresh [kg/m^3]	Moisture content [%]
Constituent A	% A	kg/m^3 A	
Constituent B	% B	kg/m^3 B	
Constituent C	% C	kg/m^3 C	
Constituent D	% D	kg/m^3 D	

For the specific case of stone wool, the full bill of materials (BOM) to produce $1m^3$ of growing media shall be provided based on company specific data Table 5-2. The BOM shall add to 100% of the total mass of $1m^3$ of stone wool growing media (considering losses). Stone wool volume shall be determined based on company specific bulk density for stone wool (EN 12580).

Table 5-2 BOM table for stone wool, all ingredients shall add up to 100% of the mass of $1m^3$ of stone wool

Ingredient	kg/m^3
Ingredient A	A
Ingredient B	B
Ingredient C	C

It is not a requirement to use primary data on the production of the different growing media constituents, however, when the operation is under the control of the practitioner, or the practitioner has access to primary data from suppliers, constituent production may be modelled after the guidelines described in section 5.2.

When no primary data is used to model the production of material constituents, the next step in the modelling of the growing media mix under study is to connect each constituent in the growing media composition to a default secondary dataset.

For stone wool each ingredient in the BOM shall be connected to a default secondary dataset for its production.

If applicable to the product under study, a complete list of additives shall also be given. The use of additives in the mix shall also be recorded based on its use by mass per m^3 of growing media (kg/m^3). The complete list of additives (A) needs to be provided based on company data and no element shall be left out.

Table 5-3 List of additives for growing media mix

Additives	kg/m^3 of GM mix	Additional information
A1		If fertilizer, nutrient content to be indicated as additional environmental information (section 3.7).
A2		
A…n		

The next step is to connect all additives enlisted in Table 5-3 to a default secondary dataset.

The BOM or list of constituents and additives shall be the weighted average composition of a growing media mix or mono-material composition specific for the application considered in the study being performed. The weighted average of a constituent mix or BOM shall be determined by taking time related variation and the variation of geographical origin for supply into account where necessary.

If a specific composition is under study, the exact composition under research shall be used.

For both growing media constituent mixes and stone wool, possible losses in mixing and processing shall be accounted when adding all components to 1m^3 in the modelling of the life cycle inventory.

5.1.2 Energy and utility consumption in site operations

Data collection for the energy consumption in mixing/processing and packing of growing media operations shall be collected directly from the production plant. Data on electricity, fuel, heat, and water use shall be always recorded and collected based on annual usage data from the GM production facility in accordance with the plant's bookkeeping. The data shall be recorded according to the format in Table 5-4. In the fourth column, the method of measurement should be explained. This includes the sources of information and any conversion of information and related assumptions.

Data accurateness for electricity, fuel, heat and water use shall be based on the scope of the study as per section 4.1.2. When specific energy/utility consumption to produce 1m^3 of a certain mix or mono-constituent is available, no allocation is required. When only average plant consumption data is available, energy and utility measurements should be divided over the specific products produced, allocating the energy use of the entire factory to the sub-products per m^3 (see section 3.5).

Table 5-4 Collection of activity data at growing media production plant

Activity data	**Unit/m^3 growing media**	**Quantity**	**Source and related assumptions (if relevant)**
Electricity use	kWh		
Gas use	MJ		
Heat use	MJ		
Other energy input (specify type)	MJ		
Water (specify type)	m^3		

In the next step activity data needs to be linked to secondary data for energy production and water supply.

5.1.3 Packaging use and production

Only when applicable, packaging material use shall be collected based on amount and type of material used per m^3 of growing media. Packaging material use shall be connected to secondary data on packaging production. Secondary data used for packaging shall include the EoL of the packaging material based on local or average European waste management system.

When supplier-specific information is available for packaging production, the packaging production may be modelled according to section 4.4 of the Suggestions for Updating the Product Environmental Footprint (PEF) Method (Zampori and Pant 2019). When using primary data, the end of life of packaging should be modelled in this life cycle stage considering the use location of the GM mix to be used for the specific waste management system.

Production and end of life of packaging shall be modelled using the circular footprint formula as defined in (Zampori and Pant 2019).

5.1.4 Inbound transport

Operators may model inbound transport using company specific data when available. When using primary data, the practitioner shall collect the following information on the logistics of the transport from their supplier to growing media plant:

- Production location (processing plant or extraction location) of material constituent or additive, before arriving to the growing media production plant and distance to growing media plant. To avoid underestimating inbound transport distances (i.e. considering only the location of post processing or warehousing), if more than one production or processing location is related to a single constituent or additive, these shall be reported.
- Share of the different transport means to travel the distance from production location to the growing media plant.

Transport of materials and logistics related to the production of individual growing media constituents shall be integrated in the modelling of each individual constituent. Same considerations apply as above, considering production locations and distances from supplier to plant.

If the practitioner cannot determine the transport distances and modes, default data on distances and modes shall be used. Default distances and modes can be found in section 4.4.3 of Zampori and Pant 2019.

In all cases, transport modes shall be connected to secondary database data for the specific transport mode.

5.1.5 Outbound transport

Outbound transport is a mandatory company-specific process, primary data shall be collected for distribution operations to final client (either B2B or B2C).

This may be done with different levels of accuracy, as indicated in the hierarchy below from the most accurate to the least accurate, depending on data availability:

1. Fuel consumption for producer means of delivery and transport to user.
2. Producer specific delivery distance and means of transportation.
3. Average fuel consumption per m^3 delivered and means of transport.
4. Average distance from plant to final user and transport means.

