Product Environmental Footprint Category Rules for Cut flowers and Potted plants

Final version

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WAGENINGEN UNIVERSITY & RESEARCH

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Abstract

The primary objective of this FloriPEFCR is to fix a consistent and specific set of rules to calculate the relevant environmental information of two main products from the sector of floriculture, namely Cut flowers and Potted plants. An important objective is to focus on what matters most for a specific product category to make PEF studies easier, faster and less costly. An equally important objective is to enable comparisons and comparative assertions in all cases where this is feasible, relevant and appropriate. Comparisons and comparative assertions are allowed only if PEF studies are conducted in compliance with a PEFCR. A PEF study for cut flowers and potted plants can be conducted following this FloriPEFCR. This FloriPEFCR - Product Environmental Footprint Category Rules for Cut flowers and Potted plants – is the report that is developed according to the Product Environmental Footprint Guidance – PEF Guidance (EC, 2021).

Key words: life cycle assessment, LCA, PEFCR, cut flowers, potted plants, environmental impact, horticulture

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Preface

The Technical Secretariat headed by Royal FloraHolland would like to offer you the FloriPEFCR - Product Environmental Footprint Category Rules - report that is developed for two product categories:

1. Cut flowers
2. Potted plants.

The European Commission launched a Product Environmental Footprint (PEF) over 10 years ago, with the aim to harmonise Life Cycle Assessment (LCA) methodology, make outcomes more comparable and provide less space for false claims. Besides the PEF Guidance, which contains the basic methodology for PEF studies, Category Rules (CRs) are developed for individual product categories. The PEFCRs provide detailed guidance for conducting PEF studies within that product category.

The following objectives are met when developing this FloriPEFCR:

- to fix a consistent and specific set of rules to calculate the relevant environmental information.
- to enable comparisons between PEF – Product Environmental Footprint - studies which are conducted in compliance with FloriPEFCR.

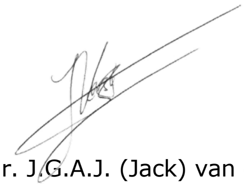
This FloriPEFCR document is structured following the PEFCR template as provided in the Guidelines of the European Commission (EC, 2021 in Annex II) and strictly follows the process of developing a new PEFCR as stipulated in the Guidelines. This process started with arranging a Technical Secretariat (TS), which is the consortium responsible for developing the FloriPEFCR. The TS decided upon the representative products (RP) to be analysed and conducted the RP studies. These studies have informed the development of the 1st and 2nd drafts of the FloriPEFCR. Both RP studies and the FloriPEFCR have been published during the 1st and 2nd open consultation in 2021 and 2023 respectively. Comments from both publications have been processed. The FloriPEFCR has been tested in six (confidential) supporting studies with growers and external consultants. The learnings have been covered in the updated FloriPEFCR. Also, both RP studies have been updated with the most recent Environmental Footprint (EF) data. Both updated RP studies and FloriPEFCR have been reviewed by an external review panel prior to the Open Public Consultations. Finally, the report has been updated and is ready to be released jointly with the final PEF-RP studies and PEF-RP models, following the final opinion issued by the EF-subgroup of the EU Expert group Sustainable Consumption and Production. .

Acknowledgement is given to the significant contribution from the Dutch Public-Private Partnership Project 'HortiFootPrint' that launched the previous version of the Category Rules for horticultural products (Helmes et al., 2020). We especially wish to thank consortium members Glastuinbouw Nederland, ABN AMRO Bank N.V., Rabobank, Netherlands Ministry of Agriculture, Nature and Food Quality for their contributions. The release of the FloriPEFCR replaces the rules developed within the HortiFootprint Category Rules for floriculture.

A word of thanks goes to several professionals that helped the team in reviewing and discussing the interim versions of this document. We thank all the participants to the 1st and 2nd Open Public Consultations who took the time to read and comment this document. In total six cases were modelled: three for cut flowers and three for potted plants. This resulted in very intensive and fruitful collaborations with individual practitioners and organisations from various countries whose efforts are highly appreciated.

With the release of this report that builds on the intense work of the past four years, the professionals are offered the state of the art calculation and modelling rules to identify the environmental footprint of cut flowers and potted plants, produced anywhere in the world under a variety of technologies. We are ready to state the assessments that follow these category rules are harmonised and can be compared within own product categories.

Stay tuned to the developments via the project website.



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Abbreviations

Abbreviation	Explanation
B2B	business to business
B2C	business to consumer
BoM	bill of materials
BSI	British Standards Institution
CF	characterisation factor
CFCs	Chlorofluorocarbons
CFF	Circular Footprint Formula
CHP	Combined Heat and Power
CPA	Classification of Products by Activity
DC	distribution centre
DNM	Data Needs Matrix
DQR	Data Quality Rating
EC	European Commission
EF	Environmental Footprint
EMAS	Eco-Management and Audit Scheme
EoL	End of life
EPD	Environmental Product Declaration
FU	functional unit
FloriPEFCR	Product Environmental Category Rules for Cut flowers and Potted plants
GHG	greenhouse gas
GLO	global
GR	geographical representativeness
GRI	Global Reporting Initiative
GWP	global warming potential
ILCD	International Reference Life Cycle Data System
ILCD-EL	International Reference Life Cycle Data System – Entry Level
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCDN	Life Cycle Data Network
LCI	life cycle inventory
LCIA	life cycle impact assessment
NGO	non-governmental organisation
NMVOC	non-methane volatile compounds
OCAP	organic CO_2 for assimilation by plants
P	precision
PCR	Product Category Rules
PEF	Product Environmental Footprint

Abbreviation	Explanation
PEFCR	Product Environmental Footprint Category Rules
PEF-RP	PEF study of the representative product
RP	representative product
SS	supporting study
TeR	technological representativeness
TiR	time representativeness
TS	Technical Secretariat
UNEP	United Nations Environment Programme
UUID	Universally Unique Identifier
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute

Definitions

Activity data – This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). The aggregated LCI results of the process chains that represent the activities of a process are each multiplied by the corresponding activity data[1] 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.

Active substance – A plant protection product ('pesticide') usually contains more than one component. The component that works against pests/plant diseases is called an 'active substance'.

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

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

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

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

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

Application specific – This term refers to the generic aspect of the specific application in which a material is used. For example, the average recycling rate of PET in bottles.

Attributional – This term refers to process-based modelling intended to provide a static representation of average conditions, excluding market-mediated effects.

Average Data – This term refers to a production-weighted average of specific data.

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

Benchmark – A standard or point of reference against which any comparison may be made. In the context of PEF, the term 'benchmark' refers to the average environmental performance of the representative product sold in the EU market.

[1] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (WBCSD & WRI, 2012).

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

Blue water – Blue water is water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint.

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

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

Characterisation – Calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with characterisation factors for each substance and EF impact category of concern. For example, with respect to the EF impact category 'climate change', 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, 2006b).

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 – The consequences of activities leading to greenhouse gas emissions resulting in increased average global temperatures and sudden regional climatic changes. Climate change is an impact affecting the environment on a global scale.

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

Commissioner of the EF study – Organisation (or group of organisations) that finances the EF study in accordance with the PEF method and the relevant PEFCR, if available (definition adapted from ISO, 2014, point 3.4).

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

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

Comparative Assertion – An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function (including the benchmark of the product category) (adapted from (ISO, 2006c).

Comparison – A comparison, not including a comparative assertion, (graphic or otherwise) of two or more products based on the results of a PEF study and supporting PEFCRs.

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

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

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

Critical review – Process intended to ensure consistency between a PEFCR and the principles and requirements of the PEF method.

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

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

Delayed emissions – Emissions that are released over time, e.g. through long use or final disposal stages, versus a single emission at time t.

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

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

Directly attributable – This term refers to a process, activity or impact occurring within the defined system boundary.

Disaggregation – The process that breaks down an aggregated dataset into smaller unit process datasets (horizontal or vertical). The disaggregation may help make data more specific. The process of disaggregation should never compromise or threat to compromise the quality and consistency of the original aggregated dataset

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.

EF communication vehicles – This term includes all the possible ways that may be used to communicate the results of the EF study to the stakeholders (e.g. labels, environmental product declarations, green claims, websites, infographics, etc.).

EF compliant dataset – Dataset developed in compliance with the EF requirements provided at http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml.

Electricity tracking – Electricity tracking is the process of assigning electricity generation attributes to electricity consumption.

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, 2006b) 3.12). Elementary flows include, for example, resources taken from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories.

Environmental aspect – Element of an organisation's activities or products or services that interacts or can interact with the environment (ISO, 2015).

Environmental footprint – The environmental impact for a product system throughout the life cycle of the product, expressed through a set of impact categories.

Environmental Footprint (EF) Impact Assessment – Phase of the PEF analysis aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product (based on ISO, 2006c). The impact assessment methods provide impact characterisation factors for elementary flows in order to aggregate the impact to obtain a limited number of midpoint indicators.

Environmental Footprint (EF) Impact Assessment method – Protocol for quantitative translation of life cycle inventory data into contributions to an environmental impact of concern.

Environmental Footprint (EF) Impact Category – Class of resource use or environmental impact to which the life cycle inventory data are related.

Environmental Footprint (EF) impact category indicator – Quantifiable representation of an EF impact category (based on ISO 14000:2006).

Environmental impact – Any change to the environment, whether adverse or beneficial, that wholly or partially results from an organisation's activities, products or services (EMAS regulation).

Environmental mechanism – System of physical, chemical and biological processes for a given EF impact category linking the life cycle inventory results to EF category indicators (based on (ISO, 2006b)).

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

External Communication – Communication to any interested party other than the commissioner or the practitioner of the study.

Extrapolated Data – This term refers to data from a given process that is used to represent a similar process for which data is not available, on the assumption that it is reasonably representative.

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

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

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

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

Global warming potential – Capacity of a greenhouse gas to influence radiative forcing, expressed in terms of a reference substance (for example, CO_2 equivalent units) and specified time horizon (e.g. GWP 20, GWP 100, GWP 500, for 20, 100, and 500 years respectively). It relates to the capacity to influence changes in the global average surface-air temperature and subsequent change in various climate parameters and their effects, such as storm frequency and intensity, rainfall intensity and frequency of flooding, etc.

Growing media – Often also referred to as 'substrate' or 'potting soil', a growing medium is a material, other than soil on the spot, in which plants are grown.

Horizontal averaging – This term refers to the action of aggregating multiple unit process datasets or aggregated process datasets in which each provides the same reference flow in order to create a new process dataset (United Nations Environment Programme, 2011).

Human toxicity – cancer – EF impact category that accounts for adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to cancer.

Human toxicity - non cancer – EF impact category that accounts for the adverse health effects on human beings caused by the intake of toxic substances through inhalation of air, food/water ingestion, penetration through the skin insofar as they are related to non-cancer effects that are not caused by particulate matter/respiratory inorganics or ionising radiation.

Independent external expert – Competent person, not employed in a full-time or part-time role by the commissioner of the EF study or the user of the EF method, and not involved in defining the scope or conducting the EF study (adapted from (ISO, 2014) point 3.2).

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

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

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

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

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

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

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

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

Life cycle Assessment (LCA) – Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14040:2006).

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

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

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

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

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

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

Non-elementary (or complex) flows – In the life cycle inventory, non-elementary flows include all the inputs (e.g. electricity, materials, transport processes) and outputs (e.g. waste, by-products) in a system that need further modelling efforts to be transformed into elementary flows. Synonym of activity data.

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

Organic fertiliser – Fertilising materials derived from plants and animal parts or residues, such as compost and manure.

Output flows – Product, material or energy flow that leaves a unit process. Products and materials include raw materials, intermediate products, co-products and releases (ISO, 2006b).

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).

Partially disaggregated dataset – A dataset with a LCI that contains elementary flows and activity data, and that only in combination with its complementing underlying datasets yield a complete aggregated LCI data set.

Partially disaggregated dataset at level-1 – A partially disaggregated dataset at level-1 contains elementary flows and activity data of one level down in the supply chain, while all complementing underlying datasets are in their aggregated form.

