Growing Media Europe

Growing Media Environmental Footprint Guideline

V2.0

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Summary

Growing Media Europe AISBL (GME) is an international non-profit organisation representing the producers of growing media and soil improvers at the European level. The Growing Media Environmental Footprint Guideline (GMEFG) is part of GME's sustainability strategy. It provides detailed and comprehensive technical guidance on how to conduct a life cycle assessment (LCA) of growing media and their constituents.

The GMEFG provides growing media producers and users guidance on how to assess the environmental impacts of growing media in a consistent way to enable a uniform approach and comparability across the sector. The GMEFG also provides additional information necessary for the preparation of environmental impact assessments of products and processes in which growing media are an intermediate product.

The purpose of the GMEFG is to provide life cycle inventory (LCI) information on growing media mixes and constituents for use in LCA studies, horticultural studies, studies of any other process where growing media are an intermediate product. It can also be used for cradle-to-grave LCA studies of growing media for either internal or external communication.

Instructions are given for LCA practitioners on the scope and definition of GMEFG studies: functional unit, system boundaries, allocation methodology and impact assessment method.

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

Specific guidance on data management is provided, including mandatory primary data requirements and data quality evaluation methods. Secondary data that may be needed for GMEFG studies are also identified and recommendations are included on which LCA databases to use.

The GMEFG follows the latest international life cycle assessment guidelines relevant to the sector and, unless specifically stated in the document, has been developed in accordance with the European Commission (EC) Product Environmental Footprint Category Rules (PEFCR).

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Acronyms

AD: Activity data

B2B: Business to Business

B2C: Business to Consumer

BoM: Bill of Materials

CF: Characterisation Factor

CFF: Circular Footprint Formula

DEF: Direct elementary flows

DM: Dry Matter

DQR: Data Quality Rating

EC: European Commission

EF: Environmental Footprint

EFTA: European Free Trade Association

EI: Environmental Impact

EoL: End-of-Life

FU: Functional Unit

GHG: Greenhouse Gas

GM: Growing Media

GME: Growing Media Europe

GMEFG: Growing Media Environmental Footprint Guideline

GeR: 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

LUC: Land Use Change

NACE: Nomenclature Générale des Activités Economiques dans les Communautés Européennes

P: Precision

PEF: Product Environmental Footprint

PEFCR: Product Environmental Footprint Category Rules

Pt: Point

RF: Reference Flow

RP: Representative Product

RPP: Responsibly Produced Peat

SB: System Boundary

TeR: Technological Representativeness

TiR: Time Representativeness

TS: Technical Secretariat

UNEP: United Nations Environment Programme

Definitions

Acidification – Category of impacts caused by acidifying substances released to 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 soil and water when they are released in areas where the buffering capacity is low, resulting in forest decline and lake acidification.

Activity data – Information that is associated with processes included in models of 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 data 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 the study results.

Additive – growing media ingredient other than bulky constituents that is added to a mix on a weight basis, in grams or kilograms, to give particular physical and/or chemical or biological properties to the mix. They include, but are not limited to, fertilisers, liming materials, wetting agents, binders and plant biostimulants.

Allocation – An approach to solving multifunctionality problems. It involves '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, 2006a).

Average data – A production-weighted average of specific data.

Background processes – 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 are considered to be 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, subassemblies, intermediate assemblies, subcomponents, parts and the quantities of each needed to manufacture the product that are within the scope of the study. In some sectors it is equivalent to the bill of components.

Bulk density – apparent density of a growing medium, growing medium constituent, soil improver or soil improver constituent as received or reconstituted (EN 12580).

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

Business to consumers (B2C) – Transactions between a 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.'

By-product – output of a certain process that is not a determinant product (i.e. a product that is not relevant to the system under analysis).

Characterisation – Calculation of the magnitude of the contribution of each classified input/output to its respective EF impact category and aggregation of the contributions within each impact 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', CO_2 is chosen as the reference substance and kg CO_2 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.

*Coir – Coir is the fibrous husk (mesocarp) of the coconut (*Cocos nucifera*), underlying the smooth outermost layer (exocarp) and surrounding the hard woody layer (endocarp)* (GME, 2020)*.*

Coir chips – Coir chips are cut dry pieces of the coconut mesocarp comprised of the naturally occurring fibres and pith (GME, 2020)*.*

Coir fibres – Coir fibres are fibres that together with the coir pith form the mesocarp of the coconut. They are typically used for manufacturing mats, drainage pipe coverings, etc., but also as a growing media constituent (GME, 2020)*.*

Coir pith – Coir pith is the spongy tissue that lies between the coir fibres of the mesocarp of the coconut (GME, 2020)*.*

Company-specific data – 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 with 'primary data'. To determine the representativeness of the data a sampling procedure may be applied.

Company-specific dataset – A dataset (disaggregated or aggregated) compiled with company-specific data. In most cases the activity data is company-specific while the underlying subprocesses are datasets derived from background databases.

Composting system – composting using naturally occurring microbes which feed on the organic material and require oxygen. There are two types of composting systems: open and enclosed. The difference between open and enclosed composting depends on the presence (or not) of closed buildings provided with exhaust air capture and cleaning devices (typically, biofilters and scrubbers).

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) 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 to be 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.

Direct land use change – The transformation from one land use type into another in a unique land area and which does not lead to a change in another system.

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 or 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 is quantified by translating the quantity of substances emitted into a common measure that indicates the oxygen required for the degradation of dead biomass. Three EF impact categories are used to assess the impacts of 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 – 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 such as '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, CO_2 equivalent units) and specified time horizon (e.g. GWP 20, GWP 100 and 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 medium – A growing medium (plural media) is a product other than soil in situ, the function of which is for plants or mushrooms to grow in (GME, 2020).

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) – Changes outside the system boundary, i.e. in other land use types, resulting from demand for a certain land use. 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 enter a unit process. Products and materials include raw materials, intermediate products and co-products (ISO 14040:2006).

Intermediate product – Output from 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 can be sold to the end 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 size 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).

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 potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006).

Life cycle impact assessment (LCIA) – The 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 aggregate the impacts into 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 on a specified product or other reference (e.g. site, process), covering descriptive metadata and a quantitative life cycle inventory. A LCI dataset may be a unit process dataset, a partially aggregated dataset 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.

Mixing losses – This refers to product losses in volume when mixing products of different densities. For example, when you mix 50% of constituent A with 80 kg/m^3 and 50% of constituent B with 200 kg/m^3. In theory, the new density would be 140 kg/m^3, but in practice you could have a higher density after mixing as measured by EN12850. Mixing losses can be calculated using the following formula: $mixing\ loss = \frac{practical\ density - theoretical\ density}{theoretical\ density} \times 100\%$.

Multifunctionality – 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.

Normalisation – Normalisation is the step following characterisation 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. By 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 (NO_x, SO_x, NH_3).

Peat – A heterogeneous mixture of more or less decomposed plant (humus) material that has accumulated in a water-saturated environment and in the absence of oxygen (GME, 2020).

Peat harvesting – The process of removing peat raw materials from a peatland and collecting them (GME, 2020).

Peatland – An area with or without vegetation where organic matter accumulation has exceeded the decomposition rate (GME 2020).

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 man-made 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 practitioner. In this method, primary data is a 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 subcategory. Other weighting sets may be used, if justified, such as weighted average based on mass (tonne 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 as (or similar to) the distribution 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).

Responsibly Produced Peat – A certification scheme that does not allow peat extraction from high conservation value areas. It stimulates peat extraction from highly degraded areas followed up by appropriate after-use measures.

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 towards a specific attribute.

Secondary data – Data not from a specific process within the supply-chain of the company performing an LCA study. The data are 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 to be 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 – Directly measured or collected data from one facility (production site). It is synonymous with 'primary data'.

Specific data – Directly measured or collected data representative of activities at a specific facility or set of facilities. Synonymous with 'primary data.'

Supply chain – 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 – A specific aspect of the supply chain of a company. For example, the recycled content value of an aluminium may be produced by a particular 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 – Occurs 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 – The 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 – 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 – 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 AISBL (GME) is an international non-profit organisation representing the producers of growing media and soil improvers at the European level. GME 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.

The Growing Media Environmental Footprint Guideline (GMEFG) is part of GME's sustainability strategy and provides detailed and comprehensive technical guidance on how to conduct life cycle assessment (LCA) studies for growing media and their constituents.

The GMEFG follows the latest international life cycle assessment guidelines relevant to the sector and has been developed (unless specified in the document) in accordance with the Commission Recommendation on the use of the Environmental Footprint methods Annexes 1 and 2 (European Commission, 2021), which includes

- Annex I. Product Environmental Footprint (PEF) Method,
- Annex II Part A. Requirements to develop PEFCRs and perform PEF studies in compliance with an existing Product Environmental Footprint Category Rule,
- Annex II Part B. PEFCR template.

The GMEFG provides guidance to growing media producers and users on how to assess the environmental performance of growing media in a consistent way to enable a uniform approach and comparability across the sector. The GMEFG also provides additional information necessary for the preparation of environmental impact assessments of products and processes where growing media are an intermediate product, including assessments made using the guidance documents Hortifootprint Category Rules (HFCR), cut flower and potted plants Environmental Footprint Category Rules (Broekema et al., 2024) and fresh produce PEFCR (in development).

2. General Information

2.1 Guideline purpose and use

The GMEFG provides technical guidance for growing media producers and users. It has been developed with the objective of harmonising the calculation of environmental impacts in the growing media sector using LCA.

The GMEFG provides guidance for:

1) LCA of growing media as an intermediate product, the results of which are used in LCAs of products of processes in which growing media are used as an input;

2) LCA of growing media as a final product for internal or external use.

Basic LCA concepts and theory are not elaborated upon in this guidance document. Basic understanding and a certain degree of expertise in LCA is required by the practitioner.

In accordance with (European Commission, 2021), the GMEFG uses precise terminology to indicate the requirements, recommendations and options to be selected when carrying out a study.

• The term 'shall' is used to indicate what is required for a study to conform to this GMEFG.

• The term 'should' is used to indicate a recommendation rather than a requirement. Any deviation from a 'should' requirement must be transparent and justified in the study.

• The term 'may' is used to indicate a permissible option. If another available option is chosen, GMEFG compliant studies must include adequate argumentation to justify the chosen option.

2.2 Technical Secretariat

The first version of this document was published in May 2021 and was written by Paulina Gual, Elena Koukouna and Davide Lucherini of Blonk Consultants as technical advisers under the supervision of the GME Technical Secretariat.

The Technical Secretariat of the first version of this document consisted of the following GME members and industry experts:

- Arne Hückstädt (Industrieverband Garten)
- Cecilia Luetgebrune (GME)
- Cédric Abriat (Agaris)
- Fabrice Barraud (Premier Tech Horticulture)
- Folkert Moll (Kekkilä-BVB)
- Han de Groot (VPN)
- Hein Boon (RPP)
- Henri van Beerendonk (Jiffy)
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- Paul Alexander (Pindstrup)
- Paulina Gual (Blonk Consultants)
- Sander Golberdinge (Grodan)
- Simon Tabeling (Hawita Gruppe)
- Tanja Hyttinen (Biolan)

Version 2 of the Growing Media Environmental Footprint Guidelines, this document, is an update of version 1 and was written by Mariem Maaoui, Davide Lucherini and Meike Hopman under the supervision of the GME Technical Secretariat.

- Alexander Sentinella (Growing Media Europe)
- Folkert Moll (Kekkilä-BVB)
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- Nele Ameloot (Growing Media Europe)
- Richard Stevenson (Jiffy Group)
- Roline Broekema (Wageningen Economic Research)
- Roxane Chatel (DUMONA)

2.3 Consultation and stakeholders

A public open consultation of a draft of version 1 of the guideline was held to obtain feedback on the content. The open consultation started in November 2020 and was concluded at the end of December 2020. Over 300 comments of an editorial, general or technical nature were received and processed, resulting in version 1.0 of the GMEFG.

Stakeholders from the following institutions contributed to the open consultation process of version 1 of the guidelines: Wageningen University & Research, BVOR, Pindstrup, Floragard Vetriebs-GmbH, Legro Group, Jiffy Group, GME, ILVO, Agaris, Thünen Institute of Agricultural Technology, Estonian Peat Association (Eesti Turbaliit), Foundation Responsibly Produced Peat, RHP, Florentaise, Canadian Sphagnum Peat Moss Association (CSPMA), IPS, Kekkilä-BVB, Latvian Peat Association.

The Technical Secretariat maintained a log of the stakeholders who participated in the open consultation process of version 1 of the guidelines and responded to all comments received.

As part of the update to version 2 of the guidelines, the Technical Secretariat has identified the main topics to address in the GMEFG update based on input that was collected via an open request in October 2023. Four work sessions were organized to discuss the selected topics. After the four work sessions of the TS, an open consultation is organized by GME to collect feedback from stakeholders on the suggested approach for each of the selected topics. Stakeholders from the following institutions contributed to the open consultation process of version 2 of the guidelines: Agaris, ECN, Floragard, Florentaise, Gerald Schmilewski, Group DC, Guetegemeinschaft Substrate fuer Pflanzen e.V. (GGS), Jiffy Group, Meo Carbon Solutions, Responsibly Produced Peat, and Stichting Turfvrij.

2.4 Geographical validity

The GMEFG is valid for growing media products sold or used in the European Union, the UK and the European Free Trade Area.

Each study performed under this guidance document shall identify its geographical validity, listing all the countries where the growing media are used or sold and the relative market share. If the information on the market for the specific product under study is not available, Europe and EFTA shall be considered to be 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. If conflicts arise between translated versions and the original English document, the English version prevails.

2.6 Conformity with other documents and methodology

This document follows the guidance in the Product Environmental Footprint (PEF) (European Commission, 2021) Commission Recommendation on the use of the Environmental Footprint methods Annexes 1 and 2 (European Commission, 2021).) in compliance with ISO 14040 & 14044:2006.

The GMEFG also builds upon the following guidelines:

- 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories ((IPCC, 2019a)
- 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands
- PAS2050-1:2012 (BSI, 2012)
- PAS2050:2011 (BSI, 2011)

At the time this guidance was being updated, the PEF trajectory was in its final phase of transition, during which sector-specific Product Environmental Footprint Category Rules (PEFCRs) were being developed or revised. . Hence, there was no possibility to present a new PEFCR neither was it clear what the timeline for presenting new PEFCRs might be.

It is also important to highlight that the PEFCR for cut flowers and potted plants (FloriPEF) was published during the update of this guidance and it directly refers to the first version of the GMEFG 1.0, from 2021. In particular, the GMEFG 1.0 is mentioned in the chapters related to the emissions modelling of growing media as well as data collection and requirements.