The quality of data collected for outbound transport is proportionate to the level of accuracy (section 4.2).

If actual fuel use data of outbound transport can be collected, this data shall be used. Fuel use data shall be connected to secondary data of fuel production and combustion. Actual fuel use data shall be collected following Table 5-5.

Table 5-5 Data collection table for fuel use in outbound transport (when fuel data available)

Activity data	**Unit ***	**Quantity**	**Technology (EURO class 1,2,4,3,5, or 6)**	**Source and method of measurement**
Fuel (type 1)	unit/ ton delivered GM (specify unit)			
Fuel (type 2)	unit/ ton delivered GM			
Fuel (type 3)	unit/ ton delivered GM			

Fuel (type 4)	unit/ ton delivered GM			

* Ton of delivered GM should include growing media mix (considering mix bulk density for m^3), additives and packaging material (if applicable).

If data on actual fuel use is not available, then the outbound transport shall be assessed through distances according to steps 2 or 4 of the hierarchy indicated above and connected to secondary datasets for the corresponding means of transportation.

5.2 Constituent production

This section provides guidance for the modelling of relevant growing media constituents when the practitioner controls the production operation or has access to primary activity data from suppliers.

The final impact of constituents modelled shall be the weighted average of the time related variation and the variation of geographical origin for supply, unless the study aims determine the impact of a specific supplier/source location for a determined constituent.

The inventory data shall be converted to $1m^3$ of total growing media mix volume using product specific fresh bulk density and considering material losses in mixing. Bulk density shall be measured according to the European Standard specific methods for the determination of a number of soil improvers and growing media in bulk and in packages EN 12580. Variations in density and humidity of constituents from production to final mix shall be considered. For all constituents, moisture content and density at production shall be recorded to properly calculate the amount used in the final growing media mix.

In all constituent production, impact to by-products shall be allocated using economic allocation as per Table 3-4. The production location shall be declared for all constituents as secondary data or assumptions for production may be country or region specific.

Transport of materials and logistics related to the production of individual growing media constituents shall be integrated into the modelling of each individual constituent. Same considerations apply as in section 5.1.4.

5.2.1 Peat constituents

The modelling requirements of this section shall apply for primary data for peat constituent production and shall substitute default secondary datasets on peat production.

Different scenarios for peat extraction for growing media can occur. Appendix I describes some of the occurring scenarios and related CO_2 eq for peat harvesting in peat bogs and peat bog handling over a period of 100 years.

This guideline has been developed for peat harvested from European bogs or under the Responsibly Produced Peat (RPP) scheme, meaning the instructions below are only applicable for peat harvested from bogs that were degraded by a previous economic activity (scenario **B** in Appendix I)[4].

The life of a peat bog can be broken down into three general stages: a) pre-use and preparation, b) harvesting and c) after-use conditioning. The environmental impact of peat constituents shall be calculated only for the harvesting stage of peat in a peat bog.

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[4] Peat harvested from peat bogs not previously degraded shall consider emission related to changes in carbon stock from biomass loss and soil conversion following IPCC guidelines(Blain et al. 2006) (Penman et al. 2003) as well as energy use in ditching and draining the land.

For the other stages, emissions and activity are not considered. For the a) pre-use and after use, emissions from previous or consequent economic activity, in the case of previously degraded peatlands or continued activity after harvesting, shall be attributed directly to the other economic activity making use of the bog, therefore they are not accounted for peat in a GMEFG study. The natural state either in pre or after use shall not be included as the natural state is not an environmental intervention accounted for in LCA and credits associated with temporary or permanent carbon storage or delayed emissions shall not be considered (Zampori and Pant 2019).

For bog preparation before harvesting, not enough data is available to model the transition from the pre-use and the after-use, adding little value to the study [5] as uncertainty is larger than the effect of including these stages, so focus is placed in harvesting only.

The total impact of the bog throughout an average of 5 productive years shall be attributed to the 5-year average annual production of peat for a given bog in tons.

The following sections describe the data and considerations to be made to model peat harvesting from a previously degraded peat bog.

5.2.1.1 Peat bog specifications

When calculating the environmental impact of peat production, the following details of the bog (or bogs) from where the peat is harvested shall be known as an average for the 5 consecutive years previous to the study year:

Parameter	Value/unit	Comment
Bog location	Country/region	
Bog productivity	[ton /year]	Annual peat production in dry matter should be gathered for the last 5 years previous to the study
Bog area**	[ha]	Refers to the total area of managed peatland utilized for peat production. 5-year average
Ditch area**	[ha]	Refers to the area of ditches for drainage. 5-year average

** land occupation shall be documented on an annual basis and shall consider the effective harvested area for the peat constituent. If more than one peat type is produced in a site only the area for the product of interest shall be documented.

5.2.1.2 Harvesting

Data for energy use in peat harvesting shall be collected on an annual basis for 5 consecutive years previous to the study year. This includes energy coming from all fuel used in machinery or other equipment or electricity used during harvesting operation. Average peat density (kg/m^3) and humidity (%) considered to calculate bog activity (productivity and energy use) shall be registered for the peat produced and shall be considered when calculating the final growing media mix.