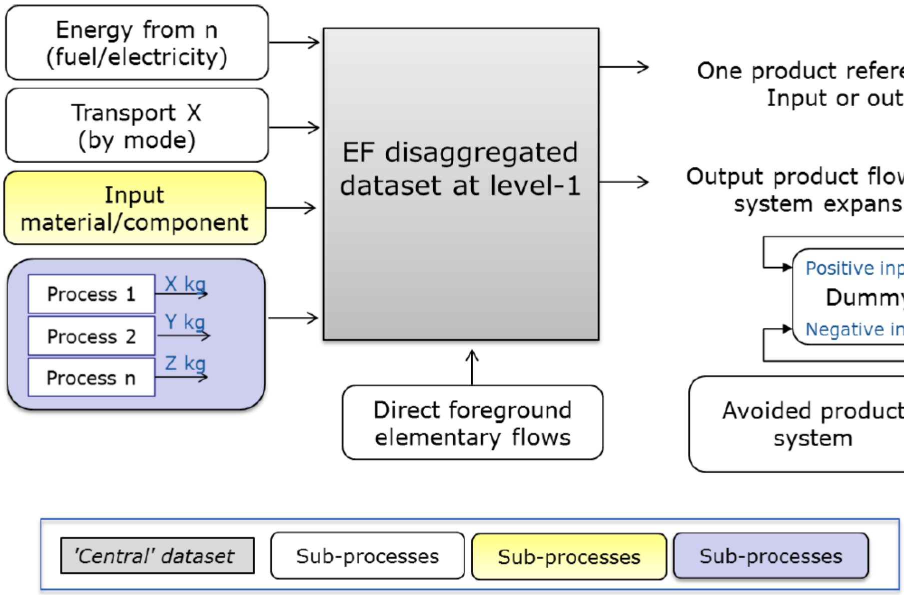

Figure 1 *Example of a dataset partially disaggregated at level-1*

Particulate Matter – EF impact category that accounts for the adverse health effects on human health caused by emissions of Particulate Matter (PM) and its precursors (NOx, SOx, NH_3).

PEFCR supporting study – PEF study based on a draft PEFCR. It is used to confirm the decisions taken in the draft PEFCR before the final PEFCR is released.

PEF profile – The quantified results of a PEF study. It includes the quantification of the impacts for the various impact categories and the additional environmental information considered necessary to report.

PEF report – Document that summarises the results of the PEF study.

PEF study of the representative product (PEF-RP) – PEF study carried out on the representative product(s) and intended to identify the most relevant life cycle stages, processes, elementary flows, impact categories and any other major requirements needed for the definition of the benchmark for the product category/sub-categories in scope of the PEFCR.

PEF study – Term used to identify the totality of actions needed to calculate the PEF results. It includes the modelling, the data collection, and the analysis of the results. It excludes the PEF report and the verification of the PEF study and report.

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

Plant protection products – Herbicides, insecticides, fungicides, biocides, soil fumigants used in all stages of cultivation, storage and in post-harvest handling.

Population – Any finite or infinite aggregation of individuals, not necessarily animate, subject to a statistical study.

Post-harvest handling – This encompasses all activities related to the handling of products after harvesting, i.e. sorting, washing, phytosanitary treatment. Several phytosanitary treatments might be carried out after harvest to enhance storage duration and maintain the quality of the product.

Primary data[2] – This term refers to data from specific processes within the supply chain of the user of the PEF method or user of the PEFCR. Such data may take the form of activity data, or foreground elementary flows (life cycle inventory). Primary data are site-specific, company-specific (if multiple sites for the same product) or supply chain specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material/product balances, stoichiometry, or other methods for obtaining data from specific processes in the value chain of the user of the PEF method or user of the PEFCR. In this method, primary data is synonymous with 'company-specific data' or 'supply-chain specific data' (WBCSD & WRI, 2012).

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

Product category – Group of products (or services) that can fulfil equivalent functions (ISO, 2006a).

Product Category Rules (PCRs) – Set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories (ISO, 2006a).

Product Environmental Footprint Category Rules (PEFCRs) – Product category specific, life cycle-based rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category. PEFCRs help to shift the focus of the PEF study towards those aspects and parameters that matter the most, and hence contribute to increased relevance, reproducibility and consistency of the results by reducing costs versus a study based on the comprehensive requirements of the PEF method. Only the PEFCRs developed by or in cooperation with the European Commission, or adopted by the Commission or as EU acts, are recognised as being in line with this method.

Product flow – Products entering from or leaving to another product system (ISO, 2006b).

Product system – Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (ISO, 2006b).

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

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, 2006b).

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[2] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard.

Refurbishment – This is the process of restoring components to a functional and/or satisfactory state to the original specification (providing the same function), using methods such as resurfacing, repainting, etc. Refurbished products may have been tested and verified to function properly.

Releases – Emissions to air and discharges to water and soil (ISO, 2006b).

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

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

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

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

Review – procedure intended to ensure that the process of developing or revising a PEFCR has been carried out in accordance with the requirements provided in the PEF method and part A of Annex II.

Review report – a documentation of the review process that includes the review statement, all relevant information about the review process, the detailed comments from the reviewer(s) and the corresponding responses, and the outcome. The document shall carry the electronic or handwritten signature of the reviewer (or the lead reviewer, if a reviewer panel is involved).

Review panel – team of experts (reviewers) who will review the PEFCR.

Reviewer – independent external expert conducting the review of the PEFCR and possibly taking part in a reviewer panel.

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

Secondary data[3] – This refers to data not from a specific process within the supply-chain of the company performing a PEF study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third party LCI database or other sources. Secondary data includes industry average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies and patents, and may also be based on financial data, and contain proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data (WBCSD & WRI, 2012).

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

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

Single overall score – sum of the weighted EF results of all environmental impact categories.

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[3] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard

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

Starting material - Seed, seedlings, plant cuttings, root cutting and/or young plants purchased by growers for the cultivation of cut flowers and potted plants meant for the final consumer (either via retail or not).

Subdivision – Subdivision refers to disaggregating multifunctional processes or facilities to isolate the input flows directly associated with each process or facility output. The process is investigated to see whether it may be subdivided. Where subdivision is possible, inventory data should be collected only for those unit processes directly attributable to the products/services of concern.

Sub-population – Any finite or infinite aggregation of individuals, not necessarily animate, subject to a statistical study that constitutes a homogenous sub-set of the whole population. Synonymous with 'stratum'.

Sub-processes – Those processes used to represent the activities of the level 1 processes (=building blocks). Sub-processes may be presented in their (partially) aggregated form (see Figure 1).

Sub-sample – A sample of a sub-population.

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

Supply chain specific – This refers to a specific aspect of the specific supply chain of a company.

Synthetic fertiliser – Fertilising inorganic compounds, usually derived from by-products of the petroleum industry, such as ammonium nitrate, ammonium phosphate, superphosphate and potassium sulfate.

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 PEF study.

Temporary carbon storage – This 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.

Type III environmental declaration – An environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information (ISO, 2006a). The predetermined parameters are based on the ISO 14040 series of standards, which is made up of ISO, 2006b and ISO, 2006c.

Uncertainty analysis – Procedure to assess the uncertainty in the results of a PEF study due to data variability and choice-related uncertainty.

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

Unit process, black box – Process chain or plant level unit process. This covers horizontally averaged unit processes across different sites. Covers also those multi-functional unit processes, where the different co-products undergo different processing steps within the black box, hence causing allocation problems for this dataset.

Unit process, single operation – Unit operation type unit process that cannot be further subdivided. Covers multi-functional processes of unit operation type.

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

User of the PEFCR – A stakeholder producing a PEF study based on a PEFCR.

User of the PEF method – A stakeholder producing a PEF study based on the PEF method.

User of the PEF results – A stakeholder using the PEF results for any internal or external purpose.

Verification – Conformity assessment process carried out by an environmental footprint verifier to demonstrate whether the PEF study has been carried out in compliance with the most updated version of the PEF method adopted by the Commission.

Validation – Confirmation by the environmental footprint verifier that the information and data included in the PEF study, PEF report and the communication vehicles are reliable, credible and correct.

Validation statement – Conclusive document aggregating the conclusions from the verifiers or the verification team regarding the EF study. This document is mandatory and shall carry the electronic or handwritten signature of the verifier or, in case of a verification panel, of the lead verifier.

Verification report – Documentation of the verification process and findings, including detailed comments from the verifier(s), as well as the corresponding responses. This document is mandatory, but it may be confidential. The document shall carry the electronic or handwritten signature of the verifier, or in case of a verification panel, of the lead verifier.

Verification team – Team of verifiers that will perform the verification of the EF study, of the EF report and the EF communication vehicles.

Verifier – Independent external expert performing a verification of the EF study and eventually taking part in a verification team.

Vertical aggregation – Technical- or engineering-based aggregation refers to vertical aggregation of unit processes that are directly linked within a single facility or process train. Vertical aggregation involves combining unit process datasets (or aggregated process datasets) together linked by a flow (United Nations Environment Programme., 2011).

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

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

Weighting – Weighting is a step that supports the interpretation and communication of the results of the analysis. PEF 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.

Summary

The Product Environmental Footprint Category Rules for Cut flowers and Potted plants (FloriPEFCR) is the report that is developed according to the Product Environmental Footprint Guidance – PEF Guidance (EC, 2021). It provides technical guidance to the horticultural sector on how to perform Product Environmental Footprint (PEF) studies of horticultural products belonging to the following categories: Cut flowers and Potted plants. The FloriPEFCR is intended for practitioners to monitor their environmental impact, identify hotspots in the life cycle of their products and recognise areas for improvement of their environmental performance.

The goal of this FloriPEFCR is to provide a harmonised methodology for conducting PEF studies using a consistent methodology for cut flowers and potted plants, resulting in comparable outcomes within both sub-categories. The document is structured along the template as required by the PEF Guidance (EC, 2021). It documents how stakeholders and experts have been involved in the process, specifies the functional unit of the analysis, guidelines for PEF studies in this product category and results of Representative Product (RP-PEF) studies as required by the PEF Guidance. This final document is prepared for validation by the European Commission.

The methodological choices are described in the main part of the document under respective sections. Previously, several methodological approaches for horticultural crops were pre-tested in 2018-2019 during the development of Hortifootprint Category Rules (Helmes et al., 2020), which is the starting point for the development of FloriPEFCR. On the basis of six cases in 2020 (rose, Phalaenopsis, tulip bulbs but also other relevant crops such as bananas, apples, tomatoes) and later on the basis of several confidential studies (tomato from the Netherlands, Morocco and Tunisia, oranges from Egypt and onions from the Netherlands) the Hortifootprint method was tested. Although these latter products are not part of this PEFCR, the unique learnings from these cases are also relevant for cut flowers and potted plants and thus are reapplied in the development of this PEFCR.

Chapters 1 and 2 provide a general introduction and information about the FloriPEFCR, describing the consortium that participated in the development of the methodology and the stakeholder engagement process.

Chapter 3 is about the PEFCR scope and provides information specifically on topics such as functional unit, system boundaries, impact assessment method and representative products. This chapter lists product classifications that are covered by this PEFCR. Chapter 3 also provides brief descriptions of each of the two product categories and how they were derived. Two Representative Product (RP) studies have been conducted to gain more experience with calculating the environmental impact according to the PEF guidance. The RP studies were also important to make methodological decisions and the learnings from the two RP studies were used for drafting this version of the FloriPEFCR. One RP study was conducted for potted plants and one for cut flowers. For both RP studies a virtual product was analysed. This virtual product is a mix of real products and is considered to represent the diversity of the products on the market for the two product categories.

For potted plants a virtual product was constituted based on three real products from the Netherlands, as the main country of origin of potted plants sold in Europe. These products are selected to represent three main groups of potted plants as follows:

- Orchid Phalaenopsis is chosen to represent indoor flowering plants as a genus of many species, grown in warm conditions in greenhouses and as the most popular potted orchid plant to keep indoors with minimum care.
- Dracaena - also a genus of many species - is chosen to represent indoor leaf plants that need lower temperatures for cultivation in greenhouses and more humidity and watering during the use.

- Lavender is also a genus of several species and is chosen to represent outdoor plants grown in gardens all over the world that can propagate itself beyond the gardens on relatively dry, well-drained, sandy soils in full sun.

The virtual representative product 'Cut flower' is composed of seven cases, each reflecting a combination of a flower and a country:
- four roses from the Netherlands, Kenya, Ethiopia, Ecuador sufficiently represent cut flowers from permanent plants of different length, grown on different types of growing media, in different types of greenhouses and climate control systems and having different cultivation techniques for growing planting materials and having different product packaging
- two chrysanthemums from Colombia and the Netherlands sufficiently represent cut flowers from cuttings and different cultivation methods
- tulips from the Netherlands being the majority of cut flowers coming from bulbs, sufficiently represent the third type of cut flowers.

Chapter 4 relates to the results obtained from PEF-Representative Product studies (Helmes et al, 2024 and Broekema et al., 2024) and lists the most relevant impact categories, life cycle stages, processes and elementary flows, as well as limitations. The classification 'most relevant' is defined as life cycle stages, processes or elementary flows that contribute cumulatively to at least 80% of the total impact of one of the most relevant impact category of the group consistent with the PEF Guidance.

In Chapter 5 the document lists the processes to be modelled with mandatory company-specific data (i.e. activity data and direct elementary flows). Most of the mandatory company-specific data will come from growers and access to these data is required to perform a PEF study. There are horticulture service providers that have access or manage data from growers that are expected to be able to perform a PEF study. Also there are owners of certification schemes which already manage a lot of the data from growers and are expected to be able to perform a PEF study. This chapter also lists the data quality requirements and specifies additional criteria for the assessment of data quality for company-specific datasets. Important allocation rules applied in the calculations are also presented in this section.