The "shadow PEFCR" for Fresh Produce is also under development at the time of updating this guidance, coordinated by WUR and with Blonk as part of the Technical Secretariat. In this case, alignment is also to be sought between the FloriPEF, the GMEFG, and the shadow PEFCR Fresh Produce. However, there is no certainty yet on how growing media modelling will be tackled in this last guideline. As this situation develops, additional information and updates will be posted on the GME webpage.

3. Scope

The scope of the GMEFG is growing media consisting of a single constituent or a mix of constituents to be used in the professional or hobby markets as intermediate or final products.

3.1 Product classification

A growing medium is a product other than soil in situ in which to grow plants or mushrooms. Growing media are mixes or single constituents 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, agriculture, forestry, and by private consumers to support healthy plant development (GME, 2019).

3.1.1 Common applications

Growing media (single constituents or mixes) can vary widely in composition, depending on the end application and user needs.

Examples of applications and representative growing media are presented in Table 3-1. This list is illustrative and not exhaustive or exclusive. No aggregated representative product has been defined for this guideline.[1]

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

Application	**Constituent**	**% vol/vol**
Pot plants & ornamentals	White peat (milled)	35%
	Black peat	20%
	White peat (sod)	20%
	Coir pith	15%
	Expanded perlite	10%
	Additive	**kg/m³**
	Limestone	3
	Fertiliser mix	0.6
Application	**Constituent**	**% vol/vol**
Soft fruits or tree nursery stock	White peat fibres	25%
	White peat (sod) (different fractions)	40%
	Expanded perlite	10%
	Wood fibre	25%
	Additive	**kg/m³**
	Fertiliser mix	3.5
	Limestone	2
Application	**Constituent**	**% vol/vol**
Hobby market	White peat (different fractions)	30%
	Black peat	20%
	Coir pith	20%
	Green waste compost	10%

[1] PEFCR 2021 indicates that a single representative product (real or virtual) shall be modelled in a PEFCR based on the European market situation at the time of the development of the study. The representative product shall be representative of all existing technologies/materials covered by the product category or subcategory. This has not been done in the GMEFG because of the high variability of mixes. No single representative product modelled would encompass all possible applications or deliver any significant additional information as benchmark.

	Composted bark	10%
	Fine bark fraction	10%
	Additive	**kg/m³**
	Clay	5
	Limestone	2.5
	Organic fertiliser	4
Application	**Constituent**	**%vol/vol**
Tomatoes & fruity vegetables	Stone wool	100%

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

3.1.2 Growing media constituents

Depending on the application, growing media may consist of only one constituent (mono-material) or a mix of different organic and/or mineral constituents. A description of different common bulky (volume binding) growing media constituents is given in Table 3-2 (GME, 2020). This list is non-exhaustive.

Table 3-2 Common growing media constituents

Constituent name	**Description**
Weakly (low) decomposed peat	Type of moss or raised bog peat, which mainly consists of various types of *Sphagnum*, Cotton grass, Rannoch rush and wood fragments. Low decomposed up to 20% (<4H von Post scale); acidity (pH) ranges from 3.0 to 4.0. The main characteristic of this peat is its high air and water absorption and distribution capacity. (Colloquially called 'white peat'.)
Strongly (well) decomposed 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. This peat comes from the lower, highly decomposed peat layer. (Colloquially called 'black peat'.)
Bark	Bark from coniferous (softwood) trees that is either fresh, aged or composted for use in growing media, soil improvers and mulches. Bark as a growing media constituent, can be used as is or can be composted (aged). Composting of bark can take place in open or closed systems. Most of the volume is aged in a heap with no additives input and frequently mixed (aging time: 12-18 months). In general, urea is not applied, only in case of missing volumes of specific sizes.
Coir	Coir products originate from the mesocarp of the coconut (Cocos nucifera), which consists of the fibres and 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 mm) depending on the intensity of the combing and sieving between 2 and 20% (v/v). However, especially assembled mixtures of fibres and pith are also available. To reduce and/or alter salt concentrations the coconut pith can be buffered by adding specific fertilizers and water. Calcium chloride is mainly used for buffering in Europe and calcium nitrate is mainly used for buffering in Asia. Nitric acid is also used. Coir can also be just washed (actively by watering or during aging by monsoon rain).

Expanded perlite	Glassy volcanic rock, crushed, sieved and then 'popped' at about 1000°C. In horticulture, expanded perlite is used as a constituent in potting soil mixtures and as pure substrate.
Wood fibres	Wood fibres are mechanically and thermally frayed wood (softwood) for horticultural purposes. Disc refining as well as extrusion are commonly used practises by some companies. If necessary, conditioning agents are added during the production process to stabilise the nitrogen balance as well as dying agents. The density of wood fibre could largely differ from one producer to the other depending on many factors such as the 'fluffiness' and compressibility of the wood fibre.
Compost	Compost is the product of a biological decomposition process under aerobic conditions, in which during several weeks the organic residues are turned into a substrate constituent rich in humus and nutrients. The purpose of composting is to return organic green residues to the materials cycles and to use compost in the various fields of agriculture and horticulture. The vast majority of compost used for growing media is from green waste and composted in open or closed systems.
Stone wool	Stone wool is produced by melting basalt and limestone after the addition of coke at elevated temperatures. Stone wool is mainly used as a mat in vegetable and flower production.

3.1.3 Growing media additives

Additives are materials other than the bulky constituents that convey diverse physical, chemical and/or biological properties to the growing media. Common additives are nutrients (fertilisers), which are added for plant growth or lime, to increase the pH of the growing media.

3.2 Growing media product types

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

Growing media as intermediate or business to business (B2B) products are inputs to other economic activities. Intermediate products are assessed from cradle to gate (European Commission, 2021) . According to the 2021 PEF guidance, the use and end-of-life (EoL) stage shall be excluded for intermediate products. However, in this GMEFG, practitioners studying intermediate products may choose to model use and EoL for the product under study, in which case the impacts corresponding to use and EoL shall be reported separately.

Growing media as final or business to consumer (B2C) products are the main products in the economic activity. In this case, the product environmental impact shall be evaluated from cradle to grave, including use and EoL.

3.3 Reference flow

The reference flow for growing media (both as intermediate and final products, 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 or in bulk) to the user. Changes in volume during use (e.g. compression) shall not be taken into account. All activities necessary to deliver 1m^3 of fresh product to the user shall be considered.

Table 3-3-3 Growing media functional unit

What?	*Growing media mix or mono-material for a specific growing application.*
How much?	*1 m^3 of fresh growing media as delivered (packed or in bulk) to the professional or hobby user. (Bulk density to be determined according to EN 12580).*
How long?	*As long as growing media fits users' purposes.*
How well?	*Fit for purpose, right product for right application.*

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

Details on the verification procedure are provided in section 7.

3.4 System boundary

The system boundary that should be applied is illustrated in Figure 1. Please note that two system boundaries are defined, one for growing media as intermediate products and one for final products. Table 3-4 provides a short description of the life cycle stages that should be considered from the perspective of the growing media producer.

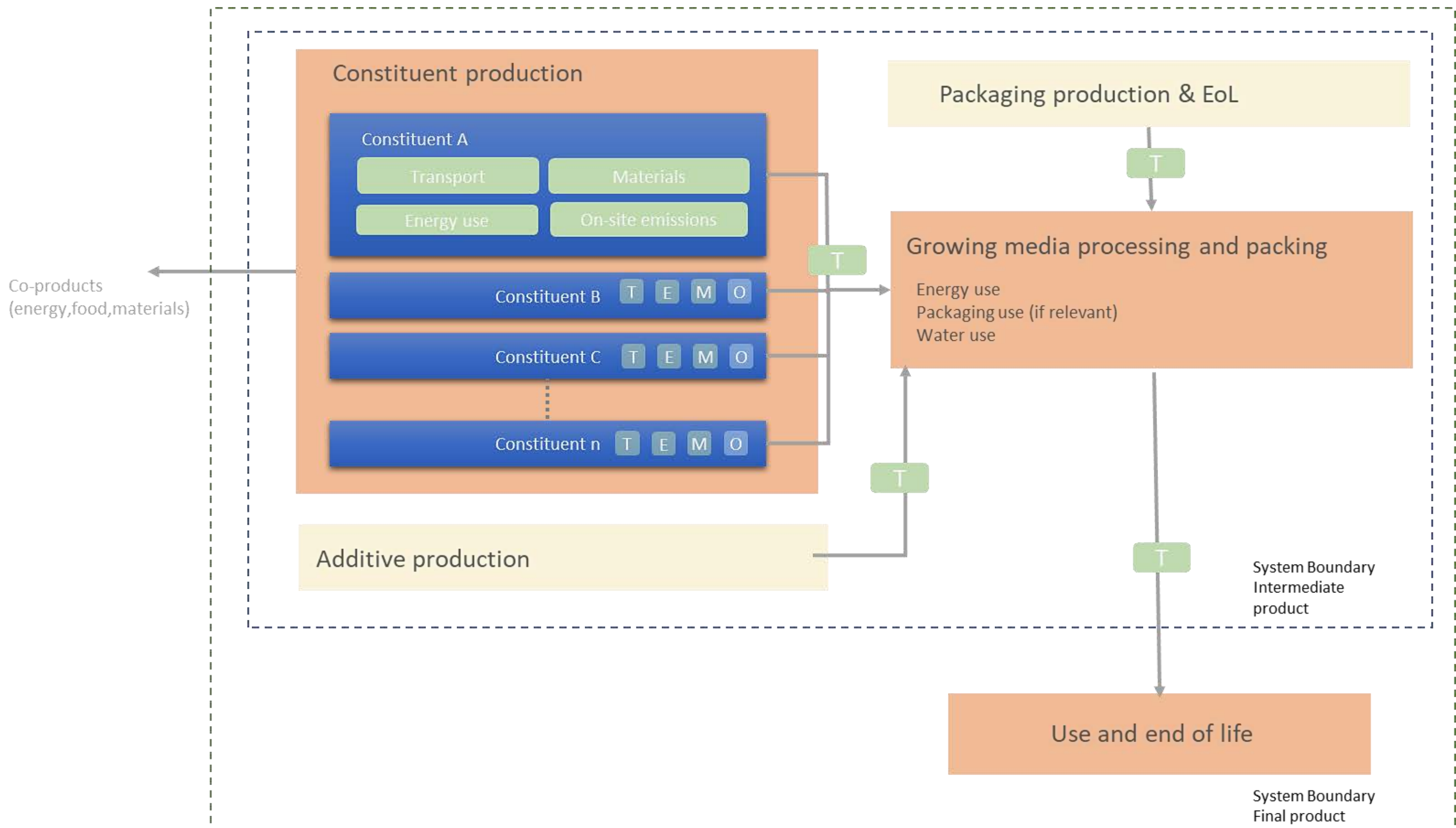

Figure 1 Simplified system boundary for a GMEFG study

Table 3-4 Description of the 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 and packed.
Packaging production	Refers to the production of primary, secondary and tertiary packaging material for growing media sold to end users. In this guideline, as further explained in section 5.1.3, both production and EoL of the packaging material are included 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 bagged or bulk growing media to the 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 to and associated emissions from the production of individual constituents and additives. Growing media constituents vary in source and type. Depending on the type of constituent, the 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 harvesting site. It includes all drained area required for peat extraction. Coconut coir considers the impacts of coconut farming, de-husking, coir production and the cleaning and buffering of coir. Details of the required inventory for different constituents can be found in section 5.2.
Use and EoL	Use and EoL refer to the emissions from the decomposition of organic components in growing media and related nitrogen emissions derived from the fertiliser content (additives) of the growing media. This stage considers, if applicable, the reuse or recycling of growing media.

According to the PEF guidance, production of capital goods can be left out of scope, unless there is evidence from previous studies that they are relevant. Capital goods are the buildings, machines and equipment that are used to produce products or provide services. More information and details on how to model each life cycle stage is provided in section 5.

3.5 Multifunctionality

3.5.1 Handling multifunctionality

If a process or facility has more than one function, it is a multifunctional process. In these situations, all inputs and emissions linked to the process shall be allocated between the product of interest and the co-products.

Whenever possible, allocation shall be avoided by dividing the main process into two or more subprocesses and collecting input/output data for each or by expanding the product system to include the additional functions related to the co-products, following the guidance in ISO 14044 (ISO 2006b).

In all other cases, allocation shall be based on relevant physical or other relationships between co-products. For common situations in which allocation may be required, it shall be performed as described in section 3.5.2.

3.5.2 Allocation

Where necessary, allocation of environmental impacts shall be performed as described in Table 3-5. Details on when to apply allocation in the different growing media life cycle stages, and exceptions to this depending on product specifications, are available in section 5.

Table 3-5 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 described in section 4.4.3 (European Commission, 2021). When using primary activity data, practitioners may modify the utilisation ratio (kg load/kg payload) in EF compliant datasets, including empty returns (if applicable). If no primary information is available, a utilisation 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 utilisation ratios. Further information on this approach can be found in section 4.4.3 (European Commission, 2021).
Co-products in constituent and additive production	Economic allocation	Economic allocation means allocating inputs and outputs associated with multifunctional 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 (European Commission, 2021).
Growing media plant operations when only average data are available	Physical allocation	When only average plant data available, impact related to plant operations, shall be attributed per m^3 of growing media produced in a year.

3.6 Impact assessment

The impact assessment method groups the collected inventory flows from the LCI according to their contribution to specific environmental impact categories. For this GMEFG, the recommended default impact assessment method is the latest EF impact category developed by the European Commission (EC) for the PEF/PEFCR projects, which at the time of publication is EF 3.1

Each study that is carried out in compliance with this GMEFG shall calculate the environmental profile of growing media including all impact categories listed in Table 3-6 or in accordance with to the most recent EF impact assessment method.

Table 3-6 Impact categories with respective impact category indicators and characterisation models to be used in the GMEFG as reported in European Commission 2021 .

EF Impact category	Indicator	Unit	Characterization model	Robustness
Climate change*	Radiative forcing as Global Warming Potential (GWP100)	kg $CO_{2\ eq}$	Bern model - Global warming potential (GWP) over a 100-year time horizon based on IPCC 2021 (Forster et al., 2021)	I
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	EDIP model based on the ODPs of the World Meteorological Organisation (WMO) over an infinite time horizon (WMO, 2014+integrations)	I
Human toxicity, cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	Based on USEtox model 2.1 (Fantke et al., 2017), Rosenadapted as in Saouter et al., 2018)	III
Human toxicity, non-cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	Based on USEtox model 2.1 (Fantke et al., 2017), adapted as in Saouter et al., 2018)	III
Particulate matter	Human health effects associated with exposure to PM2.5.	disease incidences	PM model (Fantke et al., 2016 in UNEP 2016)	I
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq $U^{235}{}_{eq}$	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 applied 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 applied in ReCiPe	II
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N_{eq}	EUTREND model(Struijs et al., 2009) as applied in ReCiPe (Huijbregts et al., 2016)	II

Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	Based on USEtox model 2.1 (Fantke et al., 2017), adapted as in Saouter et al., 2018	III
Land use	Soil quality index[1]	Dimensionless (pt)	Soil quality index based on LANCA model (De Laurentiis et al., 2019) and on the LANCA CF version 2.5 (Horn & Maier, 2018)	III
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 water eq of deprived water	Available WAter REmaining (AWARE) model (Boulay et al., 2018; UNEP, 2016)	III
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb $_{eq}$	(van Oers et al., 2002 as in CML 2002 method, v.4.8	III
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	(van Oers et al., 2002 as in CML 2002 method, v.4.8	III

[1] This index is the result of the aggregation, performed by JRC, of 4 indicators (biotic production, erosion resistance, mechanical filtration and groundwater replenishment) provided by LANCA model for assessing impacts due to land use as *reported in European Commission 2021*.