[5] Screening studies performed in preparation of the GMEFG show the pre-and after-use impacts vary greatly depending on assumptions taken on their duration and attributed activities, never exciding more than 10% of the impact of the total peat production, and representing less than 1% of the contribution over most impact categories in the total growing media mix impact assessment.

The annual energy and fuel use per ton of peat produced shall be considered as the average of the 5-year data gathered over the 5-year average bog productivity [ton /year]. If more than one type of peat is produced, then the energy use shall be separated only for the product considered. If separation is not possible, the amount of energy used for the specific peat shall be allocated in terms of the area share of the peat production in the total area of the harvested bog.

The next step is to connect the total energy/fuel inputs per ton of peat to default fuel production and combustion data.

Direct emission from managed organic soils in the peat bog and direct emissions from peat stockpiles on site shall be calculated considering the following:

If no country specific emission factors or direct bog measurements are available, soil and ditch emissions (CO_2, N_2O and CH_4), shall be calculated on an annual basis using emission factors for drained inland organic soils, peat harvesting reported in chapter 2 of the 2013 IPCC Wetlands supplement (IPCC 2014), for the appropriate land type and climate region.

Table 5-6 IPCC default emission factors for managed inland organic soils in temperate climate

Peat bog stage	EF	Unit	Source
Harvesting (soil)	2.8	[tonneC-CO_2/ha/yr]	IPCC 2014
Harvesting (soil)	6.1	[kgCH_4/ha/yr]	IPCC 2014
Harvesting (ditch)	542	[kgCH_4/ha-ditch/yr]	IPCC 2014
Harvesting (soil)	0.3	[kgN-N_2O/ha/y]	IPCC 2014
Harvesting (indirect DOC-C)	0.31	[tonne C-CO_2/ha/yr]	IPCC 2014

If available, country specific emission factors or direct measurements from bogs for greenhouse gas emissions of peat harvesting (soil and ditch) shall be preferred over default IPCC emission factors. The use of specific emission factors shall be reflected in the precision of the data quality rating of the developed dataset. The scientific basis of new country specific emission factors or direct emission measurement shall be described and documented in detail. This considers the definition of input parameters and description of the exact process by which the emission factors were derived, including sources and uncertainties (IPCC 2006b).

Emissions coming from peat stockpiles after harvesting shall also be accounted for. These emissions are directly related to the residence time and area of stockpile. In this guideline, the approach to stockpile emissions is based on default emissions factors, which shall be overridden if measured stockpile emissions are available.

The default emission factor for stockpiling is 250 gCO_2/m^2/year considering the total bog area (Hagberg and Holmgren 2008). Only CO_2 emissions are considered for peat stockpiling.

If site/country specific emission factors for stockpile emissions are available, these may be used in place of the default provided in this guidance, provided the scientific basis of this parameter is described and documented in detail.

Annual emissions per area of peat bog shall be divided over the average bog productivity to obtain the total emissions per ton of harvested peat.

5.2.2 Coconut constituents

The modelling requirements of this section shall apply for primary data available for coconut constituent production replacing default secondary data.

The coconut husk can be dried and cut up into chips (5.2.2.21) or further processed into fibre and coir (5.2.2.2.). For both instances, practitioners shall indicate country of cultivation for coconut and location for processing into chips or coir.

5.2.2.1 Coconut cultivation

Coconut palm cultivation should be linked to secondary data specific to the country of cultivation. If no country-specific data is available, a default average coconut cultivation shall be used.

If primary data on cultivation is available, the agricultural activity may be modelled following Agricultural Production guidelines described in section 4.4.1 of the (Zampori and Pant 2019).

The allocation between the coconut kernel and husk shall be performed on economic basis; the market price of all co-products should refer to the specific condition and point at which the co-products are produced.

5.2.2.2 Coconut husk chips

Coconut husk chips are husk cuttings. The production of husk may be related to primary or secondary data as described in section 5.2.2.1. Amount of husk (kg) used, moisture content and origin of husk per kg of husk chips produced shall be indicated. Energy/fuel use for husk chips production (drying, cutting and any other related activity) shall be reported per kg of chips produced, next step, is to relate the energy activity data to secondary data on energy/fuel production and combustion.

5.2.2.3 Coconut fibre and coir

Alternatively, the husk can be treated in fibre mills where fibre and coir/pith are extracted. Amount of husk (kg) moisture and origin of husk entering fibre mill should be recorded.

Fibre to coir ratio of production should be based on primary data from producer. If this is not available, a default share of 1/3 of the husk as fibre and 2/3 as coir/pith shall be used. (Coir Board and Government of India 2016).

As water can be a relevant input to the fibre mill, energy/fuel and water (including type) use at fibre mill shall be recorded per kg of processed husk and allocated to coir/fibre production on economic basis corresponding to fibre and coir prices at the fibre mill.

The energy/fuel and water use shall be connected to secondary data on fuel production and combustion and water supply.

Once extracted, fibres and coir can be further processed to be suitable as growing media, this includes activities like cleaning and buffering or further drying and pressing for transport.

If buffering operations occur at the coir producer, this shall be registered and attributed to coir production. If buffering of coconut constituents occurs at the growing media plant, the water shall be accounted as part of the mixing plant utility consumption (see section 5.1.2) and shall not be double-counted.

The energy/fuel and water (including type) use for all related processing steps (including pressing and drying for transport) shall be recorded per ton of processed fibre or coir based on producer activity data. The data shall be then connected to secondary datasets on energy/fuel production and combustion and water supply.