In Chapter 6 the FloriPEFCR elaborates on the methodological rules, providing practitioners with instructions on how to define the steady state in cultivation, deal with allocation in specific instances related to the floricultural life cycle, model electricity use, emissions of fertilisers and manure, and how to deal with the end-of-life of different products. Additionally, the FloriPEFCR provides instructions on how to develop the inventory for each life cycle stage, providing instructions on primary and secondary data to be collected.

Chapter 7 provides the results of the benchmark for each representative product. The benchmark results represent the average environmental performance of the representative product sold in the EU market and can be used for comparison. The results are characterised, normalised, and weighted (as absolute values) for potted plants and cut flowers.

Chapter 8 is about the requirements for verification. A PEF study carried out in compliance with this PEFCR shall be done according to all the general requirements stated in the PEF guidance and this chapter. Verifier(s) shall verify that the PEF study is conducted in compliance.

1 Introduction

The Product Environmental Footprint (PEF) method provides detailed and comprehensive technical rules on how to conduct PEF studies that are more reproducible, consistent, robust, verifiable and comparable. Results of PEF studies are the basis for the provision of EF information and they may be used in a diverse number of potential fields of applications, including in-house management and participation in voluntary or mandatory programmes.

For all requirements not specified in this PEFCR, the user of the PEFCR shall refer to the documents this PEFCR is in conformance with (see chapter 2.7).

The compliance with the present PEFCR is optional for PEF in-house applications, whilst it is mandatory whenever the results of a PEF study or any of its content is intended to be communicated.

Terminology: shall, should and may

This PEFCR uses precise terminology to indicate the requirements, the recommendations and options that could be chosen when a PEF study is conducted.

- The term 'shall' is used to indicate what is required in order for a PEF study to be in conformance with this PEFCR.
- The term 'should' is used to indicate a recommendation rather than a requirement. Any deviation from a 'should' recommendation has to be justified when developing the PEF study and made transparent.
- The term 'may' is used to indicate an option that is permissible. Whenever options are available, the PEF study shall include adequate argumentation to justify the chosen option.

2 General information about the PEFCR

2.1 Technical Secretariat

The Technical Secretariat (TS) responsible for the development of the PEFCR for cut flowers and potted plants is composed of the following organisations:

Table 1 *Technical Secretariat*

Name of the organisation	Type of organisation	Name of the members (not mandatory)
Royal FloraHolland (Chair)	Growers cooperation	Albert Haasnoot
UnionFleurs	Sector organisation	Sylvie Mamias/Martin de la Harpe
Wageningen Economic Research (TS support)	Research organisation	Roline Broekema
PRé Sustainability	LCA Consultancy	Marisa Vieira
Blonk Consultants	LCA Consultancy	Paulina Gual Rojas (up until January 2023) Meike Hopman
MPS Group	Certifying agency	Vincent den Breejen
Floriculture Sustainability Initiative (FSI)	Sector organisation	Jeroen Oudheusden/Caroline la Grande
Fresh Produce Centre (GroentenFruit Huis)	Trade association	Nikki Hulzebos
Natuur&Milieu	NGO	Ida Sanders
Florverde	Sector organisation	Ximena Franco

2.2 Consultations and stakeholders

The procedure for the development of a PEFCR considers a number of steps that have been followed by the TS, namely:

- Definition of the PEF product category and scope of the PEFCR
- Representative product studies
- 1st Draft PEFCR
- 1st public consultation
- PEF supporting studies
- 2nd draft PEFCR
- 2nd public consultation
- Final PEFCR

After the representative product studies, the 1st public consultation with stakeholders took place in September 2021. After completion of the supporting studies, the 2nd draft PEFCR, was submitted for public consultation in June 2023.

	1st public consultation	2nd public consultation
Start date	September 1st 2021	June 19th 2023
End date	September 30th 2021	July 16th 2023
Duration (weeks)	4	4
Number of participating stakeholders	13	14
Number of comments	215	324
Organisations that have provided comments	Universidad Escuela Colombiana de Ingeniería Julio Garavito; CTCP; SOLTUB Ltd.; Klasmann-Deilmann Gmbh; Blonk Consultants; Nordic Environmental Footprint; Wageningen Research; Orchidee Nederland; Afriflora; Addenda; Yukan/Glimpact; EF Helfdesk; PEF-team EC	Blonk Sustainability, Greenhouse Sustainability, EF Helpdesk, Universidad Escuela Colombiana de Ingeniería Julio Garavito, Environment Agency Austria, Cecodes, O2m Lab, Oxin Growers, Glastuinbouw Nederland, Growing Media Europe, Florverde Sustainable Flowers, Greenports Nederland, Coöperatie Growers United UA, Harvest House

After each public consultation, comments were analysed, and answers were published on the EF wiki space. When relevant, the PEFCR was adapted accordingly.

2.3 Review panel and review requirements of the PEFCR

During the development of the PEFCR, deliverables were reviewed by a third-party review panel (Table 2). The first deliverables under review were the representative product study reports and 1st draft PEFCR. Review took place in July-August 2021. The supporting study reports (six) were reviewed over the course of 2022. The updated representative product study reports and 2nd draft PEFCR were reviewed in May 2023. The final draft PEFCR was reviewed in August 2023).

Table 2 *Review panel of the PEFCR*

Name of the member	Affilliation	Role
Johannes Lijzen/Elias de Valk	RIVM	LCA expert, panel member
Rene Corsten/Jeroen van Buren	Delphy	Sector expert, panel member and chair
Judith Brouwer	Milieu Centraal	NGO and panel member

The reviewers have verified that the following requirements are fulfilled:

- The PEFCR has been developed in accordance with the requirements provided in the PEF method and Annex A of the PEF method;
- The PEFCR supports the creation of credible, relevant and consistent PEF profiles;
- The PEFCR scope and the representative products are adequately defined;
- The functional unit, allocation and calculation rules are adequate for the product category under consideration;
- Datasets used in the PEF-RPs and the supporting studies are relevant, representative, reliable, and in compliance with data quality requirements;
- The selected additional environmental and technical information are appropriate for the product category under consideration and the selection is done in accordance with the requirements stated in the PEF method;
- The model of the RP and corresponding benchmark (if applicable) represent correctly the product category or sub-category;
- The RP model, disaggregated in line with the PEFCR and aggregated in ILCD format, are EF compliant following the rules available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml;
- The RP model in its corresponding excel version is compliant with the rules outlined in Section A.2.3 of Annex A;
- The Data Needs Matrix is correctly implemented;
- The classes of performance, if identified, are appropriate for the product category.

The public review reports are provided in Appendix 3 of this PEFCR.

2.4 Review statement

This PEFCR was developed in compliance with the PEF method adopted by the Commission on December 16th 2021.
The representative product(s) correctly describe the average product(s) sold in Europe for the product category/sub-category in scope of this PEFCR.
PEF studies carried out in compliance with this PEFCR would reasonably lead to reproducible results and the information included therein may be used to make comparisons and comparative assertions under the prescribed conditions (see chapter 3.8 on limitations).

The final validation statement of the review panel is included in Appendix 4.

2.5 Geographic validity

This PEFCR is valid for products in scope sold or consumed in the European Union + EFTA + UK.

2.6 Language

The PEFCR is written in English. The original in English supersedes translated versions in case of conflicts.

2.7 Conformance to other documents

This PEFCR has been prepared in conformance with the following documents (in prevailing order):

- Product Environmental Footprint (PEF) method (EC, 2021)
- Hortifootprint Category Rules (Helmes et al., 2020) were used as a starting point
- Growing Media Environmental Footprint Guideline V1.0 was used as much as possible for the modelling approach for production and emissions for growing media (GME, 2021).

3 PEFCR scope

This chapter includes a description of the scope of FloriPEFCR. The product classifications covered by this PEFCR are provided, as well as the description of the representative products, which have been used to guide the development of FloriPEFCR and can be used as a benchmark. The functional unit is described for both product categories: Cut flowers and Potted plants. A flow chart is used to describe the system boundaries. This chapter also lists the EF impact categories and the underlying methods to be used. Furthermore, the additional technical and environmental information which shall be provided when conducting a PEF study according to this PEFCR are given. Limitations are provided as well as guidance in terms of comparative assertions and data gaps/proxies.

3.1 Product classification

This section lists categories and codes from the Classification of Products by Activity (CPA) that are covered by this PEFCR. Terminology used here is from the CPA, which is not necessarily consistent with the terminology used in this PEFCR. In selecting coverage of the CPA codes by this PEFCR the Representative products have been considered. The CPA codes for the products included in this PEFCR are in Table 3.

Table 3 *CPA codes for the products included in this PEFCR*

CPA code	Coverage
01.19.21 Cut flowers and flower buds	
0603 11 00 Fresh cut roses and buds, of a kind suitable for bouquets or for ornamental purposes	
0603 12 00 Fresh cut carnations and buds, of a kind suitable for bouquets or for ornamental purposes	
0603 13 00 Fresh cut orchids and buds, of a kind suitable for bouquets or for ornamental purposes	
0603 14 00 Fresh cut chrysanthemums and buds, of a kind suitable for bouquets or for ornamental purposes	
0603 15 00 Fresh cut lilies ‘Lilium spp.’ and buds, of a kind suitable for bouquets or for ornamental purposes	
0603 19 10 Fresh cut gladioli and buds, of a kind suitable for bouquets or for ornamental purposes	
0603 19 80 Fresh cut flowers and buds, of a kind suitable for bouquets or for ornamental purposes (excl. roses, carnations, orchids, gladioli, chrysanthemums and lilies)	
01.19.22 Flower seeds	
1209 30 00 Seeds of herbaceous plants cultivated mainly for flowers, for sowing	Not covered
01.30.10 Planting material: live plants, bulbs, tubers and roots, cuttings and slips; mushroom spawn	
0601 10 10 Dormant hyacinth bulbs	Not covered
0601 10 20 Dormant narcissi bulbs	Not covered
0601 10 30 Dormant tulip bulbs	Not covered
0601 10 40 Dormant gladioli bulbs	Not covered
0601 10 90 Dormant bulbs, tubers, tuberous roots, corms, crowns and rhizomes (excl. those used for human consumption, hyacinth, narcissi, tulip, gladioli and chicory plants and roots)	Not covered
0601 20 10 Chicory plants and roots (excl. chicory roots of the variety cichorium intybus sativum)	Not covered
0601 20 30 Orchid, hyacinth, narcissi and tulip bulbs, in growth or in flower	
0601 20 90 Bulbs, tubers, tuberous roots, corms, crowns and rhizomes, in growth or in flower (excl. those used for human consumption, orchids, hyacinths, narcissi, tulips and chicory plants and roots)	
0602 10 10 Unrooted vine cuttings and slips	Not covered
0602 10 90 Unrooted cuttings and slips (excl. vines)	
0602 20 10 Vine slips, grafted or rooted	Not covered

CPA code	Coverage
0602 20 90 Trees, shrubs and bushes, grafted or not, of kinds which bear edible fruit or nuts (excl. vine slips)	Not covered
0602 30 00 Rhododendrons and azaleas, grafted or not	
0602 40 00 Roses, whether or not grafted	
0602 90 10 Mushroom spawn	Not covered
0602 90 20 Pineapple plants	Not covered
0602 90 30 Vegetable and strawberry	Not covered
0602 90 45 Outdoor rooted cuttings and young plants of trees, shrubs and bushes (excl. fruit, nut and forest trees)	Not covered
0602 90 49 Outdoor trees, shrubs and bushes, incl. their roots (excl. cuttings, slips and young plants, and fruit, nut and forest trees)	Not covered
0602 90 50 Live outdoor plants, incl. their roots (excl. bulbs, tubers, tuberous roots, corms, crowns and rhizomes, incl. chicory plants and roots, unrooted cuttings, slips, rhododendrons, azaleas, roses, mushroom spawn, pineapple plants, vegetable and strawberry plants, trees, shrubs and bushes)	
0602 90 70 Indoor rooted cuttings and young plants (excl. cacti)	
0602 90 91 Indoor flowering plants with buds or flowers (excl. cacti)	
0602 90 99 Live indoor plants and cacti (excl. rooted cuttings, young plants and flowering plants with buds or flowers)	

Seeds and flowers intended for human consumption are excluded.

All production systems, indoor and outdoor, in soil and soilless, are included.

The scope of this PEFCR focuses on products from these categories that are marketed directly to the consumer, without processing (e.g. drying of flowers).

3.2 Representative product(s)

Two representative products are considered in this PEFCR; one for cut flowers and one for potted plants. All representative products are virtual products. This means they are a mix of real products and are considered to represent the diversity of the products on the market for the two product categories.