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

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

Biogenic emissions are those that originate from biological sources such as plants, trees, and soil. Biogenic carbon emissions relate to the natural carbon cycle (Harris et al., 2018).

No biogenic CO_2 uptake and capture shall be accounted, following the simplified approach for biogenic carbon reporting of the PEF guidance (European Commission, 2021).

Carbon contained in peat is considered non-biogenic (peat is treated as a fossil carbon as it takes so long to replace harvested peat (IPCC, 2019b))., while carbon contained in wood, coir, and other biomass-based materials is considered biogenic. In other words, all biomass contains non-fossil carbon except for peat.

Absolute characterised results per impact category shall be reported in all cases. Following the steps of classification and characterisation, the impact assessment shall be complemented with normalisation and weighting to calculate the PEF single score, which is an aggregation of the different impact category results into one single value. Normalisation and weighing factors provided in the EF 3.1 method are available in Table 3-7.[2]

[2] According to the ISO 14044 standard on life cycle assessment, normalisation 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.’

Table 3-7 : Normalisation and weighting factors from the EF reference package 3.1 (European Commission, 2021)

EF impact categories	Normalisation factor	Unit normalisation factor	Weighting factors (%)
Acidification	5.56E+01	mol H+ eq./person	6.2
Climate change	7.55E+03	kg CO_2 eq./person	21.06
Eutrophication, freshwater	1.61E+00	kg P eq./person	2.8
Eutrophication, marine	1.95E+01	kg N eq./person	2.96
Eutrophication, terrestrial	1.77E+02	mol N eq./person	3.71
Freshwater ecotoxicity	5.67E+04	CTUe/person	1.92
Human toxicity, cancer	1.73E-05	CTUh/person	2.13
Human toxicity, non-cancer	1.29E-04	CTUh/person	1.84
Ionising radiation, human health	4.22E+03	kBq U-235 eq./person	5.01
Land use	8.19E+05	pt/person	7.94
Ozone depletion	5.23E-02	kg CFC-11 eq./person	6.31
Particulate matter	5.95E-04	disease incidences/person	8.96
Photochemical ozone formation, human health	4.09E+01	kg NMVOC eq./person	4.78
Resource use, fossils	6.50E+04	MJ/person	8.32
Resource use, minerals and metals	6.36E-02	kg Sb eq./person	7.55
Water use	1.15E+04	m^3 water eq. of deprived water/person	8.51

3.7 Additional environmental information

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

3.7.1 Carbon and nutrient content

This information includes the bulk density of the final growing media, its moisture content, the carbon content of the peat-based constituents in the growing media in kg C/m^3 as delivered to the client, the nutrient content (NPK) of the growing media, and the nutrient (NPK) and limestone content of each additive in kg/m^3 (section 5.1.1). This information (listed above) 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).

3.7.2 Biodiversity

The current PEF method does not include any impact category on ‘biodiversity’ although an impact on biodiversity is partially captured in the categories listed in section 3.6 (table 3-6) through per example land use, climate change, eutrophication. As there is no consensus yet on a method to capture this impact, this category is added as additional environmental information in line with PEF guidance (European Commission, 2021).

The impact on biodiversity may be evaluated using the ReCiPe 2016 method endpoint categories for Ecosystem quality: terrestrial, freshwater and marine (Huijbregts et al., 2016) and shall be reported as a single score in additional environmental information.

Details on the ecosystem health indicator are available in the ReCiPe 2016 method (Huijbregts et al., 2016). The approach to reporting impacts on biodiversity may be updated when more information is available from the PEF methodological development.

3.8 Limitations

- A cradle-to-user growing media study will not capture the consequences of its application in horticultural activities and the related emissions from the growing media during its use. The use and EoL for intermediate products are outside of the scope of this GMEFG. For intermediate (B2B) products, the grower does their own calculations for use and EoL, which is more than just the EoL of growing media, but also includes energy inputs and food waste. In other words, The EoL in B2B can be accounted for but only as additional information, so not part of the product footprint. For B2C, consumers will not do any additional calculations, so it is required to communicate footprints including use and EoL to provide the full picture.
- Default emission factors for soil emissions from peat harvesting are limited to the source deemed best available, the IPCC 2013 Wetlands Supplement (IPCC, 2014). It is acknowledged that experts in the field have mixed opinions on these emission factors, but the Technical Secretariat considers these to be the best available at the time of preparing this guidance document. The GMEFG allows and encourages the use of direct measurements or country-specific emission factors for soil emissions from peat harvesting. No other sources are available for default values.
- When it comes to emissions from stockpiling in peat harvesting, a default value is given in this guidance. This is considered as a limitation as the emissions are scattered and not case-specific. Therefore, direct measurements are encouraged.
- Default emission factors for composting given in the literature differ widely and each available source reports on different sets of emissions. The GMEFG gives two sets of default emissions (open and enclosed composting) to allow practitioners to select the option which better reflects their situation. The poor availability of good default emissions for composting is acknowledged and direct emissions are encouraged whenever available.
- The GMEFG assumes full carbon oxidation of peat containing growing media in the use or EoL phase. No integration into the soil organic matter is considered. This is a conservative approach, reflecting the unpredictability and limited knowledge about the complex environmental relationships and parameters that may affect the level of peat oxidation, such as climate and soil type. It also aims to prevent compost producers or users overlooking emissions from remaining carbon in peat constituents. This aspect can be improved in later versions of this guideline.
- Claims and comparisons between intermediate and final products are not possible in this guideline as the system boundary of the studies are different.

3.9 Comparisons and comparative assertions

In line with the PEF Recommendations (2021) and ISO 14025, comparisons and comparative assertions are only allowed when the products fulfil the same function, as expressed in the functional unit. This means that only growing media that have a similar application and use can be compared. Any comparison needs to include at least the most contributing impact categories, as defined by the PEF, in order to illustrate potential trade-off between relevant impact categories. Overall comparisons are also based on single score results (i.e., characterized, normalized, and weighted results). A trade-off is when an impact category (e.g. water use) is lower for product A in comparison to product B and another impact category (e.g. carbon footprint) is higher for product A in comparison to product B. Any comparative assertion intended to be disclosed to the public shall be subject to verification by an independent verifier that is external to GME. The verification process and other conditions that the verifier needs to meet are detailed in Chapter 7 and appendix IV. For studies that are not reviewed by an independent third-party reviewer, please refer to section 7.1.

It is important to note that a lower environmental impact per m^3 of growing media does not necessarily imply a lower impact in the application of growing media, as that is highly dependent on the additional inputs required and the production of the final product (e.g., 1 kg of tomatoes) per m^3 of growing media. See Table 3-8 for an illustrative example in which mix A has a lower impact per m^3 of mix, but a higher impact (of the growing media mix) per kg of tomatoes.

Table 3-8: Illustrative example of comparative assertion

	Mix A	**Mix B**
Environmental impact per m^3 growing media mix (pt)	1	2
Amount of growing media mix per kg tomatoes (m^3)	3	1
Impact of growing media per kg tomatoes (pt)	1*3 = 3	2*1 = 2

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 within the system boundary.

Primary data shall be collected for all processes described in section 4.1. This is mandatory for a study to be considered compliant with this GMEFG. All processes not included in section 4.1 are non-mandatory for primary data and secondary data may be used for those processes. Practitioners may, however, make use of primary data where these are accessible and shall communicate which processes are modelled using primary data and which are modelled using secondary data.

Although primary data collection is recommended in all cases where the practitioner is the owner of the life cycle process, at this time the Technical Secretariat 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, the LCA practitioner (not necessarily a tool user) shall indicate which data are from primary data sources and which are from secondary sources.

One option for primary data collection is sampling. Based on PEFCR guidance (European Commission, 2021), in some cases the practitioner will need to use a sampling procedure to limit data collection to a representative sample of plants/processes. A sampling procedure may be needed, for example, where multiple production sites are involved in the production of the same product unit. This may be the case when the same raw material/input material comes from multiple sites or when the same process is outsourced to more than one subcontractor/supplier. If needed, sampling shall be performed in compliance with section 4.4.6 of the PEF document (European Commission, 2021)

4.1 Mandatory primary data collection

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

4.1.1 Growing media composition

Use of company-specific data is required for the list of the different constituent components (bill of materials) for the growing media mix or mono-material. If primary data is not used for this composition the study will not be compliant with this GMEFG. The constituent list shall add up to 100% of the volume composition for 1m^3 of growing media as delivered to the user, excluding additives (see section 5.1.1), and a corresponding mass balance shall be provided. All additives (if applicable) shall be included and reported separately, based on their use in mass per m^3 of growing media delivered to the 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 should exclude operational activities such as office lighting or employee transport. If operational activities cannot be excluded, this shall be reported and justified in the study. Data shall be recorded according to details provided in the life cycle inventory (LCI) (section 5.1.2).

Data can have different levels of accuracy:

- The minimum level of accuracy 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 on specific mix or mono-material mixing/processing and packing should preferably be based on measurements. If measurements are not possible, data shall be based on an analysis in which use of energy and auxiliary material are derived from technical specifications for the equipment.

Utility consumption measurements shall be allocated per m^3 of final growing media delivered to the user, as indicated in Table 3-5 in section 3.5.

4.1.3 Outbound transport

Primary data shall be collected for outbound transport. Outbound transport is defined as the transport from the growing media production plant to the 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.

Whenever storage at warehouse or retail premises is required before the product reaches the consumer, this shall be considered in outbound transport. Possible losses of material during this stage shall also be considered when modelling the necessary product to deliver 1m^3 of growing media to the user. According to PEF (European Commission, 2021), the default distribution losses rate of 1% can be used for ''other garden supplies'' (which includes growing media transport).

4.2 Data quality requirements

The data quality of each new dataset and of the total study shall be calculated and reported. Data quality shall be evaluated in alignment with the data quality rating (DQR) calculations and requirements described in the latest PEFCR guidance (European Commission, 2021), as described below.

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

$$\mathrm{DQR} = \frac{\mathrm{TeR} + \mathrm{GeR} + \mathrm{TiR} + \mathrm{P}}{4} \qquad \textit{Equation 1}$$

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 depict the system analysed, while the precision indicates the way the data are derived and at what level of uncertainty.

The DQR defines five quality levels (from excellent to poor), as summarised 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 using company-specific primary activity data.

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

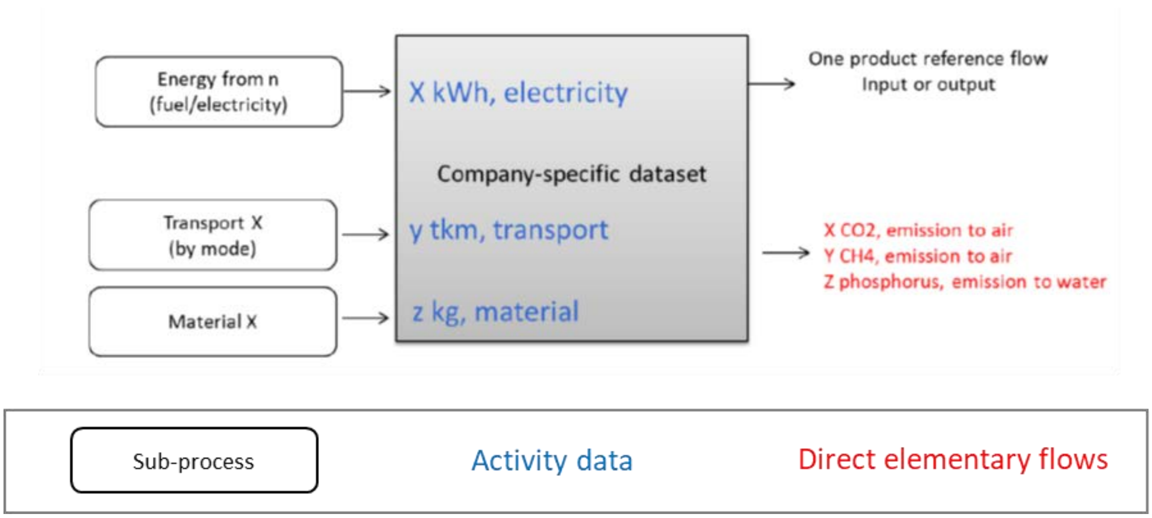

Figure 2 Representation of company-specific data set for a process (from European Commission, 2021)

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: the most relevant activity data are the ones linked to subprocesses (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset for a specific process. This contribution is determined listing the subprocesses in order from biggest to lowest contribution to a single impact score (Pt). This means that 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 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	P-DEF and P-AD	TiR-DEF and TiR-AD	TeR-DEF and TeR-AD	GeR-DEF and GeR-AD
1	Measured/calculated and externally verified	The data are for 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 and plausibility checked by reviewer	The data are for no more than two annual administration periods with respect to the EF report publication date	The elementary flows and the activity data are a proxy for the technology of the newly developed dataset	The activity data and elementary flows partly reflect the geography where the process modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by the reviewer, OR Qualified estimate based on calculations and plausibility checked by reviewer	The data are for no more than 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 contribution made by activity data and elementary flows to the total DQR, calculate the environmental contribution of each most relevant activity data (by linking to the appropriate subprocess) and direct elementary flow to the sum total of the environmental impact of all the most relevant activity data and direct elementary flows, in % (weighted, using all impact categories). For example, if 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 100/80 x 30% = 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 100/80 x 50% = 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 criterion of the most relevant activity data and direct elementary flows. The weight is the relative contribution (in %) made by 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 $Te\bar{\bar{R}}$, $G\bar{\bar{R}}$, $Ti\bar{\bar{R}}$,$\bar{\bar{P}}$ are the weighted average calculated as specified in point (4).

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

Guidance to calculate DQR values for the mandatory company-specific data in this GMEFG is given in section 5.5.

4.2.2 DQR of secondary datasets

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. The secondary database for this guideline is not yet available at the time of release.

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 within 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 carrying out 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.