5.2.3 Wood and bark constituents

The modelling requirements of this section shall apply to any primary data wood and bark growing media constituents replacing default secondary data for these constituents.

5.2.3.1 Forestry and sawmill

The inventory and emissions related to forestry should be all connected to secondary data. If primary data is available for the forestry activity, practitioners should model these activities following general LCA modelling rules as considered in the PEF method (Zampori and Pant 2019).

The impact from forestry shall be attributed based on economic allocation to bark, wood chips and other sawmill by-products.

Amount of wood input and total amount and type of sawmill outputs shall be recorded. Energy used at the sawmill may be based on primary or secondary data depending on availability. The impact of energy and utility use at the sawmill shall be allocated on economic allocation to bark, wood chips and other sawmill by-products.

5.2.3.2 Further processing of bark or wood

Transport of wood and bark from sawmill to processing shall be modelled as per instructions given in section 5.1.4.

For further processing of wood chips or bark into fibre or finer fractions, utility use shall be recorded per m^3 of bark or wood constituent produced, based on average annual activity. Practitioners shall note that the energy use in further processing can vary greatly depending on the technology used. If secondary data is used to model this process, practitioners shall make use of the appropriate high, medium or low intensity technology, that best represents the case under study.

The following information shall be collected per m^3 of processed product:

- Amount of input material used (mass).
- Output Product of interest (mass, economic value)
- Co-product (if applicable) (mass, economic value)
- Residual materials that are considered to have zero value (mass)
- Electricity/fuel use and water use

Energy and water input data shall be connected to secondary datasets on energy/fuel production and combustion and water supply. Activities shall be allocated to co-products on economic basis as per section 3.5.

5.2.4 Zero value materials

This section addresses waste streams with no commercial economic value being used as raw materials for constituents (e.g. pruning leftovers, gardening waste, manure, etc.) in general, zero value streams from other production systems.

The modelling requirements of this section shall apply to primary data for zero value raw materials processed or directly used for growing media replacing default secondary data.

Zero value materials used as growing media are considered of zero allocation; meaning no impact shall be allocated to the production of these raw materials.

Though the generation of zero value material shall be considered as zero impact, transport for collection of materials and energy/fuel and water inputs (if any) for further processing into useful growing media constituents, shall be accounted for.

Transport from collection to processing shall be modelled as per the rules defined for inbound transport (5.1.4).

For further processing of zero value materials, water and electricity/fuel use shall be recorded per kg of processed material produced based on average annual activity. Energy and water input data shall be connected to secondary datasets on energy/fuel production and combustion and water supply.

5.2.5 Composted constituents

The modelling requirements of this section shall apply to primary data for composted constituents of growing media replacing default secondary data.

Compost production for growing media is not considered a waste management system but rather a production process to deliver a growing media constituent, as such, we are able to apply a cut-off for zero value materials composted or economic allocation for other types of composted materials (as per section 3.5), thus the circular footprint formula does not apply in modelling compost for this guideline.

Zero allocation is attributed to “green waste” and other zero value material streams for composting (5.2.4). Wood products as bark for composting and other valuable materials shall be first modelled as per section 5.2.3. and then used as inputs for the composting unit process.

The impacts related to transport materials to compost facility and composting shall be considered. Transport of materials to compost shall be modelled as per instructions given in section 5.1.4.

In all cases, the input/output ratio from composted material to compost shall be recorded for the composting process and used to relate activity and emissions of input material to ton of compost produced.

Energy/fuel and water inputs for composting shall be recorded per ton of material to be composted, based on average annual activity. The data shall be connected to secondary datasets on energy/fuel production and combustion and water supply.

When available, directly measured emissions per ton of organic material input shall be registered and accounted for based on average annual emissions from composting activity. If direct emission measurements are not available, default emission factors are available in Table 5-7 for open composting systems and Table 5-8 in enclosed composting systems.

Table 5-7 Default emission factors for composting organic input per ton of fresh composted waste, in open air windrow composting facilities;

Emission	Quantity	Unit	Compartment	Source
CH_4 biogenic	3.2	kg/ton (input)	Air	Andersen et al. 2010
N_2O	0.09	kg/ton (input)	Air	Andersen et al. 2010
CO	0.38	kg/ton (input)	Air	Andersen et al. 2010
NH_3	0.66	kg/ton (input)	Air	EMEP/EEA air pollutant emission inventory guidebook

				2016

Table 5-8 Default emission factors for composting organic input per ton of fresh composted waste in enclosed composting facilities

Emission	Quantity	Unit	Compartment	Source
CH_4 biogenic	0.8	kg/ton (input)	Air	(C.J. Peek et al. 2019)[6]
N_2O	0.084	kg/ton (input)	Air	(C.J. Peek et al. 2019)
CO	0.38	kg/ton (input)	Air	Andersen et al. 2010 (assumed same ar open composting).
NH_3	0.2	kg/ton (input)	Air	(C.J. Peek et al. 2019)

5.2.6 Stone wool

The modelling in this section may replace secondary data when primary data is available from the suppliers. The BOM list for stone wool shall cover the full list of material composition to produce 1 m^3 of stone wool.

The BOM data gathered as per section 5.1.1 shall be connected to secondary databases.