These representative products represent what is potentially sold on the European market, not what is produced within the European Union. For products that are mostly exported from, or imported to the EU, this nuance may have significant effects on the size of the environmental impact of the transportation and storage stage.
Several data sources were considered for the market shares of potted plants and cut flowers in the EU. Based on data from AIPH in the period of 2015 to 2017 and the turnover of the auctions Plantation and Royal FloraHolland market shares for cut flowers were found: 32% roses, 17% tulips and 12% chrysanthemum. However, the market shares fluctuate quite a lot per year. Using EU trade statistics the market shares by origin were determined. For roses the Netherlands, Kenia and Ethiopia together represent over 85% of the EU market. Tulips mainly come from the Netherlands. Chrysanthemum mainly come from the Netherlands (84% in 2018), but together with Colombia over 90% of the EU market for chrysanthemum is represented.

For potted plants data from the auctions were also considered for the market shares. The statistics of the auctions use the following product categories for potted plants: indoor green plants, flowering plants, outdoor plants. There are a lot of different crops within the pot plant category and there are hardly any crops which clearly represent the better part of the market. Phalaenopsis was selected to represent the flowering plants, with 17% of the 2015-2019 market. Dracaena was selected to represent the green plants with 2.5% of the 2015-2019 market. Lavendula was selected to represent the outdoor plants. According to Eurostat the Netherlands is the main sourcing country for potted plants: > 70% for flowering plants and >55% for green plants. Lavender is among the top 2 crops that represent the outdoor plants in terms of turnover and in the top 5 in terms of numbers of plants sold (source: Royal FloraHollland).

3.2.1 Cut flowers

The representative product for cut flowers is characterised by roses, tulips and chrysanthemum, using 1/3 of each because the market shares fluctuate significantly over time and all three have major shares of the market. Roses that are consumed on the European market are mainly cultivated in the Netherlands, Kenya, Ethiopia and Ecuador, using 1/4 of each. Chrysanthemums are mainly cultivated in the Netherlands and Colombia, using 1/2 of each. Tulips are mainly cultivated in the Netherlands. The different countries covered also ensure coverage of different cultivation techniques, i.e. high and low tech greenhouse and open field.

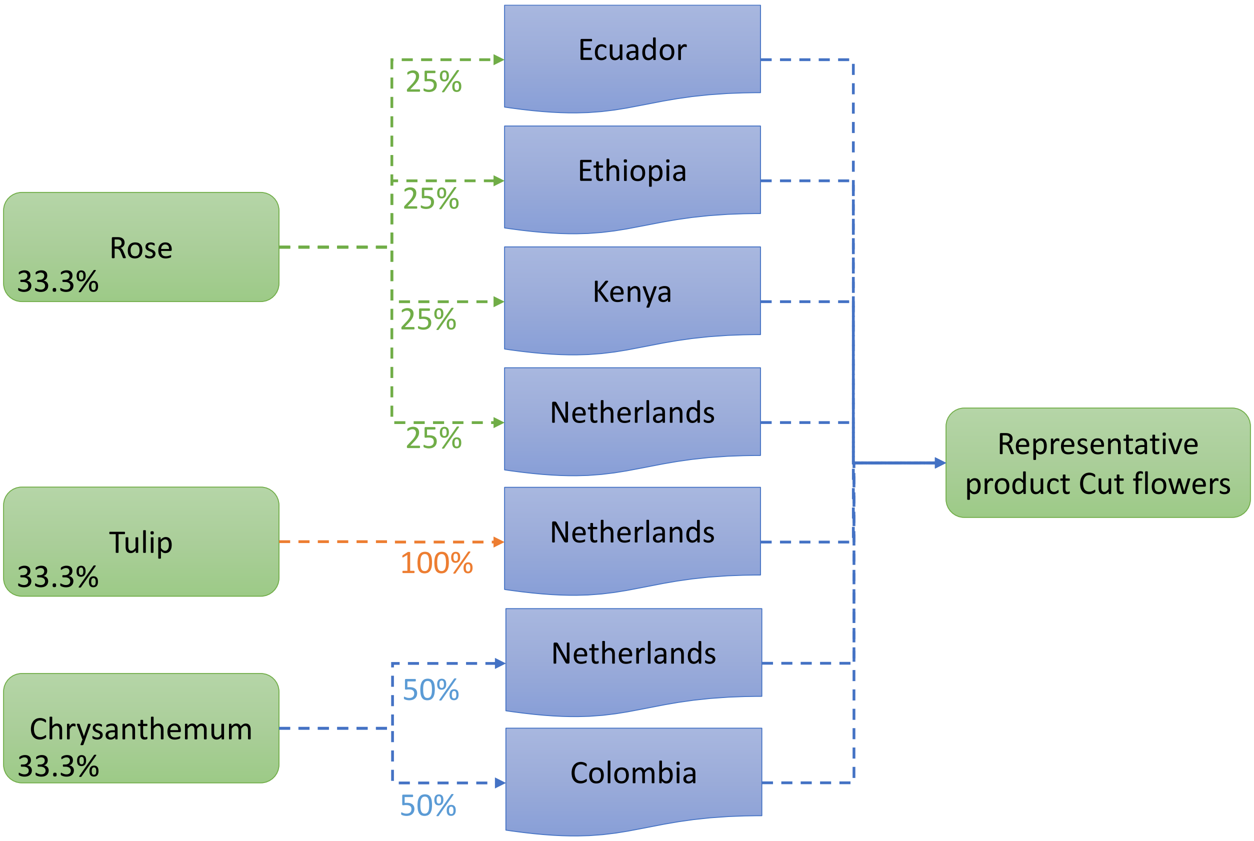

Figure 2 *Representative product for cut flowers*

3.2.2 Potted plants

The representative product for potted plants is characterised by Phalaenopsis, Dracaena and Lavendula, using 1/3 of each because the market shares fluctuate significantly over time. Phalaenopsis is a flowering plant and is assumed to come in a 12 cm diameter pot with bark/coconut fibre growing media. Dracaena is a leaf plant and is assumed to come in a 17 cm diameter pot in peat growing media. Lavendula is an outdoor plant and is assumed to come in a 12 cm pot in peat growing media. The pot sizes have been determined based on expert judgements and represent the ones most commonly used for these potted plants. All potted plants are considered to be produced in Netherlands because this was the major producing country for all potted plants.

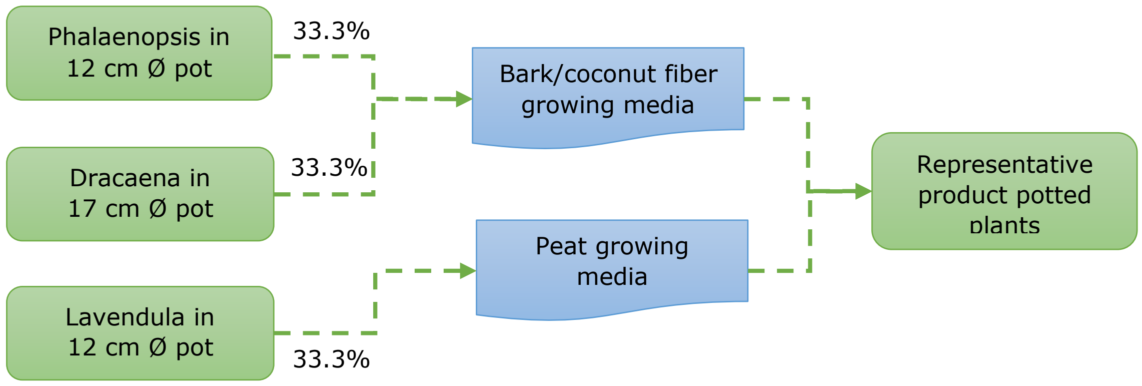

Figure 3 *Representative product for potted plants*

The PEF study of the representative product(s) (PEF-RP) is available upon request to the TS coordinator that has the responsibility of distributing it with an adequate disclaimer about its limitations.

3.3 Functional unit and reference flow

The functional unit for cut flowers (FU) is one stem.

The functional unit for potted plants (FU) is one pot (inner pot only).

Table 4 provides a description of the functional unit, encompassing its four defining aspects.

Table 4 *Key aspects of the functional unit*

Sub-category	**Aspect detail**	**Cut flowers**	**Potted plants**
What?	Function provided	To provide decoration	To provide decoration
How much?	Magnitude of the function	1 stem, as purchased by consumer	1 pot in an inner pot only, as purchased by consumer
How well?	Expected level of quality	According to the specifications of the producer or the retailer.	According to the specifications of the producer or the retailer.
How long?	Duration of the product provided	According to the specifications on consumer packaging or information otherwise known by the consumer related to the characteristics of the specific product. Variability of longevity innate to the product or storage method shall be communicated in the study report. It is expected that the user puts minimum efforts in maintaining the product (at least sufficient watering).	According to the specifications on consumer packaging or information otherwise known by the consumer related to the characteristics of the specific product. Variability of longevity innate to the product or storage method shall be communicated in the study report.

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in 1 stem and 1 pot, for cut flowers and potted plants, respectively. All quantitative input and output data collected in the study shall be calculated in relation to this reference flow[4].

The main function of a cut flower and a potted plant is to provide decoration. The magnitude of the function of 1 stem and 1 pot respectively, corresponds to the function because other quantitative aspects such as mass, volume, taste or content are not related to the function. The expected level of quality is related to the

[4] The reference flow is the amount of product needed to fulfil the defined functional unit.

amount of inputs needed in all life cycle stages to achieve the specifications of the producer or retailer. The duration of the product provided is related to the expected lifetime of the cut flower or potted plant and affects the use stage.

3.4 System boundary

The following life cycle stages and processes shall be included in the system boundary for all products under this PEFCR (see Figure 4 and Table 5). Depending on the product subcategory (cut flowers or potted plants), different activity data can be applicable per life cycle stage. The orange text in Figure 4 relates to the mandatory company-specific data to be used for the PEF study.