The following LCA databases are the preferred sources to be used:

- The latest version of Agri-footprint (currently 6.3) (Blonk et al., 2022)
- The latest version of Ecoinvent (currently 3.10) (Ecoinvent, 2023)
- The latest version of the GME database as implemented in the GME tool

The GME LCA platform methodology report includes a detailed list of suggested datasets to be used from Agri-footprint and Ecoinvent. This report also includes the Life Cycle Inventory containing the activity data used for all modelled datasets in the GME database.

Note that the GME database focuses on constituents, as these are sector specific datasets not widely available in LCA databases. The GME database is finished but will be updated to include more materials. Please check the GME website for updates. For constituents not available in the GME database, a proxy can be selected from Ecoinvent or Agri-footprint.

The EF 3.1 (European Commission, 2023)datasets are only available for existing PEFCRs and cannot be used in other studies. The EF 3.1 datasets were modelled similarly to the GME datasets. However, some modelling choices have been updated and refined in the GME datasets to be more aligned with growing media production in practice. The main update is peat modelling. In the EF 3.1 database, particulate matter emissions from peat were omitted. Additionally, flows associated with land occupation were also excluded. Therefore, these flows and emissions were omitted.

It is to be noted that the Technical Secretariat seeks alignment of growing media specific data with the EF datasets made available by the PEF. However, at the time of publication of this guidance, the EF 4 datasets that are under development do not contain yet growing media datasets.

In some cases, no relevant data will be available in databases. In such cases, proxies (regional or global averages for the constituent or product group average) will need to be used. Using proxies always lowers data quality (i.e. higher DQR). The use of proxies shall be described and justified in the study.

Due to the relatively large amount of primary data that is required in the modelling, it is also expected that data gaps might arise. Hence, all data gaps, limitations, and assumptions shall be transparently reported in the LCA study.

During the writing of this guidance, data gaps were also encountered either due to limited existing literature or lack of data available from the industry. The best information available to the Technical Secretariat has been used to develop this guidance. In the case where multiple sources of data have been identified for a certain emission or resource flow, it has been decided that an average value shall be used. This average-based approach is described for every case it is applied to within this document.

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

A growing media product can be a mix of constituents or a 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 listed as illustrated in 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 up to 100% vol/vol for a fresh mix and shall specify the fresh bulk density and moisture content as delivered to the client (Table 5-1).

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

The total volumes of each constituent used for the mix shall account for product losses when mixing. *This refers to product losses in volume when mixing products of different densities. For example, when you mix 50% of constituent A with 80 kg/m3 and 50% of constituent B with 200 kg/m3. In theory, the new density would be 140 kg/m3, but in practice you have a higher density after mixing.* To ensure correct considerations in constituent use, a mass balance of the required constituents and total mix shall be provided.

When modelling the growing media, practitioners shall use the correct moisture contents and bulk densities of all the constituents to avoid inadvertent overestimates or underestimates of material input when integrating the mix for calculation. When the moisture content and/or bulk density of a constituent at production changes before the final mix, this shall be registered and considered in the mass balance before calculating the amount of material required for the final growing media (e.g, coconut coir pith expansion and rewetting before mixing).

Losses in mixing shall be reported and considered in the amount of product to be delivered to the consumer according to the functional unit.

Table 5-1 List of constituents for growing media; all constituents shall add up to 100% in volume to guarantee that all constituents are considered

Constituent	**vol/vol [%]**	**Bulk 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 up to 100% of the total mass needed to produce 1m^3 of stone wool growing media (taking losses into account). Stone wool volume shall be determined from 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 1m³ of stone wool to guarantee that all components are considered.

Ingredient	kg/m³
Ingredient A	A
Ingredient B	B
Ingredient C	C

It is not required 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 should be modelled in accordance with the guidelines described in section 5.2.

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

For stone wool, each ingredient in the BoM shall be connected to an appropriate 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 their 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

Additives	kg/m³ of GM mix	Additional information
A1		If fertiliser, nutrient content to be indicated as additional environmental information (section 3.7).
A2		
A…n		

The next step is to connect all additives listed 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 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.

The exact composition of the growing media being studied shall be used when performing a study, as using proxies might drastically change the results.

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

If no primary data are available, the practitioner shall assume no material waste results during the mixing process as most of it will be recirculated to produce other growing media and will not leave the factory. If waste streams are known, they shall be accounted for and the appropriate waste management selected from secondary data.

5.1.2 Energy and utility consumption in factory operations

Data on the energy use in mixing/processing operations and the packaging of growing media 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 growing media production facility in accordance with the plant's bookkeeping. The data shall be recorded according to the format in Table 5-4. In the fifth column, the method of measurement should be explained, including the sources of information and any conversion of information and related assumptions.

The accuracy of data on electricity, fuel, heat and water use shall be based on the scope of the study as described in section 4.1.2. When data on specific energy/utility consumption to produce 1m^3 of a certain mix or mono-constituent are available, no allocation is required. If only average plant consumption data are available, energy and utility measurements should be divided over the specific products produced, allocating the energy use of the entire factory to the subproducts 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**	**Type**	**Quantity**	**Source and related assumptions (if relevant)**
Electricity use	kWh	*(energy carrier and technology)*		
Gas use	MJ			
Heat use	MJ			
Other energy input (specify type)	MJ			
Water (specify type)	m^3	*(Tap, surface, ground…)*		

In the next step, activity data are linked to secondary data on energy production and water supply, matching the correct type indicated.

5.1.3 Packaging use and production

Data on packaging material use shall be based on the amount and type of material used per m^3 of growing media packed. This includes primary, secondary and tertiary packaging. Packaging material use shall be connected to secondary data on packaging production, based on the amount and type of material in the inventory. Secondary data used for packaging shall include the EoL of the packaging material based on the national or average European waste management system (see section 4.4.8.1 of European Commission, 2021).

When supplier-specific information on packaging production is available, the packaging production may be modelled according to section 4.4.8 of the PEF document (European Commission, 2021). When using primary data, the EoL of the packaging should be modelled in this life cycle stage, taking into account the use location of the growing media and the specific waste management system of the use location.

Production and EoL of packaging shall be modelled using the circular footprint formula as defined in (European Commission, 2021)) and described in this document in Appendix III.

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 the growing media plant:

- The production location (processing plant or extraction location) of the constituent or additive, and distance to the 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.
- The share of the different modes of transport used to travel the distance from the production location to the growing media plant.

The transport of materials and the logistics related to the production of individual growing media constituents shall be integrated into the modelling of each individual constituent. The same considerations apply as above, taking into account the production locations and distances from supplier to plant.

If the practitioner cannot determine the transport distances and transport modes, default data on distances and modes shall be used. Default distances and modes can be found in section 4.4.3 of (Zampori, 2019) (European Commission, 2021).

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

5.1.5 Outbound transport

Outbound transport is a mandatory company-specific process. Primary data shall be collected for distribution operations to the 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 transport to user;
2. producer-specific delivery distance and mode of transport;
3. average fuel consumption per m^3 delivered and mode of transport;
4. average distance from plant to final user and mode of transport.

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

If data on the actual fuel use of outbound transport can be collected, this data shall be used. Fuel use data shall be connected to secondary data on fuel production and combustion. Actual fuel use data shall be collected as illustrated in 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/tonne delivered GM (specify unit)			
Fuel (type 2)	unit/tonne delivered GM			
Fuel (type 3)	unit/tonne delivered GM			
Fuel (type 4)	unit/tonne delivered GM			

* Tonne of delivered growing media (GM) should include growing media (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 from the distance according to steps 2 or 4 of the hierarchy indicated above and connected to secondary datasets for the corresponding means of transportation.

When warehousing or retail storage operations are required before reaching the consumer, this shall be considered and modelled in this life cycle stage. If applicable, storage shall be modelled following sections 4.2.3 and 4.4.5 of (Zampori, 2019) (European Commission, 2021)

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 shall be the weighted average of the time-related variation and the variation of geographical origin for supply, unless the study aims to determine the impact of a specific supplier or source location for a specific constituent.

The inventory data shall be converted to $1m^3$ of total growing media volume using data on product-specific fresh bulk density and taking into account material losses during mixing. For all constituents, the moisture content and bulk density at production shall be recorded to properly calculate the amount used in the final growing media.

Bulk density shall be measured using the specific methods for the determination of a number of soil improvers and growing media in bulk and in packages as set down in European Standard EN 12580.

Variations in the bulk density and humidity of constituents from production to final mix shall be considered.

In all constituent production, impact to by-products shall be allocated using economic allocation as described in Table 3-5. The production location of all constituents shall be declared.

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

5.2.1 Peat constituents

The modelling requirements of this section apply to primary data for peat constituents production and shall replace default secondary datasets on peat harvesting.

The life of a managed peatland can be broken down into three general stages: a) pre-use b) harvesting and c) after-use.

Figure 3 Illustration of possible stages of a managed peatland

Emissions or activities occurring during the pre-use (either the natural state or another economic activity) shall not be considered as they are attributed to the other economic activity making use of the area at that stage or are part of the natural state, which is not considered as an intervention in LCA.

In the after-use stage, if the land is used by another economic activity, any emissions and activities are directly attributed to that economic activity and are therefore not considered. LCA and credits associated with temporary or permanent carbon storage or delayed emissions shall not be considered (European Commission, 2021). This means, for example, that possible rewetting in future is not considered as a burden or credit to the harvested peat.

NOTE: For ecological, regulatory, economic and practical reasons, it is highly unlikely that the harvesting site will be abandoned after peat harvesting stops. Abandoned peat harvesting sites will continue to emit CO_2 until the water table is reached. In the unlikely situation that this is the case, this impact shall be allocated to the peat growing media. An estimate of the distance between the peatland surface and the water table shall be made and used to calculate the total volume of peat per hectare. Based on the reported peat carbon content, the available carbon shall be assumed to oxidise fully into CO_2. The total CO_2 emissions shall be amortised over a default period of 30 years and attributed accordingly to the peat harvest year under assessment.

Different scenarios for peat harvesting for growing media may be used. Appendix I describes some of the possible scenarios and related CO_2 eq emissions for peat harvesting in peatlands and peatland management over a period of 100 years.

Although peat constituents can be sourced from different origins, GME encourages the use of RPP-certified peat (Responsibly Produced Peat). The RPP ecolabel requires that peat is harvested from sites that were drained by a previous economic activity and the company is committed to restoration after completion of activities (scenario B in Appendix I).

The following sections provide guidance on modelling the life cycle inventory of peat harvesting in order to calculate the related environmental impact of peat constituents.

5.2.1.1 Harvesting site specifications

When calculating the environmental impact of peat harvesting, the following details of the peatland where the peat is harvested shall be known as an average for the five consecutive years previous to the study year:

Table 5-5-6 Required parameters for inventory peat harvesting

Parameter	Value/unit	Comment
Peatland location	Country/region	
Harvesting productivity	[m^3 /year]	Total annual amount of peat harvested should be gathered for the last 5 years previous to the study
Harvested area**	[ha]	Refers to the total area of managed peatland utilised for peat harvesting, specific to the type of peat; 5-year average
Ditch area**	[ha]	Refers to the area of main 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 type of peat is produced at a site, only the area for the peat type of interest shall be documented and the proportional ditch area considered (e.g. share of total main ditch area proportional to the area harvested for the type of peat under study).

To account for emissions related to changes in carbon stock from biomass loss and soil conversion from land use change (LUC), the land use shall be recorded for up to 20 years previous to the year of assessment. If land use has changed within this period of time, emissions related to changes in carbon stock from biomass loss and soil conversion from LUC shall be calculated following the guidance in PAS-2050-1:2012 (BSI, 2012) and the relevant sections of IPCC guidelines.

Often insufficient data is available from peat producers on utility use for preparing the peat harvesting site before peat harvesting can begin (e.g., utilities-related activities such as improvement or refinement of drainage). This activity shall be excluded[3] as the level of uncertainty is larger than the effect of including this activity.

The total impact of the peat harvesting site throughout an average of five productive years shall be attributed to the 5-year average annual production of peat for a given harvested area of peatland, expressed in m^3.

5.2.1.2 Harvesting

Data for energy use in peat harvesting shall be collected on an annual basis for five consecutive years previous to the assessment year. This includes energy from all fuel used in machinery or other equipment or electricity used during harvesting operations. The average peat bulk density (kg/m^3) and humidity (%) used when calculating peatland harvest activity (productivity and energy use) shall be registered for the peat harvested and shall be taken into account when calculating the final growing media mix mass balance.

The annual energy and fuel use (amount and type) per m^3 of peat harvested shall be collected and averaged for the 5 years for which harvesting productivity [m^3 /year] data are collected. If more than one type of peat is produced, the energy use shall be separated only for the product under consideration. If separation is not possible, the amount of energy used for the peat under consideration shall be allocated according to the share of the total area of the harvested peatland that is used to harvest the peat under consideration.

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

As in the IPCC Tier 1 approach, no transient period is considered between stages of a peat harvesting site. This means emissions are assumed to be the same across all years during peat harvesting.

Direct emissions from managed peatlands used for peat harvesting and direct emissions from peat stockpiles on site shall be calculated considering the following:

If no country-specific emission factors or direct 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 used for peat harvesting reported in section 2 of the IPCC's 2013 Wetlands Supplement (IPCC, 2014), for the appropriate land type and climate region.

Table 5-7 IPCC default emission factors for managed inland organic soils in boreal and temperate climate

Peat harvesting site stage	EF	Unit	Climate zone	Source
Harvesting (soil)	2.8	[tonne C-CO_2/ha/yr]	Boreal & Temperate	IPCC 2014
Harvesting (soil)	6.1	[kg CH_4/ha/yr]	Boreal & Temperate	IPCC 2014
Harvesting (ditch)	542	[kg CH_4/ha-ditch/yr]	Boreal & Temperate	IPCC 2014
Harvesting (soil)	0.3	[kg N-N_2O/ha/yr]	Boreal & Temperate	IPCC 2014
Harvesting (indirect DOC-C)	0.12	[tonne C-CO_2/ha/yr]	Boreal	IPCC 2014
Harvesting (indirect DOC-C)	0.31	[tonne C-CO_2/ha/yr]	Temperate	IPCC 2014

If available, country-specific emission factors or direct measurements from managed peatlands 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 emissions measurement shall be described and documented

[3] Screening studies performed in preparation for the GMEFG show the impact from utility use from pre-use to harvesting vary greatly depending on assumptions made about their duration and attributed activities, never being more than 1% of the impact of the total peat harvesting.

in detail, considering the definition of input parameters and the description of the exact process by which the emission factors were derived, including sources and uncertainties (IPCC 2019).