Utility use based on primary data shall be gathered as per instructions given in section 5.1.2, followed by connecting activity data to secondary databases on energy/fuel production and consumption and water provision. Direct CO_2 emissions from carbonate constituents melting in the furnace shall be modelled based on on-site measurements of emissions or calculated based on C content of materials.

Production and EoL of stone wool shall be modelled using the EC circular footprint formula (CFF) (Zampori and Pant 2019) to reflect the possible recycled material content (if any) and recyclability of this mineral material.

The CFF is used to model the EoL of products as well as the recycled content and is a combination of "material + energy + disposal", further guidance on the CFF and modelling of EoL for stone wool is given in section 5.4.2.2.

5.2.7 Perlite

Perlite is a common mineral constituent used in growing media. Perlite production considers not only mineral mining but further processing (i.e. expansion) into a low-density product.

In this guideline, the recommendation is to use secondary data to model the production of expanded perlite. When secondary data is used, practitioner shall make sure energy use for expansion is considered in the data used, otherwise, if only mining available, practitioners shall add the energy used per m^3 of (expanded) perlite produced from primary data.

[6] National inventory report 2019 for the Netherlands and other countries can be found here: https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2019

If available, practitioners may model the production of perlite using primary data in which case general LCA modelling rules as considered in PEF method (Zampori and Pant 2019) shall apply.

5.2.8 Other constituents

Constituents different from the ones above can be considered exceptions. To model the production of these constituents, secondary data may be used.

If secondary data is not available, practitioners may model the production using primary company specific data if available, in which case general LCA modelling rules as considered in Suggestions for updating the Product Environmental Footprint (PEF) method (Zampori and Pant 2019) shall apply.

In all cases, it shall be investigated if direct soil emissions from the production of other constituents are relevant and if so, these emissions shall be modelled based on direct measurements or calculations. The origin of the constituent is also relevant and shall be documented and considered in the modelling.

If no primary or secondary data is available, the special constituent(s) may be cut-off if together they represent less than 10% (vol/vol) of the growing media mix composition. The share in the mix of the rest of the constituents shall be recalculated to add to 100% vol/vol. This cut-off shall be clearly addressed in the limitations of the study. If the share in the growing media mix of the special constituent(s) amounts together to >10% (vol/vol) and no primary company specific data or secondary data is available to model them, then the study cannot be conducted under this guideline.

5.3 Additives

If available, practitioners may model the production of the specific additive using primary data in which case general LCA modelling rules as considered in Suggestions for updating the Product Environmental Footprint (PEF) method (Zampori and Pant 2019) shall apply. If not available, all additive materials used in the growing media mix shall be modelled using secondary data.

5.4 Use and End of Life

The calculation of use and End of Life shall only be performed for growing media sold as B2C (section 3.2) and shall follow the rules as defined in the sections below.

Practitioners evaluating B2B products may calculate the impact of use and EoL of growing media, however it shall be reported separately, and not included in the total environmental impact results of the product.

Downstream partners (i.e. users of growing media in the horticultural sector), may follow recommendations below in order to calculate the environmental impact of the growing media used in their respective systems.

5.4.1 Use

The environmental impact of the use of growing media is related to the oxidation of the carbon content of its peat-based constituents into CO_2, CO_2 from limestone and nitrogen and phosphorous-related emissions from fertilizer additives.

In growing media studies, all growing media emissions derived from the use phase shall be attributed to the growing media mix.

Peat-based constituents

When the object of the study is growing media, it shall be assumed that all C content of peat constituents is oxidized and released as CO_2\, in which case the impact is fully attributed to growing media.

When downstream partners perform a study and wish to calculate the impact of growing media to the life cycle of their economic activity, the recommendations to attribute the use emissions of growing media to the horticultural activity are as follows:

a) Indoor use (one or more users):

For only one user of growing media, the oxidation of the complete carbon content of the peat constituents shall be assumed to be oxidized into CO_2 and fully attributed to the growing media user.

For more than one user, peat emissions shall be calculated by considering a default oxidation rate of 5% of the peat carbon content (as provided in the additional environmental information) per year (Cleary, Roulet, and Moore 2005). If peat is transferred to a subsequent economic activity, the remaining carbon content of the peat shall be provided or calculated for the following activity, and the same consideration of 5% oxidation per year shall be made until complete oxidation.

If there is no additional economic application but the peat growing media is disposed (e.g. open field), then the remaining C shall be considered to fully decompose into CO_2 and shall be fully attributed to the last economic activity.

b) Open field and gardening (single user):

When peat constituents are applied in open field or for gardening, it shall be assumed that the peat carbon content (as provided in the additional environmental information) is oxidized completely and all emissions are attributed to the growing media mix. It is important to point out that some of the C in peat can be integrated into the soil organic matter, however, data is lacking to accurately estimate how much C is integrated into the soil so it is assumed that full carbon decomposition will occur within period of 100 years.

Additives

Emissions related to the addition of nutrients to the GM shall be accounted for. The full nutrient content of the additives and limestone shall be reported as additional environmental information (section 3.7).

Nitrate emissions are calculated according to the IPCC 2006 Guideline (IPCC 2006a), where 30% of the applied nitrogen is emitted as nitrate. Ammonia volatilization is calculated according to the IPCC 2006 Guideline (IPCC 2006a), where a fraction of the applied nitrogen is emitted to the air as ammonia. Both nitrous oxide (direct and indirect) emissions shall be calculated as indicated in the IPCC 2006 Guideline (IPCC 2006a).