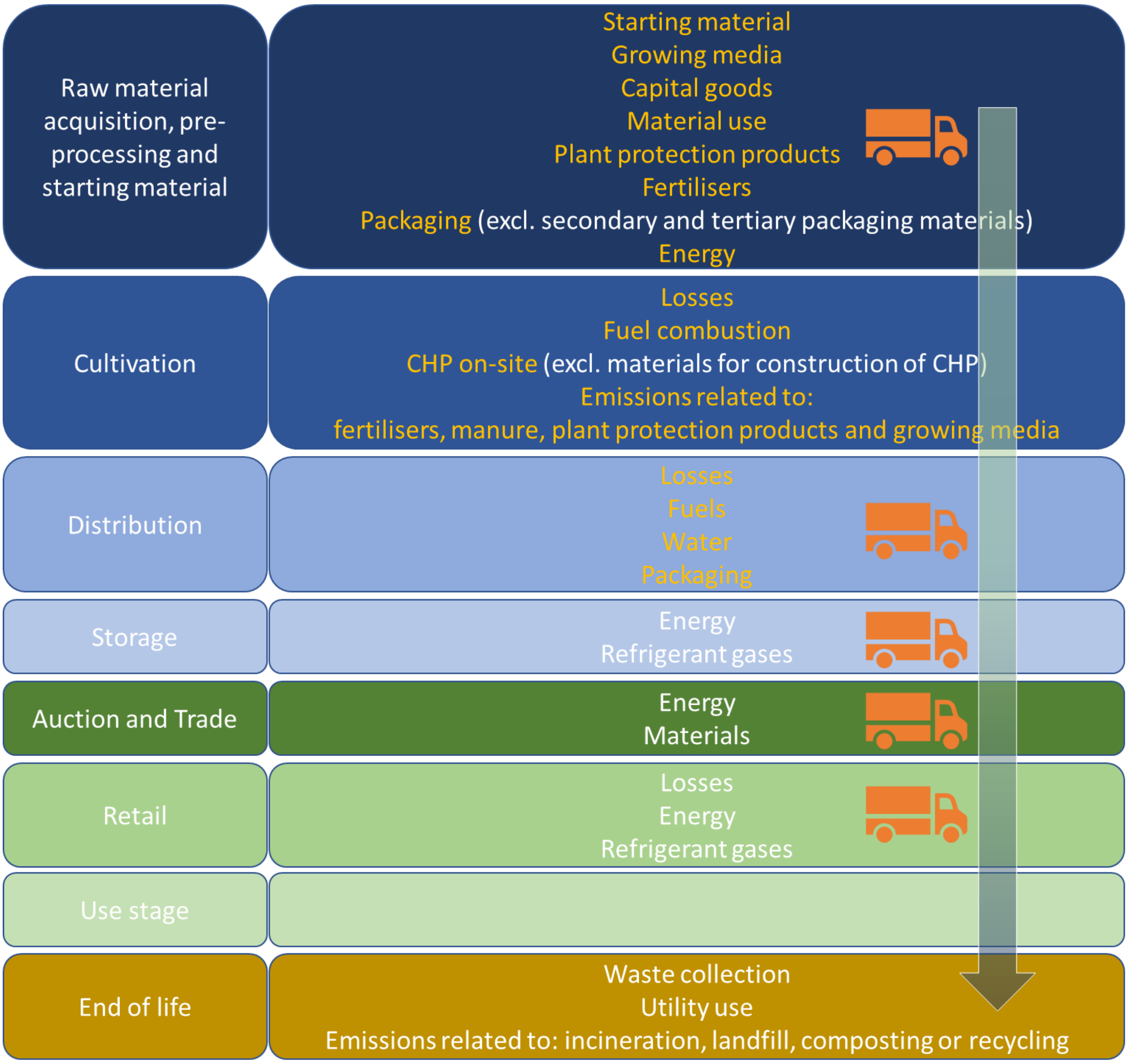

Figure 4 *Life cycle stages and processes included in the system boundaries*

Table 5 *Life cycle stages*

Life cycle stage	Short description of the processes included
Raw material acquisition, pre-processing and starting material	This life cycle stage considers the materials acquired for the cultivation stage. Materials acquired are listed in Chapter 6.1. Capital goods (including depreciation and maintenance) necessary for cultivation (e.g. greenhouse) shall be considered in this life cycle stage. This life cycle stage also includes the production of the starting material and CO_2 purchased.
Cultivation	The cultivation stage encompasses activities related to farming and harvesting of the horticultural product. These include plot preparation, planting/sowing, growing, recirculation and recuperation of nutrients and chemical, harvesting and all activities related to the handling of cut flowers and potted plants products after harvesting (e.g. sorting, washing, phytosanitary treatment). Energy used for cultivation activities and CO_2 generation via CHP on site are in this stage.
Distribution	Delivery of product to final user. This can take place by different modes of transportation and in different legs (e.g. from farm gate to retail and retail to final user).
Storage	The storage life cycle stage refers to the use of energy (e.g. in climate control) and chemicals used to store cut flowers and potted plants prior to retail and excluding storage at auction and trade. In practice, multiple types of products will be stored in one storage facility. Therefore utility use shall be correctly attributed to the reference flow of the functional unit under study.
Auction and trade	The auction involves the trading of the product and includes the use of energy and materials required for this life cycle stage. Some products do not go under the actual auction hammer, but are traded through the auction facilities, in which case the auction life cycle stage is also applicable. If products do not go under auction and are not traded via the auction facilities this life cycle stage does not apply (only storage).
Retail	This life cycle stage refers to utility use (e.g. electricity) for climate control during storage for retail and the treatment of waste which occurs.
End of life	The end of life of the horticultural product shall consider all activity data related to the management of the horticultural product as waste, including transport for collection, utility use and emissions related to incineration, landfill, composting or recycling, based on the local waste management system. The end of life of packaging materials shall be included here. Waste management of material losses at different life cycle stages shall be included in the stage where it occurs unless specifically indicated in this document.

According to this PEFCR, the following processes may be excluded based on the cut-off rule:

- Secondary and tertiary packaging materials for raw material acquisition.
- Flower food (consisting of e.g. citric acid, sugar) used to feed the flowers in use phase.
- Water used for watering in the use phase.
- Capital goods, e.g. materials for constructing the combined heat and power plant (excluding greenhouses).

No additional cut-off is allowed.

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the activities falling in situation 1, 2 or 3 of the data needs matrix.

3.5 List of EF impact categories

Each PEF study carried out in compliance with this PEFCR shall calculate the PEF-profile including all EF impact categories listed in Table 6.

Table 6 *List of the impact categories to be used to calculate the PEF profile*

EF impact category	Impact category indicator	Unit	Characterisation model
Climate change4F[5]	Radiative forcing as Global Warming Potential (GWP100)	kg CO_2 eq	Baseline model of 100 years of the IPCC (based on IPCC 2021)
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 eq	Steady-state ODPs as in (WMO 2014 + integrations)
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model 2.1 (Fankte et al., 2017)
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTUh)	CTUh	USEtox model 2.1 (Fankte et al., 2017)
Particulate matter	Impact on human health	disease incidence	PM method recommended by UNEP (UNEP 2016)
Ionising radiation, human health	Human exposure efficiency relative to ^{235}U	kBq ^{235}U eq	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al., 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC eq	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe 2008
Acidification	Accumulated Exceedance (AE)	mol H^+ eq	Accumulated Exceedance (Seppälä et al., 2006, Posch et al., 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N eq	Accumulated Exceedance (Seppälä et al., 2006, Posch et al., 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P eq	EUTREND model (Struijs et al., 2009) as implemented in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N eq	EUTREND model (Struijs et al., 2009) as implemented in ReCiPe
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTUe)	CTUe	USEtox model 2.1 (Fankte et al., 2017)
Land use	• Soil quality index5F[6] • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production • kg soil • m^3 water • m^3 groundwater	Soil quality index based on LANCA (Beck et al., 2010 and Bos et al., 2016)
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 world eq	Available WAter REmaining (AWARE) as recommended by UNEP, 2016
Resource use6F[7]106, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb eq	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al., 2002

The full list of normalisation factors and weighting factors are available in Appendix 1 - List of EF normalisation factors and weighting factors.

The full list of characterisation factors is available at this link http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

The EF reference package v3.1 (https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) shall be used.

5 The sub-indicators 'Climate change – biogenic' and 'Climate change - land use and land transformation' shall not be reported separately because their contribution to the total climate change impact, based on the benchmark results, is less than 5% each.

6 This index is the result of the aggregation, performed by JRC, of the 4 indicators provided by LANCA model as indicators for land use.

7 The results of this impact category shall be interpreted with caution, because the results of ADP after normalisation may be overestimated. The European Commission intends to develop a new method moving from depletion to dissipation model to better quantify the potential for conservation of resources.

3.6 Additional technical information

A large variety of cut flowers and potted plants are available on the market, which raises questions in terms of comparability of outcomes of analyses using the FloriPEFCR.

To allow further interpretation several characteristics of the cut flower under study shall be reported, namely:

- Length of the stem (incl. the flower), in cm

Also, to allow further interpretation, users of this PEFCR are encouraged to report the expected shelf life (lifetime in consumer phase) of the cut flower (in days). The shelf life of the cut flower should be based on the default values as provides in Table 7. Case specific data may be used, if obtained in accordance with the VBN protocol as available here. The shelf life test duration shall not be less than the minimum test duration as stated in the VBN protocol, with a maximum of 150 days.

Table 7 *Default values shelf life cut flowers (source: Post Harvest Knowledge Centre Royal FloraHolland, based on test from 2010-2021)*

Cut flower – category	Shelf life (in days)
Alstroemeria	12
Chrysanthemum	18
Dianthus	15
Eustoma	15
Freesia	8
Gerbera	16
Gypsy	7
Hypericum	11
Lilium Asiatic	10
Lilium longiflorum	11
Lilium oriental	10
Paeonia	9
Rosa multi-flowered	11
Rosa small-flowered	10
Tulip	8

To allow further interpretation several characteristics of the potted plant under study shall be reported, namely:

- Pot size, diameter in centimetres
- Height of the plant, in centimetres
- Specify whether it is an indoor flowering plant, an indoor leaf plant or an outdoor plant.

Also, to allow further interpretation, users of this PEFCR are encouraged to report the expected shelf life (lifetime in consumer phase) of the potted plant (in days). The shelf life should be based on the default values as provided in Table 8. Case specific data may be used, if obtained in accordance with the VBN protocol as available here. The shelf life test duration shall not be less than the minimum test duration as stated in the VBN protocol, with a maximum of 150 days.

Table 8 *Default values shelf life potted plants (source: Post Harvest Knowledge Centre Royal FloraHolland, based on test from 2010-2021)*

Potted plant – category	**Shelf life (in days)**
Chrysanthemum	26
Hyacinthus	19
Narcissus	16
Rosa	21

- The production and use of biological pest control is not (yet) captured in this PEFCR. If biological pest
- control is used, this shall be reported together with the type of biological pest control.

3.7 Additional environmental information

Biodiversity is considered as relevant for this PEFCR. However, impacts of horticultural systems (and their supply chain) on biodiversity are only partly covered by LCA impact categories.

This is topic of the Agricultural Working Group discussions and this PEFCR should be updated once these discussion have led to an improved method.

3.8 Limitations

There are various limitations for current agricultural modelling rules. Many of these are currently part of the mandate of the Agricultural Modelling Working Group of the EF transition phase. To name a few, the following need further improvement:
- Modelling of emissions of crop protection products based on more information than their application rate, especially for cultivation in greenhouses.
- Modelling of nitrogen and phosphorus emissions due to the application of fertilisers.
- More granularity in the regionalisation of water flows for a proper assessment of water scarcity.
- Country-specific characterisation factors for N & P emissions in eutrophication are only available for EU countries however cultivation can happen worldwide.
- Quantify biodiversity impacts that go beyond impacts covered by the current list of impact categories.

This version of the FloriPEFCR was drafted using the learnings of the Representative Product studies of cut flowers (Helmes et al., 2024) and potted plants (Broekema et al., 2024). The Representative Product studies are based on a select and representative variety of crops, cropping systems and regions. The FloriPEFCR has been tested for a broad range of crops, cropping systems and regions during the supporting studies.

Several technical aspects of cut flowers and potted plants are considered via additional technical information (chapter 3.6) to facilitate interpretation of the PEF result, namely shelf life, length of the stem, size of the pot, height of the pot plant and type of pot plant. For a future update of the PEFCR, these aspects will be reconsidered for integration in the functional unit.

Biological pest control cannot be captured in this PEFCR, because secondary data on biological pest control are not available.

The impact of crop protection active ingredients depends on the farm system, climate conditions, the distance to surface area, the spraying technology etc. In this version of the PEFCR, no specific emission model is recommended that differentiates these parameters. Crop protection is also topic of the discussions of the Agricultural Working Group and this PEFCR is intended to be updated on future learnings. Resistance to pests is not part of the assessment (Bremmer et. al 2023).

The EF 3.1 impact assessment method has country-specific characterisation factors (CFs) for Ammonia and NOx emissions to air and water to marine and terrestrial eutrophication for EU member states. This is acknowledged as a limitation in the evaluation of these impact categories for production sites outside the EU, which is frequently the case for cut flowers and potted plants. When no country-specific CF is available, practitioner shall use the non-regional substance ammonia or NOx in the appropriate compartment and indicate this limitation in the reporting of results.

Aviation emissions are calculated per tkm and the emissions factors is strongly dependent on the length of the flight, due to differences between take-off, landing, and the flight itself. In the EF dataset no distinction is made between these different phases. Furthermore, differences in environmental impact occur when allocating impacts to the product between belly freight and a dedicated freight plane. Currently allocation based on tkm is applied, whilst economic allocation might also be considered. The IPCC acknowledges that the Global Warming Potentials are not adequate to describe the climate impacts of aviation on climate change. In literature, several recommendations are made to include the radiative forcing index of emissions in the higher atmosphere, these are not included in the EF impact assessment however, but might be included in the future.

For comparability reasons non-plant decorative elements, wrapping paper or foil added in retail are not part of this PEFCR. Retailers are advised to make clear that the PEF result is applicable to the horticultural product, excluding these elements.

3.8.1 Comparisons and comparative assertions

The results of any PEF study based on this PEFCR may be used for supply chain management, product design, optimisation, and for comparative assertions among cut flowers or potted plants. The PEFCR is not designed to support comparative claims between cut flowers and potted plants or between these products and products not part of this PEFCR.

Organic production has not been part of the Representative product studies, nor the supporting studies. Hence, comparative assertions between organic and conventional production systems might not be well supported via this PEFCR. Organic production does not occur to a large extent in the florisector (Bionext, 2023).

3.8.2 Data gaps and proxies

For the cultivation stage data from three consecutive years are required, which has proven to be a challenge in the supporting studies. Yield, fertiliser and manure application and energy use shall always be obtained from three consecutive years. If data cannot be obtained for three consecutive years for the other mandatory company specific data, this should be thoroughly explained. Then they may be based on the average of the available data or extrapolated based on expert judgement from the available data.

Growing media requires a lot of specific data for modelling the environmental impact. If these cannot be based on primary data, use GME (2021) which contains many of the required parameters needed for modelling.

EF data are limited in the background processes for starting material. There is only one process available: Root stocks {GLO} | as plant starter material, | production mix, at production farm | LCI result. This process shall be used as a proxy for all starting materials for cut flowers. For potted plants however, this process shall not be used as a proxy, as the impact of the production of starting material may be more relevant for growers who only grow the plants for a short period of time. Duration allocation shall be applied to estimate the environmental impact of the starting material for potted plants. For example, grower A buys a potted plant as start material from grower B. The plant has grown at grower B for 50 days. Grower A grows the plant for another 100 days before reselling it. Grower A is calculating the environmental footprint of its own operation and then multiplies this impact by 1.5 (= total duration/ duration at grower A = 150/100). This means that for potted plants the duration of the production of the starting material as well as the duration of the production of its own product is added to the mandatory company specific data.