Emissions from peat stockpiles after harvesting shall also be accounted for. These emissions are directly related to the residence time and the stockpile area. 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 g CO_2/m^2/year considering the total peat harvesting site area (Hagberg & 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 instead 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 harvested peatland shall be divided over the average harvesting productivity to obtain the total emissions per m^3 of harvested peat.

The emissions of particulate matter shall also be accounted for during extraction of peat. Acidification is not considered a relevant environmental issue during peat extraction as it is considered that acid deposition is largely neutralized by plants uptake and microbial reduction under the water table (Gorham et al., 1987)

(Boldrin et al., 2010) provide an extensive list of emissions from peat as detailed in table 8 (per tonne peat)

Table 5-8 : Emissions from peat (1 tonne of peat) - (Boldrin et al., 2010)

Emissions to air		
Methane (biogenic)	0.199	kg
N_2O	0.014	kg
CO_2	142	kg
CO	0.171	kg
NOx	0.48	kg
Hydrocarbons unspecified	0.07	kg
PM <2.5	0.014	kg
PM>2.5<10	0.00923	kg
PM>10	0.0266	kg
SO_2	0.038	kg
Emissions to water		
P	0.0058	kg
Organic compounds	0.003	kg
COD	1.8	kg
Suspended solids	1.7	kg
Nitrogen	0.18	kg
Ammonia	0.104	kg

5.2.2 Coconut-based constituents

The modelling requirements of this section shall apply to primary data available for coconut-based constituent production that replace default secondary data.

The coconut coir can be dried and cut into chips (5.2.2.2) or used as fibre or pith (5.2.2.3). For both instances, practitioners shall indicate the country of cultivation for coconut and the processing location.

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, default average coconut cultivation data shall be used.

If primary data on cultivation are available, the agricultural activity may be modelled following the agricultural production guidelines described in section 4.4.1 of (European Commission, 2021).

The allocation between the coconut kernel (meat) and coir shall be performed on an 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 coir chips

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

Final product bulk density shall be recorded so that the practitioner may attribute activity to $1m^3$ of coir chips produced.

5.2.2.3 Coconut coir fibre and coir pith

Alternatively, the coir can be treated in fibre mills where fibre and pith are separated. The amount of coir (kg), its moisture content and the origin of the coir entering the fibre mill should be recorded.

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

Some producers make the coco fibre with the material of the whole husk. In this case, the only output from the husk is coconut fibre and no pith is produced. Therefore, the previous paragraph regarding the fibre to pith ratio is no longer applicable.

As water can be a relevant input to the fibre mill, energy/fuel and water (including type) use at the fibre mill shall be recorded per kg of processed coir and allocated to pith/fibre production on an economic basis corresponding to fibre and pith 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 pith can be further processed to make them suitable as growing media, which includes activities such as cleaning and buffering or further drying and pressing for transport.

If buffering operations occur at the coir producer, they shall be registered and attributed to coir production. If buffering of coconut-based 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 input of chemicals required for buffering shall be recorded as the amount of chemical used per kg of fibre or pith produced and modelled using the correct corresponding secondary data. The coconut pith can be buffered by adding a fertilizer and water. Calcium chloride is mainly used for buffering in Europe and calcium nitrate is mainly used for buffering in Asia. Nitric acid is also used.

When considered relevant, land occupation shall be accounted for. This is especially relevant when comparing coconut growing media products coming from different countries. Coconut yield per hectare varies significantly between countries, which is evident in the land occupation impact value. According to FAOstat (2022), coconut yields per hectare range from 709 to 29,861.3 kg/ha.

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

Final product bulk density shall be recorded so that practitioner may attribute activity to $1m^3$ of coir fibre or pith produced.

5.2.3 Wood and bark constituents

The modelling requirements of this section shall apply to any primary data on wood and bark growing media constituents that replace 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 in the PEF method (European Commission, 2021).

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

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

5.2.3.2 Further processing of bark or wood

If applicable, transport of wood and bark from the sawmill to processing shall be modelled as instructed 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 are 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.

In wood fibreization, fertilizers are typically not added. Although some wood fibre producers previously incorporated urea or other organic fertilizers during processing, this practice was discontinued due to reactions in the machine nozzles that caused clogging. Colorants can be added to wood fibre (example: soft lignite). The following information shall be collected per m^3 of final 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
- Bulk density final product (kg/m^3)

Final product bulk density shall be recorded so that the practitioner may attribute activity to $1m^3$ of processed wood or bark.

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

When considered relevant, Volatile Organic Compounds (VOC) emissions during processing operations and use shall be accounted for. In fact, some studies (Adamová et al., 2020; Fuczek et al., 2023) showed that VOC can be emitted during the use of wood fibre.

Further processing of bark involves composting. Bark may be composted or aged prior to incorporation into growing media. In Europe much pine bark is aged, whereas spruce bark, or bark from mixed conifer plantations is composted. Prior to stacking, bark is commonly shredded, milled or ground to about 1–3 cm particle size.

In the composting process, nitrogen and sometimes other nutrients are added to bark. During the composting phase, piles of bark may be turned, usually at weekly intervals. Composting for 10–15 weeks is normal practice in several parts of the world, including the Southeastern USA, Australia and the UK(W. R. Carlile, 2008)**.**While in western Europe, turning the piles is done every four Weeks and takes approximately 6-8 months.

A typical composting cycle usually includes the following processes. The coarsely milled ('hogged') bark is piled into heaps of approximately 500 m 3 and left to 'age'. Thereafter water and nitrogen (which is usually in the form of urea) are added to initiate composting. Temperatures within the heaps rise substantially, with peak temperatures sometimes as high as 80°C. Subsequently the heaps are watered and 'turned' or mixed weekly for aeration, for a period of about three months as composting continues (stabilisation). The finished product is then screened to obtain particles of a uniform size, and then distributed. (**Hinch et al, 1992**)**.**

Ageing of bark does not involve addition of nutrients and turning of piles may be intermittent. Piles of bark are usually aged for longer than composting; six months and more is common. In some cases, producers (for example in New Zealand and parts of the USA) have been able to utilise deposits of bark stripped from trees many years ago, and which has undergone ageing over several decades.

Aged bark refers to material that may be left in piles for several months or even years. During this time, potentially phytotoxic materials such as phenols and terpenes may dissipate, and low molecular weight organic materials absorbed by microorganisms leading to biological stability. (Carlile et al, 2019).

A rate of urea addition of 3% of the initial bark dry weight was optimum. As a result of composting, there is a decrease in easily decomposable organic compounds(Carlile et al, 2019).

Bark is normally supplemented with urea at 2 to 4 kg m^3 depending on species (Prasad and Carlile 2009;) Even after composting, supplementary N may be added to media. For example, the nitrogen drawdown index devised by Handreck (1993b) suggests that composted pine bark requires addition of 0.2 g/L $Ca(NH_4)_2NO_3$ and 0.5 g/L of slow-release N before planting and that aged pine bark needs 0.4 and 0.8 g/L, respectively. (Carlile et al. 2019) Prasad 2019)

5.2.4 Residual-based constituents

This section addresses residual materials used as inputs to produce constituents for a growing media mix, such as pruning leftovers, gardening waste, manure, etc. Residuals are materials whose economic value is considered to be negligible, excluding the cost of collection or transportation. In general, residuals are not the intended end product of a process (FAO LEAP, 2015).

The modelling requirements of this section shall apply to primary data for residual raw materials processed or directly used for growing media that replace default secondary data.

Although the generation of residual materials is considered to have zero impact, transport for the collection of materials and the energy/fuel and water inputs (if any) for further processing, including hygienisation, into useful growing media constituents shall be accounted for.

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

Water and electricity/fuel use for further processing, including hygienisation, of residual materials 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 on water supply.

The final product bulk density shall be recorded so that the practitioner may attribute activity to $1m^3$ of residual constituent.

5.2.5 Composted constituents

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

Compostable organic residual materials can be of different origins: green waste (e.g., grass, grass clippings, prunings, clippings from bushes and shrubs), manure, sewage sludge, digestates from anaerobic digestion facilities, paper wastes and food waste. In this guidance, green waste is considered as the most representative source of residual materials that are composted for growing media.

The impacts of residual materials for composting are not allocated (cut-off or zero allocation) (5.2.4). Wood products as bark for composting and other valuable materials shall be first modelled as described in section 5.2.3 and then used as inputs to the composting unit process. The circular footprint formula does not apply to modelling compost as composting is not a recycling method but a growing media production process.

The impacts related to transport materials to compost facility and composting shall be accounted for. Transport of materials to compost facilities shall be modelled as instructed in section 5.1.4.

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

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

When it comes to emissions accounting, it is difficult to establish standard composting EFs, for the relevant GHGs, that can have a wide applicability. This is due to the variability of the composted material as explained above. All the various compost waste categories differ in their properties such as the moisture content, pH, carbon-to-nitrogen ration (C:N), volatile solids (VS) content, etc., which can result in different aerobic decomposition rates and emission profiles.

Apart from the feedstock material and its characteristics, some other factors influencing decomposition rates and emissions include:

- The local climate where the composting facility is located.
- The method used to compost the waste and the time duration.
- The type of aeration applied and its frequency.
- The type of bulking agents used to give structure to wet wastes.

Additionally, EFs in literature largely vary based on the measurement methods used to quantify on-field composting emissions.

When available, directly measured emissions per tonne of organic material input shall be registered and accounted for, based on average annual emissions from the composting activity. If direct emission measurements are not available, average emission factors are available in Table 5-9 for open composting systems and Table 5-10 for enclosed composting systems.

It is important to note that for countries such a Belgium and the Netherlands ammonia removal technologies are applied. The most efficient technology is acid scrubbing using sulfuric acid with NH_3 removal efficiencies of 90% to 99% (Melse & Ogink, 2005).

Table 5-9 Average emission factors for composting organic input per tonne of fresh composted waste in open air windrow composting facilities

Emission	Quantity	Unit	Compartment	Source
CH_4 biogenic	2.54	kg/tonne (input)	Air	average of multiple sources (see table below)
N_2O	0.12	kg/tonne (input)	Air	average of multiple sources (see table below)
CO	0.38	kg/tonne (input)	Air	Andersen et al. 2010
NH_3	0.66	kg/tonne (input)	Air	EMEP/EEA air pollutant emission inventory guidebook 2016

Table 5-10 average emission factors for composting organic input per tonne of fresh composted waste in enclosed composting facilities

Emission	Quantity	Unit	Compartment	Source
CH_4 biogenic	0.761	kg/tonne (input)	Air	average of multiple sources (see table below)
N_2O	0.079	kg/tonne (input)	Air	)average of multiple sources (see table below)
CO	0.38	kg/tonne (input)	Air	Andersen et al. 2010 (assumed same as open composting)
NH_3	0.2	kg/tonne (input)	Air	C.J. Peek et al. 2019

The table below gives an overview of the multiple sources used for calculating the average EFs for open and closed composting

Table 5-11 Composting emissions factors

Source	GHG	Emission factor (g GHG/kg of input)	Type of compost
(Beck-Friis et al., 2001) (open)[4]	CH_4	7.63	OFMSW[5]
	N_2O	0.10	
(Colón et al., 2012) (open)	CH_4	4.37	OFMSW

[4] Type of composting system in which naturally present microorganisms decompose organic material.
[5] Organic Fraction of Municipal Solid Waste

	N_2O	0.25	
(IPCC, 2006a) (open)	CH_4	4.00	Solid wet waste
	N_2O	0.24	
(Andersen et al. 2010) (open)	CH_4	3.20	Garden waste
	N_2O	0.09	
(Colón et al. 2012) (open)	CH_4	1.68	OFMSW
	N_2O	0.08	
(Amlinger et al. 2008) (open)	CH_4	0.24	Biowaste
	N_2O	0.12	
(Andersen et al. 2010) (closed)[6]	CH_4	0.80	Garden waste
	N_2O	0.08	
(Amon et al., 2001) (open)	CH_4	0.87	OFMSW
	N_2O	0.04	
(Colón et al. 2012) (closed)	CH_4	0.34	OFMSW
	N_2O	0.08	
(Martínez-Blanco et al., 2013) (closed)	CH_4	0.03	OFMSW
	N_2O	0.09	
(Amlinger et al. 2008) (open)	CH_4	0.29	OFMSW
	N_2O	0.03	
(Amlinger et al.2008) – (open)	CH_4	0.6	Green waste
	N_2O	0.18	
(Cuhls et al., 2015) (closed)	CH_4	1.4	Green waste
	N_2O	0.049	
(Ecoinvent, 2023) (closed)	CH_4	1	Biowaste
	N_2O	0.025	
(Schleiss, 2011) (closed)	CH_4	1	Green waste
	N_2O	0.15	

Final product bulk density shall be recorded so that the practitioner may attribute activity to $1m^3$ of compost produced.

Please note that digestate (anaerobic digestion) is a different method than normally used in the sector. It is therefore another material not yet considered in the guidelines. Once this product becomes more used in the industry, it will be added to the guidelines.

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 described in section 5.1.1 shall be connected to secondary databases.

Utility use based on primary data shall be gathered as instructed in section 5.1.2, and then activity data shall be connected to secondary databases on energy/fuel production and consumption and on water provision. Direct CO_2

[6] Type of composting system which is enclosed to prevent emissions and maintain controlled conditions.

emissions from carbonate constituents melting in the furnace shall be modelled based on on-site measurements of emissions or calculated based on the carbon content of the materials.

Production and EoL of stone wool shall be modelled using the EC circular footprint formula (CFF) (European Commission, 2021) 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.

To fulfil the calculation rules of the CFF for stone wool as an intermediate product, only the material fragment of the CFF shall be calculated.

5.2.7 Expanded Perlite

Expanded perlite is a common mineral constituent used in growing media. Perlite production includes mineral mining and further processing (i.e. expansion) of the mineral into a low-density product. Perlite is first surface mined. Afterwards, it's transported to the factory to go through a mechanical processing including crushing, drying and sieving, followed by a thermal processing aiming to expand the perlite.

This guideline recommends using secondary data to model the production of expanded perlite.

If available, practitioners may model the production of expanded perlite using primary data, in which case the general LCA modelling rules in the PEF method (European Commission, 2021) shall apply.

The final product bulk density shall be recorded so that the practitioner may attribute activity to $1m^3$ of expanded perlite.

5.2.8 Other constituents

Constituents other than those discussed above can be considered to be exceptions. Primary or secondary data may be used to model the production of these constituents.

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' (European Commission, 2021) shall apply. If primary data is not available, secondary data may be used if available.

In all cases, the relevance of direct soil emissions from the production of other constituents shall be investigated. If these emissions are relevant, they 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 are available, constituents categorised as 'other' may be cut off if together they represent less than 10% (vol/vol) of the growing media composition. The share in the mix of the remainder of the constituents shall be recalculated so that they add up 100% vol/vol. This cut-off shall be clearly addressed in the limitations of the study. If the constituents categorised as 'other' together amount to >10% (vol/vol) of the growing media and no primary company-specific data or secondary data are 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 additives using primary data, in which case general LCA modelling rules as described in 'Suggestions for Updating the Product Environmental Footprint (PEF) Method' (European Commission, 2021) shall apply. If primary data are not available, all additive materials used in the growing media shall be modelled using secondary data.