Phosphorus-related emissions shall be calculated as indicated in (Zampori & Pant, 2019), in order of preference:

1. The P emissions should be modelled as the amount of P emitted to water after run-off and the emission compartment 'water' shall be used.

2. The P emissions should be modelled as the amount of P applied on the agricultural field (e.g. growing media used as soil improver) and the emission compartment 'soil' shall be used. In this case, the run-off from soil to water is part of the impact assessment method.

The practitioner shall justify the selected option.

CO_2 emissions from lime used directly as an additive or lime containing additives shall also be modelled following the IPCC Guideline (IPCC 2006a).

Due to the small input of nutrients in growing media compared to the use of fertilizer in the horticultural sector, nitrogen and CO_2 emissions from growing additives shall be assumed to be fully emitted and attributed to the first user of the growing media, regardless if the mix is reused at a later stage.

If growing media is recycled after being used, for downstream partners, the environmental impact of the production of growing media shall be attributed to each economic activity applying the circular footprint formula (CFF) as established by (Zampori and Pant 2019). Further explanation is available in section 5.4.2.2.

5.4.2 End of Life

Options for the end of life of growing media are identified in three broad groups: composting, field applications as soil improver and recycling.

Transport for waste collection should also be modelled, considering primary activity data for distances and transport modes. If primary data is not available, practitioner may use default values for waste collection provided in section 4.4.3.6 of Zampori and Pant 2019.

5.4.2.1 Composting and soil improvement

Under this guideline, a cut-off shall be considered for growing media being used for composting or as soil-improver. Composting is considered a new economic activity and not a waste treatment of the current economic system, meaning no impact from growing media shall be allocated to the composting system (including collection), but also, no impact of the growing media production shall be attributed to the compost. This same reasoning shall apply for the use of growing media as soil improver.

Emissions from organic C in peat from growing media used as soil improver or compost shall be allocated to the horticultural activity that originally used the GM mix , and no emissions due to peat oxidation are attributed to the activity producing compost or repurposing GM.

5.4.2.2 Recycling of growing media

Recycling of growing media is specifically relevant for stone wool and shall be modelled using the Circular Footprint Formula (CFF) considering the point of substitution. The Circular Footprint Formula is a combination of "material + energy + disposal", e.g.:

Material

$$(1-R_1)E_v + R_1 \times \left(AE_{recycled} + (1-A)E_v \times \frac{Q_{Sin}}{Qp}\right) + (1-A) \times R_2 \times \left(E_{recyclingEoL} - E^*{}_v \times \frac{Qsout}{Qp}\right)$$

Energy

$$(1-B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$$

Disposal

$$(1-R_2-R_3) \times E_D$$

Equation 3

The parameters of the CFF are explained in Appendix II.

The default approach for any growing media mix (including stone wool) is to set the parameters R1, R2, and R3 as zero, simplifying the CFF to Ev and ED. Ev in this case are the emissions and resources consumed for the production of growing media modelled following this guideline or using secondary data and ED represents the emissions and resources for waste disposal without energy recovery, which shall be connected to a secondary database on waste management.

More details on the CFF can be found in section 4.4.8 of the Suggestions for updating the Product Environmental Footprint (PEF) Method (Zampori and Pant 2019).

If specific data on the recycled material content and EoL of the growing media mix is available, primary data shall be used for the CFF parameters and recommendations for the CFF available in Annex C to the PEF methods (Zampori and Pant 2019) and available in (https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) shall be followed.

5.5 Environmental impact result reporting

Practitioners shall report the total environmental impact of all the life cycle stages under scope. Practitioners may choose to break down the environmental impact results per life cycle stage, in which case, users may use a report table as Table 5-9. Regardless of the practitioner chooses to breakdown their results, a GMEFG report shall always include the total environmental impact results for all life cycle stages.

Table 5-9 Example breakdown results per life cycle stage.

Life cycle stage	Climate change	Particulate Matter	Acidification	Resource Use, Fossil
Constituent or additive production				
Inbound transport				
Processing and packing Growing Media				
Outbound transport				
Use and EoL*				
Total				

* Use and EoL are only mandatory for growing media as an end product (i.e. hobby market, B2C). Practitioners may choose to calculate the impact of this life cycle stage for intermediate products (i.e. B2B); however, they shall report these results separately as additional information. See section 3.2 for more information.

5.6 Assessing data quality

Modelling choices in the LCI shall be reflected in the data quality rating of the developed primary data inventories and the study.

In this section, examples are provided on how to assess the DQR parameters for processes where company specific data is used. Processes not discussed in this section, when using primary data, the DQR shall be assessed using Table 4-2.