4 Most relevant impact categories, life cycle stages, processes and elementary flows

This chapter lists the most relevant EF impact categories, most relevant life cycle stages, most relevant processes and most relevant elementary flows which have been identified for cut flowers and potted plants in the Representative Product Studies (Broekema et al., 2024 and Helmes et al., 2024).

4.1 Most relevant EF impact categories

According to the PEF Guidance the identification of the most relevant impact categories shall be based on the normalised and weighted results. The most relevant impact categories shall be identified as all impact categories that cumulatively contribute to at least 80% to the total environmental impact. This shall start from the largest to the smallest contributions. The most relevant impact categories for the sub-category cut flowers in scope of this PEFCR are the following:
- Climate change (39%)
- Resource use, fossil (24%)
- Particulate Matter (7%)
- Acidification (6%)
- Photochemical ozone formation (5%)

According to the PEF guidance, at least three impact categories shall be identified as the most relevant ones. More impact categories may be added to the list of the most relevant ones but none shall be deleted. The Technical Secretariat of this FloriPEFCR states that additionally impact on ecotoxicity; freshwater, water use and land use shall be reported for the impact category, life cycle stage, processes and direct elementary flows.

The most relevant impact categories for the sub-category potted plants in scope of this PEFCR are the following:
- Climate change (47%)
- Resource use, fossil (33%)
- Particulate matter (5%)

Additionally impact on ecotoxicity; freshwater, land use and water use, shall be reported for the impact category, life cycle stage, processes and direct elementary flows.

4.2 Most relevant life cycle stages

According to the PEF guidance the most relevant life cycle stages are the ones that together contribute at least 80% to any of the most relevant impact categories identified. This shall start from the largest to the smallest contributions. The most relevant life cycle stages for the sub-category Cut flowers in scope of this PEFCR are the following:
- Stage 3. Distribution
- Stage 2. Cultivation
- Stage 1. Raw material acquisition, pre-processing and starting material

The most relevant life cycle stages for the sub-category potted plants in scope of this PEFCR are the following:
- Stage 2. Cultivation
- Stage 1. Raw material acquisition, preprocessing and starting material
- Stage 8. End-of-life
- Stage 3. Distribution

More life cycle stages to the list of the most relevant ones may be added but none shall be deleted.

4.3 Most relevant processes

According to the PEF Guidance each most relevant impact category shall be further investigated by identifying the most relevant processes used to model the product in scope. The most relevant processes are those that collectively contribute at least 80% to any of the most relevant impact categories identified. Identical processes taking place in different life cycle stages (e.g. transportation, electricity use) shall be accounted for separately. Identical processes taking place within the same life cycle stage shall be accounted for together. The list of most relevant processes shall be reported in the PEF report together with the respective life cycle stage (or multiple life cycle stages if relevant) and the contribution in %. The most relevant processes for the sub-category Cut flowers and Potted Plants in scope of this PEFCR are listed in respectively Table 9 and Table 10.

More processes to the list of the most relevant ones may be added but none shall be deleted.

4.4 Most relevant direct elementary flows

According to the PEF guidance each most relevant process shall be further investigated by identifying the most relevant direct elementary flows. Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% of the process, for each most relevant impact category. The analysis shall be limited to the direct emissions of the level-1 disaggregated datasets. This means that the 80% cumulative contribution shall be calculated against the impact caused by the direct emissions only, and not against the total impact of the process.
The most relevant direct elementary flows for the product category in scope of this PEFCR are the listed in Table 9 and Table 10.

More elementary flows to the list of most relevant ones may be added but none shall be deleted.

Table 9 *List of the most relevant impact categories, life cycle stages, processes and elementary flows for cut flowers*

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
Climate change	38.6%	Stage 3. Distribution RP cut flowers	36.7%	Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	27.4%	n.a. because it's aggregated	-
				Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result	1.7%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result	1.5%	n.a. because it's aggregated	-
		Stage 2. Cultivation RP cut flowers	33.7%	Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	8.9%	n.a. because it's aggregated	-
				Heat, from CHP, natural gas {NL}	6.3%	Carbon dioxide, fossil	97.5%
				Electricity, from CHP, natural gas {NL}	4.9%	Carbon dioxide, fossil	97.5%
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	2.8%	n.a. because it's aggregated	-
				Thermal energy from natural gas {RoW} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result	2.1%	n.a. because it's aggregated	-
				Stage 2 Cultivation Tulip {NL}	1.7%	Carbon dioxide, fossil	99.5%
		Stage 1. Raw material Acquisition RP cut flowers	23.1%	Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	5.3%	n.a. because it's aggregated	-
				Landfill of biodegradable waste {EU+EFTA+UK} | LCI result	2.4%	n.a. because it's aggregated	-
				Stage 1a Tulip Bulb {NL}	2.3%	Carbon dioxide, fossil	96.0%
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result	2.1%	n.a. because it's aggregated	-
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result	2.0%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	2.0%	n.a. because it's aggregated	-
				Carbon dioxide, liquid production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result	1.5%	n.a. because it's aggregated	-
		Other		Landfill of biodegradable waste {EU+EFTA+UK} | LCI result - Stage 8 End of Life RP cut flowers	2.7%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result - Stage 8 End of Life RP cut flowers	2.3%	n.a. because it's aggregated	-
		Other		Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result - Stage 6 Retail RP cut flowers	1.4%	n.a. because it's aggregated	-
Resource use, fossils	24.4%	Stage 3. Distribution RP cut flowers	36.6	Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	25.8%	n.a. because it's aggregated	-
				Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result	1.8%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result	1.5%	n.a. because it's aggregated	-
		Stage 2. Cultivation RP cut flowers	35.1%	Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	18.1%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	8.3%	n.a. because it's aggregated	-
				Thermal energy from natural gas {RoW} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result	2.4%	n.a. because it's aggregated	-
		Stage 1. Raw material Acquisition RP cut flowers	25.0%	Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	13.9%	n.a. because it's aggregated	-
				Barge {EU+EFTA+UK} | technology mix, diesel driven, cargo | consumption mix, to consumer | 1500t payload capacity | LCI result	2.6%	n.a. because it's aggregated	-
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result	2.1%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	2.0%	n.a. because it's aggregated	-
		Other		Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result - Stage 8 End of Life RP cut flowers	2.4%	n.a. because it's aggregated	-
Particulate matter	7.2%	Stage 1. Raw Material Acquisition RP Cut flowers	46.8%	Barge {EU+EFTA+UK} | technology mix, diesel driven, cargo | consumption mix, to consumer | 1500t payload capacity | LCI result	10.6%	n.a. because it's aggregated	-
				Calcium ammonium nitrate, per kg substance {EU+EFTA+UK} | production mix, at plant | 26.5% N | LCI result	10.2%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	6.0%	n.a. because it’s aggregated	-
				Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	3.0%	n.a. because it’s aggregated	-
				Diesel combustion in agricultural machine {GLO} | diesel driven | production mix, at plant | 30kW to 180kW | LCI result	2.8%	n.a. because it’s aggregated	-
				Stage 1a Tulip Bulb {NL}	1.7%	Ammonia. NL	100.0%
				Freight train, average {EU+EFTA+UK} | mix of electricity driven and diesel driven, cargo | consumption mix, to consumer | average train, gross tonne weight 1000t/726t payload capacity | LCI result	1.7%	n.a. because it’s aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	1.5%	n.a. because it’s aggregated	-
				Ammonium nitrate, per kg n {GLO} | production mix, at plant | 100% N | LCI result	1.5%	n.a. because it’s aggregated	-
				Carbon dioxide, liquid production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result	1.1%	n.a. because it’s aggregated	-
				Barley straw {EU+EFTA+UK} | technology mix | production mix, at farm | ‘as is’ cultivated and dried product | LCI result	1.0%	n.a. because it’s aggregated	-
		Stage 3. Distribution RP cut flowers	25.0%	Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	12.9%	n.a. because it’s aggregated	-
				Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result	5.4%	n.a. because it’s aggregated	-
				Aluminium, production mix, at plant {GLO} | primary production | single route, at plant | 2.7 g/cm^3 | LCI result	1.6%	n.a. because it’s aggregated	-
				Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result	1.1%	n.a. because it’s aggregated	-
		Stage 2. Cultivation RP cut flowers	23.4%	Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	3.4%	n.a. because it’s aggregated	-
				Diesel combustion in agricultural machine {GLO} | diesel driven | production mix, at plant | 30kW to 180kW | LCI result	3.3%	n.a. because it’s aggregated	-
				Stage 2 Cultivation Rose {EC}	3.1%	Ammonia	100.0%
				Stage 2 Cultivation Chrysantemum {CO}	2.4%	Ammonia	64.6%
						Particulates, <2.5 um	33.3%

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Electricity grid mix 1kV-60kV {RSA} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	1.3%	n.a. because it's aggregated	-
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	1.3%	n.a. because it's aggregated	-
				Thermal energy from hard coal {RoW} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result	1.2%	n.a. because it's aggregated	-
				Stage 2 Cultivation Chrysantemum {NL}	1.1%	Ammonia, NL	100.0%
				Stage 2 Cultivation Rose {KE}	0.9%	Ammonia	100.0%
Acidification	5.8%	Stage 3. Distribution RP cut flowers	40.1%	Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	32.1%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result	2.7%	n.a. because it's aggregated	-
				Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result	1.8%	n.a. because it's aggregated	-
		Stage 2. Cultivation RP cut flowers	28.5%	Stage 2 Cultivation Chrysantemum {CO}	4.7%	Ammonia	100.0%
				Stage 2 Cultivation Rose {EC}	4.3%	Ammonia	100.0%
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	3.3%	n.a. because it's aggregated	-
				Stage 2 Cultivation Chrysantemum {NL}	2.3%	Ammonia, NL	100.0%
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	1.9%	n.a. because it's aggregated	-
				Heat, from CHP, natural gas {NL}	1.8%	Nitrogen oxides	96.7%
				Diesel combustion in agricultural machine {GLO} | diesel driven | production mix, at plant | 30kW to 180kW | LCI result	1.6%	n.a. because it's aggregated	-
				Electricity, from CHP, natural gas {NL}	1.4%	Nitrogen oxides	96.7%
				Stage 2 Cultivation Rose {KE}	1.3%	Ammonia	100.0%
		Stage 1. Raw Material Acquisition RP cut flowers	25.7%	Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	3.9%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	3.7%	n.a. because it's aggregated	-
				Barge {EU+EFTA+UK} | technology mix, diesel driven, cargo | consumption mix, to consumer | 1500t payload capacity | LCI result	3.6%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Stage 1a Tulip Bulb {NL}	3.5%	Ammonia, NL	100.0%
				Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	2.4%	n.a. because it's aggregated	-
				Freight train, average {EU+EFTA+UK} | mix of electricity driven and diesel driven, cargo | consumption mix, to consumer | average train, gross tonne weight 1000t/726t payload capacity | LCI result	1.5%	n.a. because it's aggregated	-
				Diesel combustion in agricultural machine {GLO} | diesel driven | production mix, at plant | 30kW to 180kW | LCI result	1.3%	n.a. because it's aggregated	-
		Other		Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result - Stage 6 Retail RP cut flowers	1.6%	n.a. because it's aggregated	-
Photochemical ozone formation	5.2%	Stage 3. Distribution RP cut flowers	52.4%	Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	44.4%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result	2.8%	n.a. because it's aggregated	-
				Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result	2.0%	n.a. because it's aggregated	-
		Stage 1. Raw material acquisition RP cut flowers	25.1%	Barge {EU+EFTA+UK} | technology mix, diesel driven, cargo | consumption mix, to consumer | 1500t payload capacity | LCI result	5.8%	n.a. because it's aggregated	-
				Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	4.4%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	3.9%	n.a. because it's aggregated	-
				Diesel combustion in agricultural machine {GLO} | diesel driven | production mix, at plant | 30kW to 180kW | LCI result	2.2%	n.a. because it's aggregated	-
		Stage 2. Cultivation RP cut flowers	15.5%	Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	3.4%	n.a. because it's aggregated	-
				Heat, from CHP, natural gas {NL}	2.8%	Nitrogen oxides	97.3%
				Diesel combustion in agricultural machine {GLO} | diesel driven | production mix, at plant | 30kW to 180kW | LCI result	2.6%	n.a. because it's aggregated	-
				Electricity, from CHP, natural gas {NL}	2.1%	Nitrogen oxides	97.3%
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	2.1%	n.a. because it's aggregated	-
		Other		Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result - Stage 6 Retail RP cut flowers	2.2%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
Ecotoxicity, freshwater	5.1%	Stage 3 Distribution RP cut flowers	39.0%	Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	33.2%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result	1.4%	n.a. because it's aggregated	-
		Stage 1 Raw Material Acquisition RP cut flowers	37.3%	Stage 1b Tulip bulb crop protection {NL}	13.4%	Mancozeb	34.5%
						Folpet	25.5%
						Mancozeb	8.0%
						Folpet	6.4%
						Esfenvalerate	5.6%
						Chloramine	5.5%
				Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	10.4%	n.a. because it's aggregated	-
				Barley straw {EU+EFTA+UK} | technology mix | production mix, at farm | 'as is' cultivated and dried product | LCI result	2.2%	n.a. because it's aggregated	-
				Barge {EU+EFTA+UK} | technology mix, diesel driven, cargo | consumption mix, to consumer | 1500t payload capacity | LCI result	2.0%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	1.8%	n.a. because it's aggregated	-
		Stage 2 Cultivation RP cut flowers	18.6%	Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	1.9%	n.a. because it's aggregated	-
				Crop protection emissions for Rose {KE/ET}	9.0%	Lambda-cyhalothrin	30.7%
						Deltamethrin	10.9%
						Teflubenzuron	9.0%
						Mancozeb	6.2%
						Carbendazim	6.1%
						Fipronil	4.1%
						3-Pyridinecarboxamide, n-[(phenylamino)carbonyl]	3.9%
						Avermectin B1	3.6%
						Diazinon	2.9%
						Fipronil	2.4%
						Teflubenzuron	2.4%
				Crop protection emissions for Chrysantemum {CO}	2.9%	Chlorpyrifos	56.3%