5.4 Use and end-of-life

The calculation of use and EoL shall 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, but this 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 impacts of the use of growing media are from the oxidation of the carbon content of its peat-based constituents into CO_2, from nitrogen and phosphorous-related emissions, from fertiliser additives and the nutrient content of growing media, and from CO_2 released from limestone and urea. Below, guidance is given on how to account for direct emissions during use.

Peat-based constituents

When the object of the study is growing media as a final product, it shall be assumed that the entire carbon content of peat constituents is oxidised and released as $CO_{2,}$ in which case the impact is fully attributed to the growing media.

For growing media as an intermediate product, when downstream operators perform a study and wish to calculate the impact of growing media to the life cycle of their activity, the recommendations to attribute the emissions of growing media to the horticultural activity are as follows:

a) Indoor use:

The carbon content of the peat constituents shall be assumed to be oxidised into CO_2 at a default oxidation rate of 5%[7] of the peat carbon content (as provided in the additional environmental information) per year (Cleary, Roule, and Moore 2005). The 5% value has been also confirmed in a recent publication by Sharma et al. (2024), where the annual decomposition of carbon in peat has been set at 5,4% annually. Growing media can be used in subsequent cultivation cycles or transferred to other growers for reuse or to the final consumer (i.e. products with growing media sold to consumers, such as pot plants and trees). The remaining carbon content in the peat constituents at each stage in the use of the growing media shall be recorded. It is acknowledged that the 5% value is an estimate and does not necessarily represent all cases.

Full oxidation of the remaining C in peat constituents shall be assumed and reported in the EoL stage. (5.4.2.1)

The topic of peat oxidation during indoor use and the burden transfer to EoL is still under discussion also within the Fresh Produce shadow PEFCR development (which is developing technical rules for calculating the environmental footprint of fruits and vegetables as part of Freshfel´s Environmental Footprint Initiative). In fact, it is acknowledged that in the situation where peat substrates are only used for a few indoor growing cycles, the burden would mostly be allocated to the EoL.

b) Open field:

When peat constituents are used in open field cultivation, it shall be assumed that they are not reused and that the peat carbon content (as provided in the additional environmental information) is oxidised completely and is fully allocated to the crop. It is important to point out that some of the carbon in peat can be integrated into the soil

[7] PAS2050-1:2012 guidance considers a decomposition rate of 1% per week, but 5% annual decomposition is deemed more realistic by this Technical Secretariat based on available research (Cleary, Roulet and Moore 2005).

organic matter. However, as insufficient data are available to accurately estimate how much carbon is integrated into the soil, it is assumed that full carbon decomposition will occur.

Growing media nutrients and additives

Emissions related to additives and the nutrient content of the growing media shall be calculated. The full nutrient content of the growing media, the additives, and limestone or lime-containing additives shall be reported as additional environmental information (section 3.7).

For studies of growing media as a final product, emissions shall be modelled as follows:

Nitrate emissions are calculated according to the IPCC 2019 Guideline (IPCC 2019), where 24% of the applied nitrogen is emitted as nitrate. Ammonia volatilisation is calculated according to the IPCC 2019 Guideline (IPCC 2019), 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 2019 Guideline (IPCC 2019) (IPCC, 2019c)

Phosphorus-related emissions shall be calculated as indicated in European Commission, 2021, in order of preference:

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

2. The phosphorus emissions should be modelled as the amount of phosphorus applied to 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 and urea used directly as an additive and from lime-containing additives shall also be modelled following the IPCC Guideline (IPCC 2019).

For growing media used as an intermediate product, the growing media producer shall provide the nutrient content of growing media and additives as described in section 3.7 to the grower or downstream partner using the growing media.

Nitrogen, phosphorous and CO_2-related emissions from additives and growing media nutrient content shall be assumed to be fully emitted and attributed to the first user of the growing media, regardless of whether or not the growing media is reused at a later stage.

The nutrient content of growing media and additives shall be considered in the calculation of nitrogen- and phosphorus-related emissions and limestone CO_2 attributed to the grower. When calculating nutrient-related emissions from the horticultural system, the practitioner may give priority to a higher tier approach when required by a specific methodology for modelling nutrient-related emissions. If there is no specific emission modelling methodology to be followed, the practitioner may follow the same approach as used for modelling emissions of growing media as a final product, as described above.

5.4.2 End-of-life

For most growing media, options for the EoL of used growing media are composting or field applications as a soil improver. A specific case is considered for stone wool.

5.4.2.1 Composting and use as soil improver of spent growing media

Growing media which are disposed of after their use cycle and used for further composting or as a soil improver should be treated as a residual material unless a value other than the cost of collection can be determined, in which case economic allocation shall be applied.

As a residual, a cut-off shall be applied for spent growing media used for composting or as a soil improver. Hence, no impact from the production of the growing media (e.g., peat harvesting, coir production) and no impact from the EoL shall be attributed to the residual growing media.

When economic allocation is applied, the spent growing media is then considered as a by-product of the cultivation of a certain crop. Hence, all emissions occurring at the crop cultivation stage as well as the use and EoL emissions of the growing media are partially allocated to the subsequent user. In practice, this approach results in allocating most of the emissions from the growing media production, use, and EoL to the first user of the growing media.

It is acknowledged that the transfer of burden of peat related emissions is a topic of discussion also within the Fresh Produce shadow PEFCR. It is generally recognized that the largest environmental burden (including that originating from peat carbon oxidation) should be attributed to the first user.

Additionally, composting or further processing of growing media shall be considered to be a separate economic activity from the system under study. This means that no impact from composting (including collection) or further processing shall be attributed to the growing media life cycle.

5.4.2.2 Recycling of stone wool

Recycling of stone wool shall be modelled using the circular footprint formula (CFF) considering the appropriate point of substitution. The CFF is a combination of 'material + energy + disposal':

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 III.

If no information is known for stone wool, the default approach is to set the parameters R1 and R2 as zero. In this case E_v are the emissions and resources consumed for the production of stone wool from virgin materials.

If specific data on the recycled material content and EoL of stone wool are available, primary data shall be used to derive the CFF parameters. If these are not available, the default values provided in Annex C to the PEF methods (European Commission, 2021) (available in https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm) shall be used.

For energy and disposal, the CFF parameters shall be filled in, taking into account the local waste management system ratio between landfill and incineration and using primary data if available. If primary data are not available, default values are available in section 4.4.8.1 (European Commission, 2021).

Transport for waste collection of stone wool should also be modelled using primary activity data for distances and transport modes. If primary data are not available, the practitioner may use the default values for waste collection provided in section 4.4.3.6 of (Zampori, 2019) European Commission, 2021.

5.5 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 showing how to assess the DQR parameters for processes where company-specific data are used. For processes not discussed in this section and when using primary data, the DQR shall be assessed using Table 4-2.

Table 5-12 How to assess data quality for growing media processing

Rating	P-DEF and P-AD	TiR-DEF and TiR-AD	TeR-DEF and TeR-AD	GeR-DEF and GeR-AD
1	Measured/calculated and externally verified	Data cover the time period within the scope of the study and are for the most recent annual administration period with respect to the 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 give the weighted share of production of the specific growing media production plant(s) within the scope of the study
2	Measured/calculated and internally verified and plausibility checked by reviewer	The data are for no more than two annual administration periods with respect to the EF report publication date	The elementary flows and the activity data are a proxy of the technology of the newly developed dataset	The activity data and elementary flows partly reflect 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 and plausibility checked by reviewer	The data are for no more than 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 5-13 How to assess data quality for outbound transport

Rating	P-DEF and P-AD	TiR-DEF and TiR-AD	TeR-DEF and TeR-AD	GeR-DEF and GeR-AD

1	Measured/calculated and externally verified	Data cover the time period within the scope of the study and are for the most recent annual administration period with respect to the report publication date.	The technologies and logistics are specific to the growing media products within the scope of the study and based on fuel consumption measurements	The data concern the specific growing media production plants location and logistics within the scope of the study, weighted according to their share of production
2	Measured/calculated and internally verified and plausibility checked by reviewer	The data are for the previous administration period with respect to the EF report publication date	The technologies and logistics are specific for the products within the scope of the study and based on distance estimation	The data concern unweighted average logistics of the growing media plants where production of growing media within the scope of the study takes place
3	Measured/calculated/literature and plausibility not checked by reviewer, OR Qualified estimate based on calculations and plausibility checked by reviewer	Not applicable	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

6. Environmental Impact Result Reporting

Practitioners shall report the total environmental impact of all the life cycle stages within the scope of the study. Practitioners may choose to break down the environmental impact results per life cycle stage, in which case users may use a report table as shown in Table 6-1. Whether or not the practitioner chooses to break down their results, a GMEFG report shall always include the total environmental impact results for all life cycle stages.

Table 6-1 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 of growing media				
Outbound transport				
Use*				
EoL*				
Total				

* Use and EoL are only mandatory for growing media as a final 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.

6.1 Interpretation of LCA results

Interpretation of LCA results enables conclusions to be drawn and recommendations to be made about the system under study.

As a minimum, the practitioner of a GMEFG study shall determine the life cycle stage processes and elementary flows that contribute most to the life cycle environmental impact results and the most relevant impact categories. To do this, a contribution analysis shall be conducted that quantifies the relative contributions made by the different stages/categories/items to the total result per impact category.

A sensitivity assessment shall be performed to assess the extent to which the results are determined by specific methodological choices and the impact of implementing alternative, defensible choices where these are identifiable. This is particularly important with respect to allocation choices. More details can be found in the PEF document (European Commission, 2021).

7. Verification and validation

Verification ensures compliance with the relevant standards, such as the PEF rules. Validation assesses whether the data and conclusions are logical and reasonable.

The verification step is needed to show that the study has been carried out in compliance with the most updated version of the GMEFG and to confirm that the information and data included in the GMEFG study, the report and the communication vehicles are reliable, credible and correct. The reviewer(s) must be independent.

The reviewer(s) and the study commissioner will together decide on which part of the study to be public, and which is not following the conditions detailed in Appendix IV and chapter 8 of the PEF guidelines (European Comission, 2021).

An external verification of the GME secondary database and the GME web-based LCA tool is mandatory and shall be ensured by GME. If the database or the tool are adjusted or updated, the verification shall be reviewed.

An external validation step for company-specific primary data and verification of compliance with this methodology shall be performed when the results of a GMEFG study are to be disclosed to third parties and may be performed in all other situations as required by the practitioner. If the LCA is performed for internal purposes, no verification of primary data is required. For studies that are not reviewed by an independent third-party reviewer, please refer to section 7.1.

The external verification of an LCA study performed following this GMEFG shall be done following the general recommendations established in ISO 14044 and shall validate compliance with the methodology described in this GMEFG.

The validation of a PEF study or report conducted in adherence to this PEFCR must adhere to the criteria outlined in section A.8 of the Annex of the PEF guidance (European commission, 2021) verification and validation of PEF studies,

The PEF gives guidance on the following requirements (see Appendix IV):

- Verification procedure
- Number of verifier(s)
- Requirements for data verifier(s)
- Verification and validation techniques
- Data confidentiality
- Validation report / statement
- Validity of the validation report

In accordance with the FloriPEFCR (Broekema et al., 2024), verification can be divided into two cases:

- The study is not performed in a pre-verified tool.
- The study is performed in a pre-verified tool

In the first case where the study is not performed in a pre-verified tool, the PEF procedure shall be followed (European commission, 2021).

The minimum requirements for the verification and validation of the study are:

1) The verifier(s) shall check if the correct version of all impact assessment methods was used. For each of the most-relevant EF impact categories (ICs), at least 50% of the characterisation factors shall be verified, while all normalisation and weighting factors of all ICs shall be verified. In particular, the verifier(s) shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance. This may also be done indirectly, for example: Export the EF-compliant datasets from the LCA software used to do the PEF study and run them in Look@LCI to obtain LCIA results. If Look@LCI results are within a deviation of 1% from the results in the LCA software, the verifier(s) may assume that the implementation of the characterisation factors in the software used to do the PEF study was correct.
2) Compare the LCIA results of the most-relevant processes calculated with the software used to do the PEF study with the ones available in the metadata of the original dataset. If the compared results are within a deviation of 1%, the verifier(s) may assume that the implementation of the characterisation factors in the software used to do the PEF study was correct.

- The verifier(s) shall check that the cut-off applied (if any) fulfils the requirements.
- The verifier(s) shall check that all datasets used fulfil the data requirements.
- For at least 80% (in number) of the most-relevant processes (80% most impactful impact categories in the single score), the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them shall also be validated in the same way. The verifier(s) shall check that the most-relevant processes are identified
- For at least 30% (in number) of all other processes (corresponding to 20% of the processes) the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them shall also be validated in the same way.

The verifier(s) shall check that the datasets are correctly implemented in the software (i.e. LCIA results of the dataset in the software are within a deviation of 1% to the ones in the metadata). At least 50% (in number) of the datasets used to model most-relevant processes and 10% of those used to model other processes shall be checked. The verifier(s) shall check if the aggregated EF compliant dataset representing the product in scope is made available to the European Commission. The commissioner of the PEF study may decide to make the dataset public.

In the second case where the study is performed in a pre-verified tool, requirements detailed in FloriPEFCR shall be followed.

- The verifier(s) shall check if the correct version of all impact assessment methods was used.
- All secondary datasets included by default in the tool shall be checked against the data requirements
- The tool shall require the user to populate fields related to the list of mandatory-specific data required in this PEFCR.
- Universal model created for allowing for product-specific calculations to be verified in the tool.
- The LCA model used in the tool is parameterised for the bill of potential materials and/or activities in a way which allows the user of the tool, to modify a pre-defined selection of input data or choose from a pre-defined menu of activities connected to a specific product life cycle in order to produce product-specific PEF results.
- The output of a pre-verified PEFCR-compliant tool is a list of characterised and single score results per life cycle stage.
- Besides pre-verification of the tool, additional verification (e.g., activity data) is required for specific PEF studies conducted using the tool.

More details are provided in table 46 of the FloriPEFCR.

The aim of the verification of a tool is to check the compliance with this PEFCR. A tool is verified based on the tool itself as well as the first PEF report and the first PEF verification report based on the tool. The tool owner shall arrange for the verification of the tool.

The tool verification shall be documented by the verifier in a tool verification report and shall be made available to tool users.