Table 5-10 How to assess data quality for the growing media mix or mono-material operations

Rating	PEF and PAD	TiR-EF and TiR-AD	TeR-EF and TeR-AD	GR-EF and GR-AD
1	Measured/calculated and externally verified	Data cover the time period in the scope of the study and refers to the most recent annual administration period with respect to the report publication date.	The elementary flows and the activity data exactly the technology of the newly developed dataset	The activity data and elementary flows concern the specific growing media production plant(s) in scope in their weighted share of production
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the EF report publication date	The elementary flows and the activity data is a proxy of the technology of the newly developed dataset	The activity data and elementary flows) partly reflects the geography where the process modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the EF report publication date	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

Table 5-11 How to assess data quality for Outbound transport

Rating	PEF and PAD	TiR-EF and TiR-AD	TeR-EF and TeR-AD	GR-EF and GR-AD
1	Measured/calculated and externally verified	Data cover the time period in the scope of the study and refers to the most recent annual administration period with respect to the report publication date.	The technology(ies) and logistics are specific for the GM product(s) in scope and based on fuel consumption measurements	The data concern the specific growing media production plant(s) location and its logistics in scope in their weighted share of production
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to the previous administration period with respect to the EF report publication date	The technology(ies) and logistics are specific for the product(s) in scope based on distance estimation.	The data concern unweighted average logistics of the growing media plants where production of feed in scope takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	Not applicable	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

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Appendix I

In this appendix four different scenarios of different situations for peat bogs and their related climate change emissions over a period of 100 years are shown.

This simplified model aims to describe the different sources of greenhouse gas emissions related to peat bogs and peat extractions to ease the understanding of the environmental impact calculations related to peat constituents

Four different scenarios are considered and we used two sets of emission factors (EF), IPCC emissions for inland organic soils (Blain et al. 2006; IPCC 2014) and country specific emissions factors developed for Latvian peat bogs in the context of the LIFE Restore project (Priede et al. 2019).

The emissions factors considered as summarized in Table A- 2.

Table A- 1 Summary of peat bog scenarios.

Scenario	Description
A	*Managed and degraded peat bog that is abandoned without rewetting or rehabilitation after the conclusion of a previous economic activity that managed the bog. Emissions considered for peat degradation until water table is reached.*
B	*Degraded peat bog, taken for peat extraction under responsible produced peat (RPP). Groundwater table will be lowered year after year to make sure peat extraction is possible. Extraction stops after certain time when not economic viable anymore, land is rewetted after peat extraction stops.*
C	*Pristine peatbog drained for peat extraction. Groundwater table will be lowered year after year to make sure peat extraction is possible. Extraction stops after certain time when not economic viable anymore, land is rewetted after extraction stops*
D	*Natural state (unmanaged) peat bog, no extraction or degradation.*

Table A- 2 Summary of emission factors used for calculation.

Rewetting/Natural	**IPCC**	**LIFE***	**Unit**
Emission rate CO2-C	-0.23	1.6	tonC-CO_2/ha/y
Emission rate CH4	122.7	177.33	kg CH_4/ha/y
Harvesting	**IPCC**	**LIFE**	**Unit**
Emission rate CO2	2.8	1.09	tonC-CO_2/ha/yr
Emission rate CH4	6.1	16.7	kg CH_4/ha/y
Emission rate CH4 ditches	542	*n/a used same as IPCC for calculation*	kg CH_4/ha ditch/y
Emission rate N2O	0.47	0.79	kgN_2O/ha/y
Harvesting (indirect DOC-C)	0.31	*n/a used same as IPCC for*	tonC-CO_2/ha/yr

		calculation	
Change in land use	**IPCC**	**LIFE**	**Unit**
Change carbon stock above ground biomass (assumed as temperate wet grassland)	6.8	*n/a used same as IPCC for calculation*	EF ton C-CO_2/ha
Change carbon stock Soil carbon (nutrient poor)	0.2	*n/a used same as IPCC for calculation*	EF ton C-CO_2/ha/y
Change in land use	**IPCC**	**LIFE**	**Unit**
Abandoned peat bog	2.8	0.96	tonC-CO_2/ha/y

*LIFE emission factors had to be calculated derived from partially reported figures so some numbers may vary slightly from the publication.

Each scenario was modelled considering certain assumptions for the depth of the water level or annual bog productivity. For each scenario main assumptions are explained below. In all scenarios, no transient period is assumed between the different stages of the bog life.

Scenario A

Initial water level depth below surface peat	0.5	m
Peat available	5,000.00	m^3/ha
C content peat	0.05	tonC/m^3
C total	250	tonC/ha

Scenario B

Peat layer depth	3	m
Annual peat extraction	953	m^3/ha/y
Bog life for extraction	31	years
C content peat	0.05	tonC/m^3
Ditch area	5% of total area	
Diesel use	610	L/ha/y

Scenario C

Conversion from pristine bog to harvest	5	years
Peat layer depth	3	m
Annual peat extraction	953	m^3/ha/y
Bog life for extraction	31	years
C content peat	0.05	tonC/m^3
Ditch area	5% of total area	
Diesel use	610	L/ha/y

Scenario D

The natural state is considered. As no emissions factors were available, assumed similar to the situation of re-wetting a bog after extraction.