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
						Avermectin B1	12.2%
						Bifenthrin	8.0%
						Cypermethrin	7.6%
		Other		Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result - Stage 6	1.7%	n.a. because it's aggregated	-
Water use	1.78%	Stage 2 Cultivation RP cut flowers	39.4%	Stage 2 Cultivation Rose {ET}	11.9%	Water, lake, ET	100%
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	7.1%	n.a. because it's aggregated	-
				Stage 2 Cultivation Rose {EC}	6.6%	Water, well, EC	100%
				Stage 2 Cultivation Rose {KE}	5.8%	Water, lake, KE	100%
				Electricity grid mix 1kV-60kV {RSA} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	4.5%	n.a. because it's aggregated	-
		Stage 3 Distribution RP cut flowers	24.2%	Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result	18.4%	n.a. because it's aggregated	-
				Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	1.4%	n.a. because it's aggregated	-
		Stage 1 Raw Material Acquisition RP cut flowers	20.8%	Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	3.5%	n.a. because it's aggregated	-
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result	2.8%	n.a. because it's aggregated	-
				Sugar, from sugar beet {GLO} | from sugar production | production mix | LCI result	2.6%	n.a. because it's aggregated	-
				Freight train, average {EU+EFTA+UK} | mix of electricity driven and diesel driven, cargo | consumption mix, to consumer | average train, gross tonne weight 1000t/726t payload capacity | LCI result	1.6%	n.a. because it's aggregated	-
				Starting material Chrysantemum {NL}	1.6%	Water, river, UG	100%
				Carbon dioxide, liquid production {EU+EFTA+UK} | technology mix | production mix, at plant | 100% active substance | LCI result	1.3%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	1.1%	n.a. because it's aggregated	-
		Others		Tap water {EU+EFTA+UK} | average technology mix | consumption mix, at consumer | Technology mix for supply of drinking water to users | LCI result - Stage 7	3.4%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant life stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Tap water {EU+EFTA+UK} | average technology mix | consumption mix, at consumer | Technology mix for supply of drinking water to users | LCI result - Stage 5	3.2%	n.a. because it's aggregated	-
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result - Stage 8	3.1%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	1.0%	n.a. because it's aggregated	-
Land use	1.1%	Stage 1 Raw Material Acquisition RP cut flowers	46.5%	Greenhouse, multi-tunnel, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 1,94 ha of land used | Partly terminated system	14.4%	n.a. because it's aggregated	-
				Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	7.8%	n.a. because it's aggregated	-
				Barley straw {EU+EFTA+UK} | technology mix | production mix, at farm | 'as is' cultivated and dried product | LCI result	3.5%	n.a. because it's aggregated	-
				Articulated lorry transport, Euro 4, Total weight >32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight/24.7t payload capacity | LCI result	1.5%	n.a. because it's aggregated	-
				Coconut fibre {GLO} | virgin | production mix, at plant | 1kg of fiber | LCI result	1.0%	n.a. because it's aggregated	-
		Stage 3 Distribution RP cut flowers	31.3%	Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result	27.9%	n.a. because it's aggregated	-
				Unbleached kraft pulp, softwood {EU+EFTA+UK} | technology mix | production mix, at plant | dry mass 0.89, carbon content, non-fossil 0.494 | LCI result	14.8%	n.a. because it's aggregated	-
				Cargo plane {GLO} | technology mix, kerosene driven, cargo | consumption mix, to consumer | 65t payload | LCI result	1.5%	n.a. because it's aggregated	-
		Stage 2 Cultivation RP cut flowers	17.2%	Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	3.7%	n.a. because it's aggregated	-
				Stage 2 Cultivation Rose {EC}	2.9%	Occupation, agriculture, EC	100%
		Other		Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result - Stage 6	1.4%	n.a. because it's aggregated	-

The most relevant processes for the sub-category potted plants in scope of this PEFCR are the following:

Table 10 *List of the most relevant impact categories, life cycle stages, processes and elementary flows for potted plants*

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
Climate Change	47.2%	Stage 2. Cultivation RP potted plants	64.3%	Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result	28.9%	n.a. because it's aggregated	-
				Heat, from CHP, natural gas {NL}	18.7%	Carbon dioxide, fossil	97.5%
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	5.1%	n.a. because it's aggregated	-
				Electricity, from CHP, natural gas {NL}	1.7%	Carbon dioxide, fossil	97.5%
		Stage 1. Raw materials RP potted plants	13.2%	Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	2.6%	n.a. because it's aggregated	-
				PP granulates {EU+EFTA+UK} | polymerisation of propene | production mix, at plant | 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	2.2%	n.a. because it's aggregated	-
				Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	2.2%	n.a. because it's aggregated	-
		Stage 8. End-Of-Life RP potted plants	8.5%	Landfill of biodegradable waste {EU+EFTA+UK} | LCI result	5.8%	n.a. because it's aggregated	-
				Stage 8. End-of-life Lavendula 12 cm {EU-28+3}	5.3%	Carbon dioxide, fossil	100.0%
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result	5.0%	n.a. because it's aggregated	-
		Other		Corner foam, PS {EU+EFTA+UK} | polymerisation of styrene, foam production | production mix, at plant | 28 kg/m^3, tensile strengh: 3 kg/cm^2 | LCI result - Stage 3. Distribution RP potted plants	3.2%	n.a. because it's aggregated	-
Resource use, fossils	33.2%	Stage 2. Cultivation RP potted plants	70.7%	Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result	30.2%	n.a. because it's aggregated	-
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	30.2%	n.a. because it's aggregated	-
		Stage 1. Raw materials RP potted plants	17.6%	PP granulates {EU+EFTA+UK} | polymerisation of propene | production mix, at plant | 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	5.9%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	2.2%	n.a. because it's aggregated	-
				Plastic Film, PE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | grammage: 0.0943 kg/m^2 | LCI result	1.8%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
		Other		Corner foam, PS {EU+EFTA+UK} | polymerisation of styrene, foam production | production mix, at plant | 28 kg/m^3, tensile strengh: 3 kg/cm^2 | LCI result - Stage 3. Distribution RP potted plants	6.5%	n.a. because it's aggregated	-
		Other		Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result - Stage 8. End-of-life RP potted plants	4.7%	n.a. because it's aggregated	-
Particulate matter	5.2%	Stage 1. Raw materials RP potted plants	59.8%	Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	20.3%	n.a. because it's aggregated	-
				Concrete, production mix, at plant {GLO} | aggregates mixing | production mix, at plant | C20/25 | LCI result	10.8%	n.a. because it's aggregated	-
				Pallet, wood (80x120) {EU+EFTA+UK} | sawing, piling, nailing | single route, at plant | 25 kg/piece, nominal loading capacity of 1000kg | LCI result	8.1%	n.a. because it's aggregated	-
				Calcium ammonium nitrate, per kg substance {EU+EFTA+UK} | production mix, at plant | 26.5% N | LCI result	5.5%	n.a. because it's aggregated	-
				Coconut coir {DO} | for growing media | production mix, at plant | 350 kg/m^3 | LCI result	4.1%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	1.6%	n.a. because it's aggregated	-
				PP granulates {EU+EFTA+UK} | polymerisation of propene | production mix, at plant | 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	2.0%	n.a. because it's aggregated	-
				Barge {EU+EFTA+UK} | technology mix, diesel driven, cargo | consumption mix, to consumer | 1500t payload capacity | LCI result	1.8%	n.a. because it's aggregated	-
				Steel, recycled, post-consumer (EAF) {GLO} | collection, sorting, EAF route | production mix, at plant | 6% loss | LCI result	1.6%	n.a. because it's aggregated	-
		Stage 2. Cultivation RP potted plants	20.0%	Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result	8.6%	n.a. because it's aggregated	-
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	4.0%	n.a. because it's aggregated	-
				Heat, from CHP, natural gas {NL}	3.8%	n.a. because it's aggregated	-
				Stage 2b. Cultivation Phalaenopsis 12 cm, large plant {NL}	1.5%	n.a. because it's aggregated	-
		Other		Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result – Stage 6 RP potted plants	1.0%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Corner foam, PS {EU+EFTA+UK} | polymerisation of styrene, foam production | production mix, at plant | 28 kg/m^3, tensile strengh: 3 kg/cm^2 | LCI result – Stage 3 Distribution RP potted plants	2.5%	n.a. because it's aggregated	-
				Passenger car, average {GLO} | technology mix, gasoline and diesel driven, Euro 3-5, passenger car | consumption mix, to consumer | engine size from 1,4l up to >2l | LCI result – Stage 3 Distribution PR potted plants	1.6%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result – Stage 6 – RP potted plants	1.4%	n.a. because it's aggregated	-
Freshwater ecotoxicity	2.1%	Stage 1. Raw materials RP potted plants	65.1%	Coconut coir {DO} | for growing media | production mix, at plant | 350 kg/m^3 | LCI result	27.9%	n.a. because it's aggregated	-
				Corner foam, PS {EU+EFTA+UK} | polymerisation of styrene, foam production | production mix, at plant | 28 kg/m^3, tensile strengh: 3 kg/cm^2 | LCI result	1.4%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	1.6%	n.a. because it's aggregated	-
				Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	5.6%	n.a. because it's aggregated	-
				Plastic Film, PE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | grammage: 0.0943 kg/m^2 | LCI result	4.3%	n.a. because it's aggregated	-
				PP granulates {EU+EFTA+UK} | polymerisation of propene | production mix, at plant | 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	14.1%	n.a. because it's aggregated	-
		Stage 3. Distribution RP potted plants	21.9%	Corner foam, PS {EU+EFTA+UK} | polymerisation of styrene, foam production | production mix, at plant | 28 kg/m^3, tensile strengh: 3 kg/cm^2 | LCI result	13.8%	n.a. because it's aggregated	-
				Passenger car, average {GLO} | technology mix, gasoline and diesel driven, Euro 3-5, passenger car | consumption mix, to consumer | engine size from 1,4l up to >2l | LCI result	4.1%	n.a. because it's aggregated	-
		Other		Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result - Stage 2	2.4%	n.a. because it's aggregated	-
				Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result - Stage 2	2.5%	n.a. because it's aggregated	-
				Coconut coir {DO} | for growing media | production mix, at plant | 350 kg/m^3 | LCI result - Stage 6	1.5%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result - Stage 6	1.1%	n.a. because it's aggregated	-
				Landfill of biodegradable waste {EU+EFTA+UK} | LCI result - Stage 8	3.7%	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result - Stage 8	3.2%	n.a. because it's aggregated	-
Land use	1.3%	Stage 1. Raw materials RP potted plants	75.1%	Coconut coir {DO} | for growing media | production mix, at plant | 350 kg/m^3 | LCI result	8.3%	n.a. because it's aggregated	-
				Coconut, dehusked {PH} | from dehusking | production mix | LCI result	5.0%	n.a. because it's aggregated	-
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	1.7%	n.a. because it's aggregated	-
				Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	24.9%	n.a. because it's aggregated	-
				Pallet, wood (80x120) {EU+EFTA+UK} | sawing, piling, nailing | single route, at plant | 25 kg/piece, nominal loading capacity of 1000kg | LCI result	24.4%	n.a. because it's aggregated	-
				Stage 1b. Raw materials Phalaenopsis 12 cm, large plant {NL}	4.5%	Occupation, industrial area	100%
		Stage 2. Cultivation RP potted plants	15.1%	Stage 2b. Cultivation Dracaena 17 cm, large plant {NL}	2.8%	Occupation, industrial area, NL	100%
				Stage 2b. Cultivation lavendula 12 cm, large plant {NL}	2.2%	Occupation, industrial area, NL	100%
				Stage 2b. Cultivation Phalaenopsis 12 cm, large plant {NL}	5.3%	Occupation, industrial area, NL	100%
		Others		Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result - Stage 6	1.3%	n.a. because it's aggregated	-
				Pallet, wood (80x120) {EU+EFTA+UK} | sawing, piling, nailing | single route, at plant | 25 kg/piece, nominal loading capacity of 1000kg | LCI result - Stage 6	1.3%	n.a. because it's aggregated	-
Water use	0.8%	Stage 1. Raw materials RP potted plants	45.7%	Coconut coir {DO} | for growing media | production mix, at plant | 350 kg/m^3 | LCI result	16.6%	n.a. because it's aggregated	
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	5.7%	n.a. because it's aggregated	
				Greenhouse, Venlo type, to consumer {GLO} | greenhouse materials production and assembling | production mix, at plant | 4 ha of land used | LCI result	4.2%	n.a. because it's aggregated	
				PP granulates {EU+EFTA+UK} | polymerisation of propene | production mix, at plant | 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result	3.9%	n.a. because it's aggregated	
				Plastic Film, PE {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | grammage: 0.0943 kg/m^2 | LCI result	3.5%	n.a. because it's aggregated	