In addition to the validation and verification steps, the PEF provides guidance on handling confidential data. The PEF indicates that only confidential input data can be excluded, while all output data must be included. The verifier(s) would check the nature of the excluded data and the justification for its exclusion. The commissioner should keep a file of the non-disclosed information for possible future re-evaluation of the decision for non-disclosure.

7.1 General advice on communication

If the study/report has been reviewed by an independent third-party reviewer (based on ISO 14040/14044):

- The study commissioner may externally communicate on the results of a study to third-parties as long as it

(1) includes the applicable disclaimer(s) related to the review, as provided by the reviewers, and

(2) gets the approval of the company conducting the study on any claims or communications related to the work.

If the study/report has NOT been reviewed by an independent third-party reviewer (based on ISO 14040/14044):

- Use the following disclaimer: "The results of this study have not been verified or reviewed by an independent third party and therefore do not fully comply with ISO 10440/44 standards requirements. The company conducting the study and its data providers cannot be held liable for any claims relating to the results of the study” and
- Get the approval of the company conducting the study on any claims or communications related to the work.

In general:

- Follow applicable Laws, guidelines, policies and good practices when communicating (e.g., environmental footprint or sustainability claims).
- To explicitly or implicitly refer to the company conducting the study as a partner, or otherwise imply it’s endorsement, prior permission in writing is required.
- In order to ensure transparency, especially in case of comparing products, the LCA report shall include results for all impact categories as long as the single score and not focus only on one impact category (ex : climate change).

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Appendix I

This Appendix presents four scenarios for different situations of managed peatlands and their related climate change emissions over a period of 100 years (see Table A-1).

This simplified model aims to describe the different sources of greenhouse gas emissions related to managed peatlands and peat harvesting to ease understanding of the environmental impact calculations related to peat constituents.

Four different scenarios are considered and we used two sets of emission factors: IPCC emissions for inland organic soils (IPCC 2014) and country-specific emission factors developed for Latvian managed peatlands in the context of the LIFE Restore project (Priede et al., 2019). IPCC emission factors are the default for use in the GMEFG. Latvian emission factors are used to illustrate how measured emissions from peat soil can vary from direct measurements.

These scenarios are presented to illustrate the expected emissions during different stages of a peat harvesting site over 100 years. However, they do not reflect all possible peat situations and shall not be taken as definitive results. Please note that that pre-use and after-use are considered in these scenarios, but these are not considered for attributional LCA modelling in the GMEFG.

The emissions factors considered are summarised in Table A-2.

Table A-1 Summary of peatland scenarios

Scenario	Description
A	*Managed and degraded peatland that is abandoned without rewetting or rehabilitation after the conclusion of a previous economic activity that managed the peatland. Emissions are calculated for peat degradation until the water table is reached.*
B	*Degraded peatland acquired for peat harvesting under Responsible Produced Peat (RPP) conditions. The water table is lowered year on year to ensure peat harvesting is possible. Harvesting ceases when it is no longer economic viable and the land is rewetted.*
C	*Pristine peatland drained for peat harvesting. The water table is lowered year on year to ensure peat harvesting is possible. Harvesting ceases when it is no longer economic viable and the land is rewetted.*
D	*Natural state (unmanaged) peatland. No harvesting or degradation.*

Table A-2 Summary of emission factors used for calculation

Rewetting/Natural	**IPCC**	**Latvia (country emission factor)***	**Unit**
Emission rate CO_2-C	-0.34	*n/a used same as IPCC for calculation*	tonne C-CO_2/ha/y
Emission rate CH_4	41	*n/a used same as IPCC for calculation*	kg CH_4-C/ha/y
Emission rate DOC-C	0.08	*n/a used same as IPCC for calculation*	tonne C-CO_2/ha/yr
Harvesting	**IPCC**	**Latvia (country EF)***	**Unit**
Emission rate CO_2	2.8	1.09	tonne C-CO_2/ha/yr
Emission rate CH_4	6.1	16.7	kg CH_4/ha/y

Emission rate CH_4 ditches	542	*n/a used same as IPCC for calculation*	kg CH_4/ha ditch/y
Emission rate N_2O	0.3	0.5	kg N_2O-N/ha/y
Harvesting (indirect DOC-C)	0.12	*n/a used same as IPCC for calculation*	tonne C-CO_2/ha/yr
Change in land use	**IPCC**	**Latvia (country emission factor)***	**Unit**
Change carbon stock above ground biomass (assumed boreal grassland)	4	*n/a used same as IPCC for calculation*	tonne C-CO_2/ha
Change carbon stock soil carbon (nutrient poor)	0.2	*n/a used same as IPCC for calculation*	tonne C-CO_2/ha/y

*Latvian emission factors had to be calculated from partially reported figures so some numbers may vary slightly from the publication (Priede et al., 2019).

Each scenario was modelled under certain assumptions for the depth of the water table or annual peat harvesting site productivity. The main assumptions for each scenario are explained below. In all scenarios, no transient period is assumed between the different stages in the life of the peat harvesting site.

Scenario A

Initial water table, depth below surface peat	0.5	m
Peat available	5.000,00	m^3/ha
Carbon content peat	0.05	tonne C/m^3
Carbon total	250	tonne C/ha

Scenario B

Peat layer depth	3	m
Annual peat harvesting	953	m^3/ha/y
Peatland life for harvesting	31	years
Carbon content peat	0.05	tonne C/m^3
Ditch area	5% of total area	
Diesel use	610	l/ha/y

Scenario C

Conversion from pristine peatland to harvest	5	years
Peat layer depth	3	m
Annual peat harvesting	953	m^3/ha/y
Peatland life for harvesting	31	years
Carbon content peat	0.05	tonne C/m^3
Ditch area	5% of total area	
Diesel use	610	l/ha/y

Scenario D

As no emissions factors were available for the natural state, it is assumed to be similar to the situation of rewetting a peatland after harvesting.

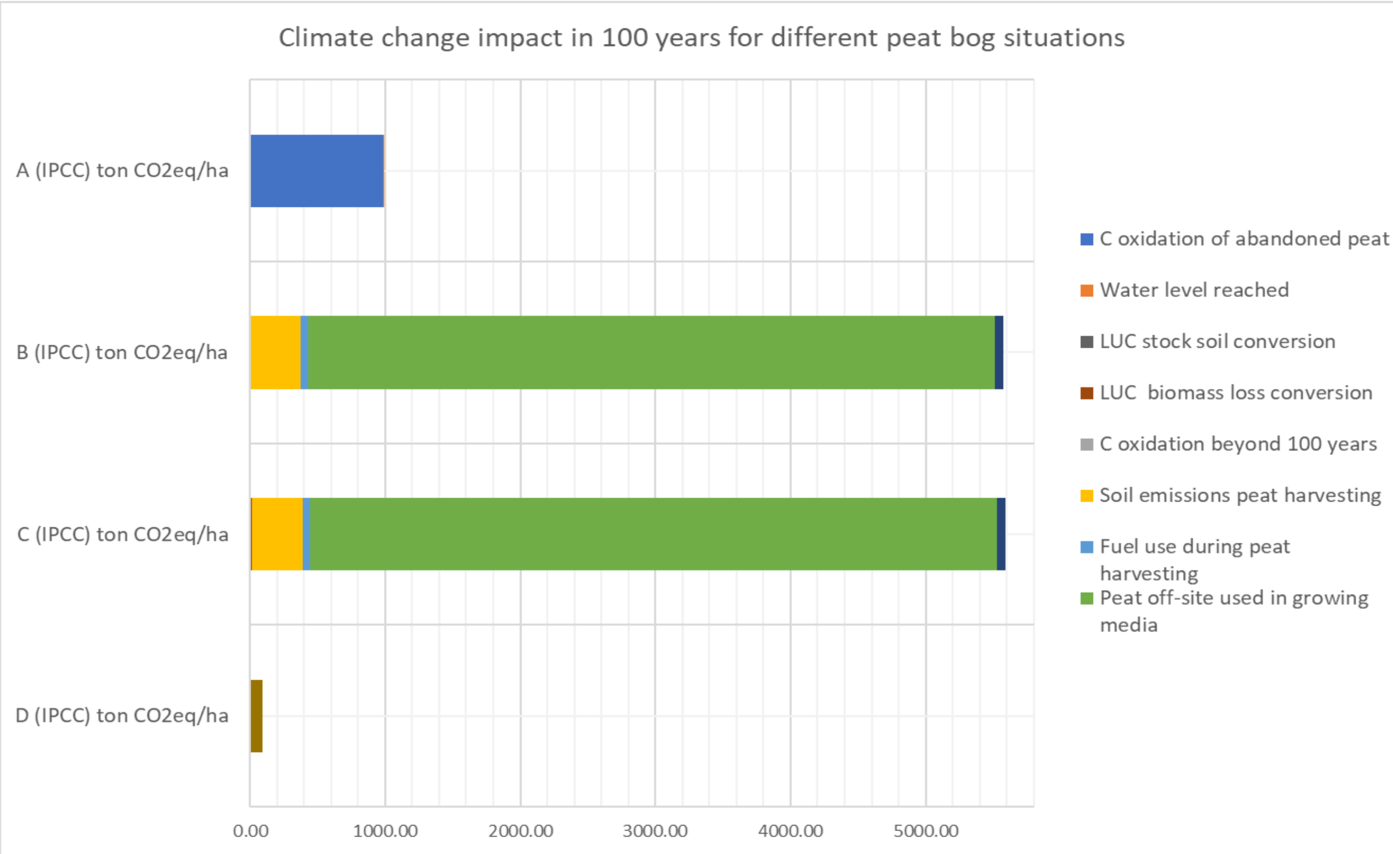

Figure A-1 Comparative results for 100-year emissions in tonne CO_2 eq/ha for different peat scenarios using IPCC emission factors

Table A-3 Results in tonne CO_2 eq/ha in 100 years for different bog scenarios using IPCC emission factors

	A (IPCC) tonne CO_2 eq/ha	B (IPCC) tonne CO_2 eq/ha	C (IPCC) tonne CO_2 eq/ha	D (IPCC) tonne CO_2 eq/ha
C oxidation of abandoned peat	987.01			
Water level reached	9.70			
Soil emissions peat harvesting		371.25	371.25	
Fuel use during peat harvesting		57.26	57.26	
Peat off-site used in growing media		5079.88	5079.88	
Rewetted peatland		62.47	62.47	
LUC biomass loss conversion			14.67	
LUC stock soil conversion			3.67	
Natural emissions				90.53
Total (100 years)	**996.71**	**5570.87**	**5589.20**	**90.53**

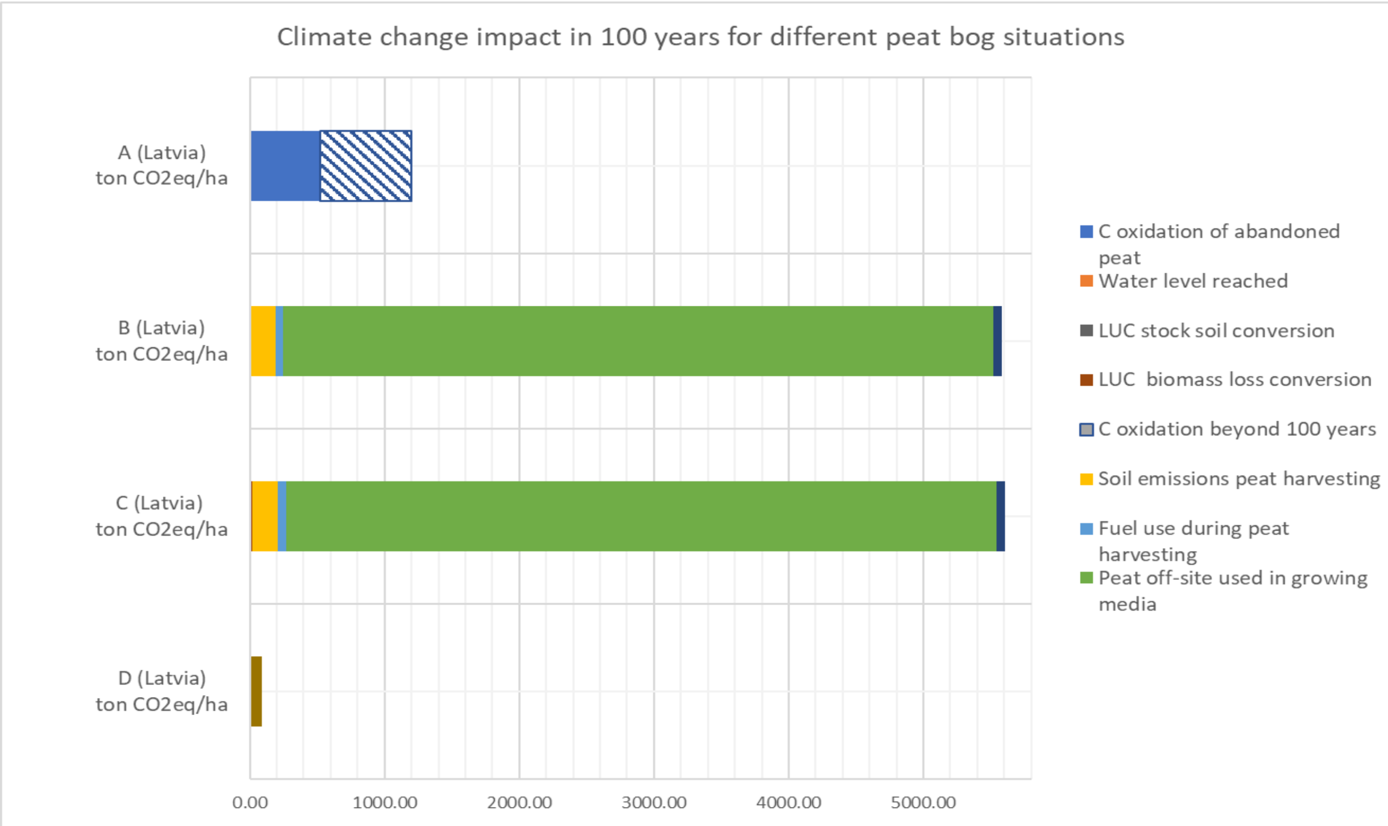

Figure A-2 Comparative results for 100-year emissions in tonne CO_2 eq/ha for different peat scenarios using Latvian emission factors. Emissions beyond 100 years in Scenario A are indicated by the hatched box: We assume peat C content will oxidise into CO_2 until it reaches the water table. The country-specific CO_2 emission rate for Latvia is smaller than IPCC so it takes longer than 100 years for the peat surface to reach the water table.