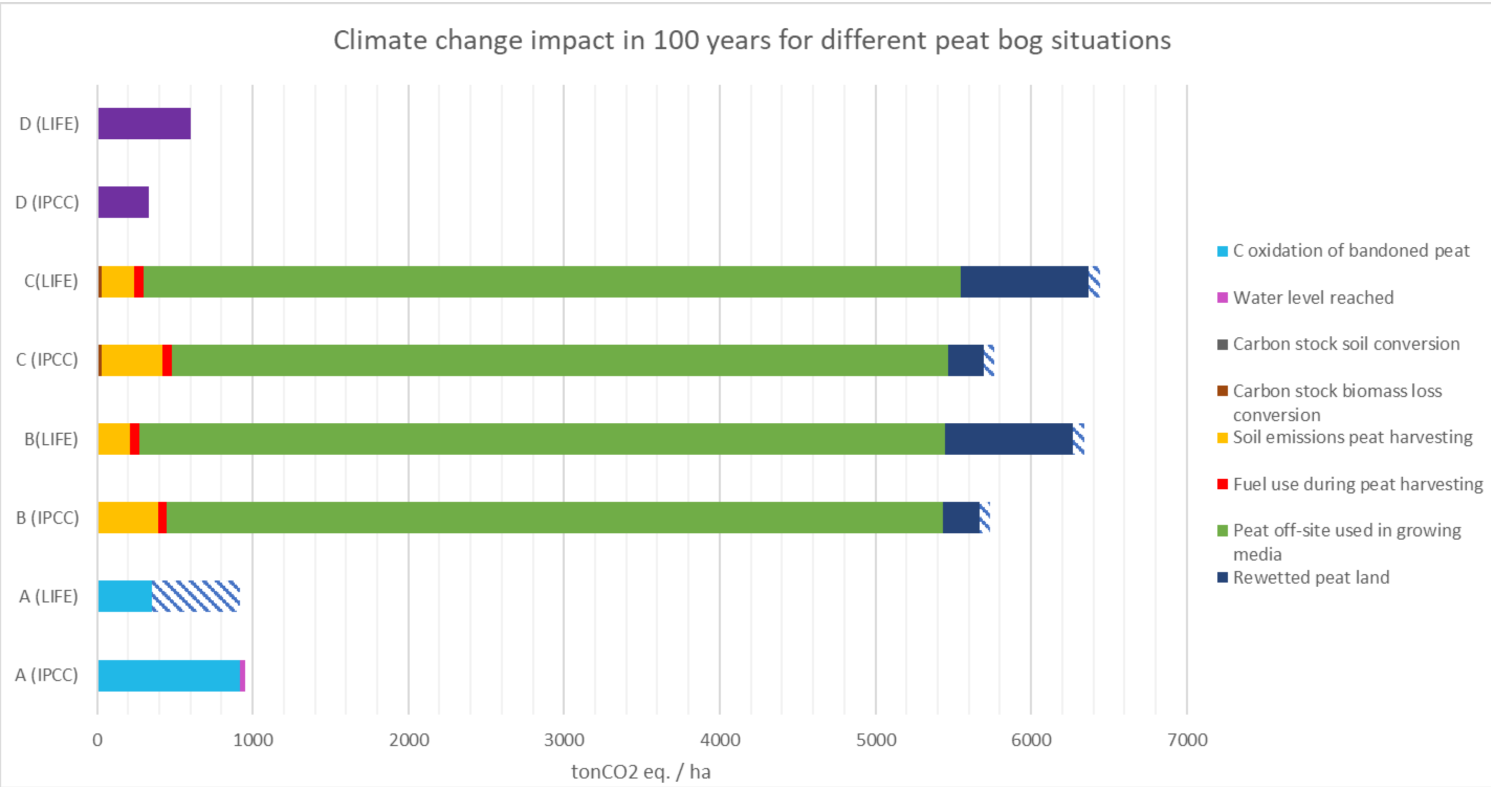

*Figure A- 1 Comparative results for 100-year emissions kgCO_2eq./ha of different peat scenarios using different emissions factors. Emissions beyond 100 years refer to: *Scenario A (LIFE): We assume peat C content will oxidize into CO2 until it reaches the water table. The country specific CO2 emission rate for Latvia is smaller than IPCC so it takes longer than 100 years for the peat surface to reach the water table.** Scenario C: Extracted peat continues to oxidize at a rate of -5% per year beyond 100 years until C in peat extracted is completely exhausted.*

Appendix II

The circular footprint formula (Zampori and Pant 2019)

Material $(1-R_1)E_v + R_1 \times \left(AE_{recycled} + (1-A)E_v \times \frac{Q_{Sin}}{Qp}\right) + (1-A) \times R_2 \times \left(E_{recyclingEoL} - E^*{}_v \times \frac{Qsout}{Qp}\right)$

Energy

$$(1-B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$$

Disposal

$$(1-R_2-R_3) \times E_D$$

A: allocation factor of burdens and credits between supplier and user of recycled materials.

B: allocation factor of energy recovery processes: it applies both to burdens and credits.

Qsin: quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.

Qsout: quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.

Qp: quality of the primary material, i.e. quality of the virgin material.

R1: it is the proportion of material in the input to the production that has been recycled from a previous system.

R2: it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.

R3: it is the proportion of the material in the product that is used for energy recovery at EoL.

Erecycled (Erec): specific emissions and resources consumed (per unit of analysis) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

ErecyclingEoL (ErecEoL): specific emissions and resources consumed (per unit of analysis) arising from the recycling process at EoL, including collection, sorting and transportation process.

Ev: specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material.

E*v: specific emissions and resources consumed (per unit of analysis) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.

EER: specific emissions and resources consumed (per unit of analysis) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, …).

ESE,heat and ESE,elec: specific emissions and resources consumed (per unit of analysis) that would have arisen from the specific substituted energy source, heat and electricity respectively.

ED: specific emissions and resources consumed (per unit of analysis) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.

$X_{ER,heat}$ and $X_{ER,elec}$: the efficiency of the energy recovery process for both heat and electricity.

LHV: Lower Heating Value of the material in the product that is used for energy recovery.

Appendix III

The EF normalization factors to be used are available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.