Table A-4 Results in tonne CO_2 eq/ha in 100 years for different bog scenarios using Latvian emission factors

	A (Latvia) tonne CO_2 eq/ha	B (Latvia) tonne CO_2 eq/ha	C (Latvia) tonne CO_2 eq/ha	D (Latvia) tonne CO_2 eq/ha
C oxidation of abandoned peat	523.86			
C oxidation beyond 100 years to reach water level	677.65			
Soil emissions peat harvesting		190.96	190.96	
Fuel use during peat harvesting		57.26	57.26	
Peat off-site used in growing media		5273.35	5273.35	
Rewetted peat land		62.47	62.47	
LUC biomass loss conversion			14.67	
LUC stock soil conversion			3.67	
Natural emissions				90.53
Total (100 years)	**523.86**	**5584.04**	**5602.37**	**90.53**

Appendix II

This appendix gives an overview of the bark compost, it's origin and history of processing.

The utilization of wood wastes for vegetables under protection was initiated in Poland in the mid 1960s. Fresh pine bar was used as an additive to black peat, 30 to 50% by volume, in order to improve the physical properties of this growing medium in its long-term use for cucumber growing under glass. (Pudelski, 1985) The impetus to use bark in growing media came from increased production within wood-processing industries in the 1940s and 1950s which led to the stockpiling of large quantities of bark at pulp and sawmills. Research into the use of bark in growing media initially began in the 1950s, with many major studies being carried out in the 1960s. In the UK the Forestry Commission instigated studies into the use of bark as a replacement for peat in horticulture in 1967, and by 1982 at least 14 companies/organisations were supplying bark or bark-based growing media to both the commercial and amateur (hobby) sector of the market in the UK (Aaron, 1982). Research into the use of bark has been undertaken in many other countries including the USA, Canada, New Zealand, France, Norway, Spain and Australia. (Carlile, 2008).

The principal reasons for composting or ageing have been considered at length by many authors: the intention is to eliminate any problems that may arise from phytotoxic components in raw bark. In addition, composting may reduce the immobilisation of nitrogen that arises during colonisation of media by microorganisms which can utilise the carbon sources in some barks much more freely than in materials rich in lignin, such as peat. In this respect some barks, particularly derived from species of Pinus sop, that have a relatively high lignin (and wax) content lead to a lower rate of nitrogen immobilisation when incorporated into media than other barks such as that from Picea spp. as well as some hardwoods (Bilderback, 1982). Finally, heating of piles to 50°C may serve to kill unwanted pathogens, pests and weed seeds. A major benefit arising from the use of composted bark is its ability to exert a degree of control over root diseases through their suppression (Raviv, 2008). **(Carlile, 2008).**

A method of composting coniferous tree bar was developed in the late 1960's in the Forest Research Institute in Warsaw, later also a method of composting common beech bark. The method involves addition of urea. 3kg per $1m^3$. And 10 to 15% by volume of biologically active sediment from waste purification plants of paper mills. Composting takes place in piles of 6m width and 2m height over a period of 4 to 6 months. In this time, the compost piles are inverted several times. (Pudelski, 1985).

Prior to composting, bark may be shredded, milled or ground. Considerable variation is evident in the procedures adopted for composting of bark to ensure suitability for use as a constituent of growing media. In some cases, piles may be established and turned or moved occasionally with mechanical shovels for a number of months, or even years. Such 'mature' piles may almost be regarded as 'aged' bark. The composting process here may be sporadic, depending on the extent and frequency of turning, moisture content of the piles, and the length of time of composting. In other situations, piles may be established in true windrows, nitrogen added at the beginning of the composting process, water added as necessary, and piles turned with specifically designed composting apparatus. Piles may be monitored for temperature, CO2, moisture content as well as ammoniacal and nitrate nitrogen. This forms part of the quality control process in several companies that utilise composted bark in the manufacture of growing media. (Prasad, 2009).

Appendix III

The circular footprint formula (European Commission, 2021):

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 preprocess

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

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

R2: 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: 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 preprocessing of virgin material

E*v: specific emissions and resources consumed (per unit of analysis) arising from the acquisition and preprocessing 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

XER,heat and XER,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 IV

Verification and validation of PEF studies, reports, and communication vehicles

If policies on implementing the PEF method define specific requirements as regards verification and validation of PEF studies, reports and communication vehicles, then these requirements shall prevail.

Defining the scope of the verification

The verification and validation of the PEF study is mandatory whenever the study, or part of the information therein, is used for any type of external communication (i.e. communication to any interested party other than the commissioner or the user of the PEF method of the study).

Verification means the conformity assessment process carried out by an environmental footprint verifier(s) to check whether the PEF study has been carried out in compliance with Annex I.

Validation means the confirmation by the environmental footprint verifier(s) who carried out the verification, that the information and data included in the PEF study, the PEF report and the communication vehicles available at the time of validation are reliable, credible and correct.

The verification and validation shall cover the following three areas:

1. the PEF study (including, but not limited to the data collected, calculated, and estimated and the underlying model);
2. the PEF report;
3. the technical content of the communication vehicles, if applicable.

The verification of the PEF study shall ensure that the PEF study is conducted in compliance with Annex I or the applicable PEFCR.

The validation of information in the PEF study shall ensure that the data and information used for the PEF study are consistent, reliable and traceable and that the calculations performed do not include significant mistakes. The verification and validation of the PEF report shall ensure that:

(1) the PEF report is complete, consistent, and compliant with the PEF report template provided in Part E of Annex II;
(2) the information and data included are consistent, reliable and traceable;
(3) the mandatory information and sections are included and appropriately filled in;
(4) all the technical information that could be used for communication purposes, independently from the communication vehicle to be used, are included in the report.

The validation of the technical content of the communication vehicle content shall

ensure that**:**

(1) the technical information and data included are reliable and consistent with the information included in the PEF study and the PEF report;
(2) that the information is compliant with the requirements of the Unfair Commercial Practices Directive[85];
(3) that the communication vehicle complies with the principles of transparency, availability and accessibility, reliability, completeness, comparability and clarity, as described in the Commission Communication on Building the Single Market for Green Products.

Verification procedure

The verification procedure covers the following steps.

1. The commissioner shall select the verifier(s) or verification team
2. The verification shall take place following the verification process
3. The verifier(s) shall communicate to the commissioner any misstatement, non-conformities and need for clarifications and draft the validation statement
4. The commissioner shall respond to the verifier's comments and introduce necessary corrections and changes (if needed) to ensure the final compliance of the PEF study, PEF report and technical content of PEF communication vehicles. If, in the verifier's judgement, the commissioner does not respond appropriately within a reasonable time period, the verifier shall issue a modified validation statement.
5. The final validation statement is provided, considering (if needed) the corrections and changes introduced by the commissioner.
6. Surveillance that the PEF report is available during the validity of the validation statement
7. If a matter comes to the verifier's attention that causes the verifier to believe in the existence of fraud or noncompliance with laws or regulations, the verifier shall communicate this immediately to the commissioner of the study.

Verifier(s)

The verification may be conducted by a single verifier or by a verification team, external to the organisation that conducted study and external of GME.

Minimum score: six points, including at least one point for each of the three mandatory criteria

Table : Scoring system for each relevant competence and experience topic for the assessment of the competences of verifier(s)

			Score (points)				
	Topic	**Criteria**	**0**	**1**	**2**	**3**	**4**
Mandatory criteria	Verification and validation practice	Years of experience (1)	<2	$2 \leq x < 4$	$4 \leq x < 8$	$8 \leq x < 14$	≥ 14
		Number of verifications (2)	≤ 5	$5 < x \leq 10$	$11 \leq x \leq 20$	$21 \leq x \leq 30$	>30
	LCA method-logy and practice	Years of experience (3)	<2	$2 \leq x < 4$	$4 \leq x < 8$	$8 \leq x < 14$	≥ 14
		Number of LCA studies or reviews (4)	≤ 5	$5 < x \leq 10$	$11 \leq x \leq 20$	$21 \leq x \leq 30$	>30
	Knowledge of the specific sector	Years of experience (5)	<1	$1 \leq x < 3$	$3 \leq x < 6$	$6 \leq x < 10$	≥ 10
Additional criteria	Review, verification/ validation practice	Optional scores relating to verification/ validation	— 2 points: Accreditation as third party verifier for EMAS — 1 point: Accreditation as third party reviewer for at least one EPD scheme, EN ISO 14001:2015, or other EMS				

Verification and validation requirements

The verifier(s) shall present all the outcomes related to the verification of the PEF study and the validation of the PEF study, PEF report and PEF communication vehicles and give the commissioner of the PEF study the opportunity to improve the work, if necessary. Depending on the nature of the outcomes, additional iterations of comments and responses may be necessary. Any changes made in response to the verification or validation outcomes shall be documented and explained in the verification or validation report. Such a summary may take the form of a table in the respective documents. The summary shall include the comment(s) from the verifier(s), the commissioner's answer and the motivation for the changes.

Verification may take place after the PEF study has been concluded or in parallel (concurrent) to the study, while validation shall always take place after the study has been concluded.

The verification/validation shall combine document review and model validation.

- The document review includes the PEF report, the technical content of related communication vehicles available at the time of validation, and the data used in the calculations through requested underlying documents. Verifier(s) may organise the document review either as an 'at desk' or 'on-site' exercise, or as a mix of the two. The validation of the company-specific data shall always be organised through a visit to the production site(s) the data refer to.
- The validation of the model may take place at the production site of the commissioner of the study or be organised remotely. The verifier(s) shall access the model to verify its structure, the data used, and its consistency with the PEF report and PEF study. The commissioner of the PEF study and the verifier(s) shall agree on how the verifier(s) accesses the model.
- The validation of the PEF report shall be carried out by checking enough information to provide reasonable assurance that the content is in line with the modelling and results of the PEF study.

The verifier(s) shall ensure that data validation includes:

a) coverage, precision, completeness, representativeness, consistency, reproducibility, sources and uncertainty;
b) plausibility, quality and accuracy of the LCA-based data;
c) quality and accuracy of additional environmental and technical information;
d) quality and accuracy of the supporting information.

Verification and validation techniques

The verifier(s) shall assess and confirm whether the calculation methodologies applied are of acceptable accuracy, reliable, are appropriate and performed in line with the PEF method. The verifier(s) shall confirm the correct application of conversion of measurement units.

The verifier(s) shall check if applied sampling procedures are in line with the sampling procedure defined in the PEF method. The data reported shall be checked against the source documentation in order to check their consistency.

The verifier(s) shall evaluate whether the methods for making estimates are appropriate and have been applied consistently.

The verifier(s) may assess alternatives to estimations or choices made, to determine whether a conservative choice has been selected.

The verifier(s) may identify uncertainties that are greater than expected and assess the effect of the identified uncertainty on the final PEF results.

Outputs of the verification/validation process

Content of the verification and validation report

The verification and validation report[90] shall include all findings of the verification/ validation process, the actions taken by the commissioner to answer the comments of the verifier(s), and the final conclusion. The report is mandatory, but it may be confidential. Confidential information shall only be shared with the European Commission or the body overseeing the PEFCR development, and the review panel at their request.

The final conclusion may be of a different nature:

- 'compliant' if the document or on-site checks prove that the requirements of this section are fulfilled;
- 'not compliant' if the document or on-site checks prove that the requirements of this section are not fulfilled;
- 'complementary information needed' if the document or on-site checks do not allow the verifier(s) to conclude on compliance. This may happen if the information is not transparently or sufficiently documented or made available.

The verification and validation report shall clearly identify the specific PEF study under verification. To this purpose, it shall include the following information:

- title of the PEF study under verification/validation, together with the exact version of the PEF report to which the validation statement belongs;
- the commissioner of the PEF study;
- the user of the PEF method;
- the verifier(s) or, in the case of a verification team, the team members with the identification of the lead verifier;
- absence of conflicts of interest of the verifier(s) with respect to concerned products and the commissioner and any involvement in previous work (where relevant, consultancy work carried out for the user of the PEF method over the last three years);
- a description of the objective of the verification/validation;
- the actions taken by the commissioner to answer the comments of the verifier(s);
- a statement of the result (findings) of the verification/validation containing the final conclusion of the verification and validation reports;
- any limitations of the verification/validation outcomes;
- date on which the validation statement has been issued;
- version of the underlying PEF method and, if applicable, of the underlying PEFCR;
- signature of the verifier(s).

Content of the validation statement

The validation statement is mandatory and shall always be provided as an annex to the PEF report. The verifier(s) shall include at least the following elements and aspects in the validation statement:

- title of the PEF study under verification/validation, together with the exact version of the PEF report to which the validation statement belongs;
- the commissioner of the PEF study;
- the user of the PEF method;
- the verifier(s) or, in the case of a verification team, the team members with the identification of the lead verifier;
- absence of conflicts of interest of the verifier(s) with respect to concerned products and the commissioner and any involvement in previous work (where relevant, consultancy work carried out for the user of the PEF method over the last three years);
- a description of the objective of the verification/validation;
- a statement of the result of the verification/validation containing the final conclusion of the verification and validation reports;
- any limitations of the verification/validation outcomes;

- date on which the validation statement has been issued;
- version of the underlying PEF method and, if applicable, of the underlying PEFCR;
- signature of the verifier(s).

Validity of the verification and validation report and the validation statement

A verification and validation report, and a validation statement shall refer to one specific PEF report only. The verification and validation report and the validation statement shall clearly identify the specific PEF study under verification (e.g. by including the title, the commissioner of the PEF study, the user of the PEF method), together with the explicit version of the final PEF report to which the verification and validation report and a validation statement apply (e.g. by including the report date, the version number).

Both the verification and validation report and the validation statement shall be completed based on the final PEF report, after the implementation of all the corrective actions requested by the verifier(s). They shall carry the handwritten or electronic signature of the verifier(s) in line with Regulation (EU) n° 910/2014[91].

The maximum validity of the verification and validation report and of the validation statement shall not exceed three years starting from their issue date.

During the validity period of the verification, surveillance (follow-up) shall be agreed between the commissioner of the PEF study and the verifier(s) to evaluate if the content is still consistent with the current situation (the suggested periodicity for this follow-up is once per year, to be agreed between the PEF study commissioner and the verifier(s)).

The periodic checks shall focus on the parameters that according to the verifier(s) might lead to relevant changes in the results of the PEF study. This means, that the results shall be recalculated considering the changes of the identified parameters. The list of such parameters includes:

- bill of material/bill of components;
- energy mix used for processes in Situation 1 of the Data Needs Matrix;
- change of packaging;
- changes in the suppliers (materials/geography);
- changes in the logistics;
- relevant technological changes in the processes in Situation 1 of the Data Needs Matrix.

At the time of the periodic check the reasons for non-disclosure of information should also be reconsidered. The surveillance verification may be organised as a document check and/or through on-site inspections.

Regardless of the validity, the PEF study (and consequently the PEF report) shall be updated during the surveillance period if the results of one of the impact categories communicated has worsened by more than 10.0% compared to the verified data, or if the total aggregated score has worsened by more than 5.0% compared to the verified data.

If these changes also affect the content of the communication vehicle, it shall be updated accordingly.