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				Tap water {EU+EFTA+UK} | average technology mix | consumption mix, at consumer | Technology mix for supply of drinking water to users | LCI result	2.4%	n.a. because it’s aggregated	
				Thermoforming {EU+EFTA+UK} | plastic thermoforming | production mix, at plant | 25% loss, 2.5 MJ electricity, 0.5 MJ thermal energy | Partly terminated system	1.6%	n.a. because it’s aggregated	
		Stage 8. End-of-life RP potted plants	19.5%	Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result	18.4%	n.a. because it’s aggregated	
		Stage 3. Distribution RP potted plants	13.9%	Corner foam, PS {EU+EFTA+UK} | polymerisation of styrene, foam production | production mix, at plant | 28 kg/m^3, tensile strengh: 3 kg/cm^2 | LCI result	6.6%	n.a. because it’s aggregated	
				Passenger car, average {GLO} | technology mix, gasoline and diesel driven, Euro 3-5, passenger car | consumption mix, to consumer | engine size from 1,4l up to >2l | LCI result	2.2%	n.a. because it’s aggregated	
				Thermoforming {EU+EFTA+UK} | plastic thermoforming | production mix, at plant | 25% loss, 2.5 MJ electricity, 0.5 MJ thermal energy | Partly terminated system	1.6%	n.a. because it’s aggregated	
		Stage 2. Cultivation RP potted plants	10.7%	Thermal energy from natural gas {EU+EFTA+UK} | technology mix regarding firing and flue gas cleaning | production mix, at heat plant | MJ, 100% efficiency | LCI result	3.2%	n.a. because it’s aggregated	
				Natural gas mix {EU+EFTA+UK} | technology mix | consumption mix, to consumer | medium pressure level (< 1 bar) | LCI result	3.1%	n.a. because it’s aggregated	
				Electricity grid mix 1kV-60kV {NL} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result	2.7%	n.a. because it’s aggregated	
		Others		Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result - Stage 6	5.3%	n.a. because it’s aggregated	

5 Life cycle inventory

This chapter specifies which data need to be collected to conduct a PEF study according to this PEFCR. It specifies processes for which company-specific data shall be collected as well as rules for additional company-specific data. Company-specific data enhance the quality of the PEF study. Data quality requirements (DQR) and calculation of DQR are explained. The data needs matrix, to be used to evaluate which data is needed for processes outside the list of mandatory company-specific data, is explained. This chapter also elaborates on which secondary datasets to use.

Furthermore modelling rules are elaborated for allocation in case of multifunctional processes, electricity modelling, climate change modelling and modelling of end-of-life and recycling.

All newly created datasets shall be EF compliant.

In case sampling is needed, it shall be conducted as specified in this PEFCR. However, sampling is not mandatory and any user of this PEFCR may decide to collect the data from all the plants or farms, without performing any sampling.

In this PEFCR, sampling is allowed for the collection of primary data. This may be applicable when cultivation of a certain type of flower or potted plant occurs in several different farms or when raw materials are produced in multiple different sites. When sampling is used, it shall be done according to the requirements defined in section 4.4.6 of the PEF Guidance (EC, 2021). Description of the population and of the selected sample used for the EF study shall be clearly described in the EF report.

Additionally to the requirements defined in Section 4.4.6 of the PEF Guidance the following requirements apply:

- Practitioner shall clearly report on all possible distinctive technologies/ farm practices, climate zones (regions) and classes of capacity of companies when defining a sub-population and the considerations made.
- Reviewer shall verify the considerations made for defining sub-population for technologies/ farm practices and classes of capacity.
- The selection of sites shall be done from highest to lowest contributing to the production of a sub-population for at least 50%.

5.1 List of mandatory company-specific data

The following section describes the processes for which mandatory company-specific data shall be collected to comply to this PEFCR. For all other processes the Data Needs Matrix is applicable, as explained in chapter 5.4.

To offset fluctuations due to seasonal differences, cultivation activity data shall be collected and averaged for 3 consecutive years.

A data collection template has been developed to aid the data collection process for mandatory company specific data (FloriPEFCR data collection requirements overview.xls). It is an Excel file connected to this document. The EF background processes to use for mandatory company specific data are listed in the Excel file.

Raw materials acquisition, pre-processing and starting material
Practitioner shall gather company-specific activity data for certain raw material inputs to the cultivation of potted plants or cut flowers. Data shall be collected in relation to the functional unit for the activities and modelling parameters described below.

The origin in the points below refers to the country that the material originates from.

Starting material or young plant input: Type, amount and origin (a country e.g. Italy or Brazil) of starting materials (seed, seedlings, plant cuttings or other) and/or young plant input shall be registered. Input losses for the required functional unit shall be considered. For potted plants the lifetime of the production of the starting material is collected from the supplier as well as the lifetime of the cultivation of its own product from starting material to sales. This is needed to estimate the environmental impact of the starting material for potted plants (see chapter 3.8.2).

Growing media use: Amount, type and origin of growing media use shall be collected. Growing media information shall include amount of single growing medium or mix used. If mix, proportion of individual constituents in 1 m^3 of growing media mix. Also the peat C-content of the growing media and the N-, P-, and K-content and limestone, dolomite, urea content and the density and moisture content shall be collected (necessary information can be provided by the growing media producers). We refer to GME (2021), which contains many of the growing media specific data.

Material use: Amount, type and origin of materials shall be collected. Data shall be collected for use of materials for soil covering, for guiding plants and for lifting plants to ease handling (e.g. sticks, strings).

Fertilisers and manure: N, P, K input per pot plant or cut flower shall be collected and distinguished between organic and synthetic input. Mass, type and origin for both synthetic and organic fertiliser used shall be registered.

Plant protection products: Amount of active ingredient, type and origin of plant protection product shall be collected for the cultivation of 1 stem or 1 pot plant.

Water use: Amount of water used for irrigation and other types of blue water used shall be collected. Water source shall also be registered.

Packaging: Primary packaging material use such as pots and trays shall be collected. Data regarding secondary packaging materials such as pallets or paper do not need to be collected. Type of material, origin and weight shall be collected.

For raw material acquisition the origin is to be registered, as stated before. This information is needed to model the distribution of the raw materials between production and location of use. Collecting information on the origin of raw materials allows for modelling transport from origin to location of cultivation. It also allows specific electricity mixes to be used for the production of raw materials. Additionally the transport modality needs to be recorded, to be able to select the right secondary process for transport of the raw materials. If transport consists of multiple stretches, these stretches need to be recorded separately.

CO_2 enrichment: Use and source of CO_2 shall be modelled. Practitioner shall indicate if CO_2 is produced on site or off site. Activities related to flue gas cleaning and transport shall be based on company-specific data.

Data collection parameters for raw material input to cultivation, can be found in the Excel named FloriPEFCR data collection requirements overview.xls.

Cultivation emissions and resources
The use of resources and direct emissions for the cultivation of potted plants and cut flowers are mandatory company-specific data. Chapter 6.2 provides guidance on the cultivation emissions to be calculated.

Practitioner shall also register product losses and related co-products at farm for cut flower and potted plant cultivation.

Combined Heat and Power (CHP) Unit
Natural gas input, unit efficiency and related emissions from heat and electricity use at farm produced in a CHP unit shall be based on company-specific data. The Excel named FloriPEFCR data collection requirements overview.xls, shows direct elementary flows to be collected for the activity related to the CHP unit.

Modelling of emissions shall follow guidance provided in chapter 6.2.4.3 of this PEFCR.

Distribution
Data on distribution to first location in Europe after cultivation, shall be based on mandatory company-specific data. Practitioner shall register distance and type of transport for the different transport modes for the delivery of the potted plants or flowers at their first destination after cultivation.
Practitioner shall also indicate first destination e.g.: if it is DC, auction or retailer who receives the plant after cultivation. Transported weight shall account for packaging material used for transport and losses during transport based on primary activity data.

Most of the mandatory company-specific data will come from growers and access to these data is required to perform a PEF study. However, performing a PEF study is not limited to growers. There are horticulture service providers that have access or manage data from growers that are expected to be able to perform a PEF study. Also there are owners of certification schemes which already manage a lot of the data from growers and are expected to be able to perform a PEF study.

See excel file named FloriPEFCR data collection requirements overview.xls for the list of all company-specific data to be collected.

5.2 List of processes expected to be run by the company

Processes carried out by the company for a large part depend on the type of company performing the PEF study.
For example, farmers may run the cultivation of starting materials in addition to the plant or flower cultivation. Retailers will run certain distribution legs, retail operations but might also run consumer packaging.

Therefore, the rules of the data needs matrix (chapter 5.4) are to be followed by users of this PEFCR for company-specific processes which have not been identified as mandatory in chapter 5.1. Several additional processes may be expected to be run by the company, but will vary greatly on the company running the PEFCR study. On this account, no further description of processes is given in this PEFCR.

Companies in Situation 1- Option 1 and Situation 2- Option 1 of the data needs matrix (chapter 5.4), shall collect activity data, resources and elementary flows, following guidance given in the corresponding life cycle stage in 6 of this PEFCR.

'There are no further processes expected to be run by the company in addition to those listed as mandatory company-specific data.'

5.3 Data quality requirements

The data quality of each dataset and the total PEF study shall be calculated and reported. The calculation of the DQR shall be based on the following formula with four criteria:

$$DQR = \frac{TeR+GR+TiR+P}{4}$$ Equation 1

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

The next chapters provide tables with the criteria to be used for the semi-quantitative assessment of each criterion.

5.3.1 Company-specific datasets

The DQR shall be calculated at the level-1 disaggregation, before any aggregation of sub-processes or elementary flows is performed. The DQR of company-specific datasets shall be calculated as following:

1. Select the most relevant activity data and direct elementary flows: most relevant activity data are the ones linked to sub-processes (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one. Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% to the total impact of the direct elementary flows.
2. Calculate the DQR criteria TeR, TiR, GR and P for each most relevant activity data and each most relevant direct elementary flow. The values of each criterion shall be assigned based on Table 11.
   a. Each most relevant direct elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, the user of the PEFCR shall evaluate the 4 DQR criteria named TeR-EF, TiR-EF, TeR-EF, P-EF. For example, the user of the PEFCR shall evaluate the timing of the flow measured, for which technology the flow was measured and in which geographical area.
   b. For each most relevant activity data, the 4 DQR criteria shall be evaluated (named TiR-AD, P-AD, GR-AD, TeR-AD) by the user of the PEFCR.
   c. Considering that the data for the mandatory processes shall be company-specific, the score of P cannot be higher than 3, while the score for TeR, TiR and GR cannot be higher than 2 (The DQR score shall be ≤1.5).
3. Calculate the environmental contribution of each most relevant activity data (through linking to the appropriate sub-process) and direct elementary flow to the total sum of the environmental impact of all most-relevant activity data and direct elementary flows, in % (weighted, using all EF impact categories). For example, the newly developed dataset has only two most relevant activity data, contributing in total to 80% of the total environmental impact of the dataset:
   - Activity data 1 carries 30% of the total dataset environmental impact. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).
   - Activity data 2 carries 50% of the total dataset environmental impact. The contribution of this process to the total of 80% is 62.5% (the latter is the weight to be used).
4. Calculate the TeR, TiR, GR and P criteria of the newly developed dataset as the weighted average of each criteria of the most relevant activity data and direct elementary flows. The weight is the relative contribution (in %) of each most relevant activity data and direct elementary flow calculated in step 3.
5. The user of the PEFCR shall calculate the total DQR of the newly developed dataset using Equation 1, where $\overline{TeR}$, $\overline{GR}$, $\overline{TiR}$ and $\bar{P}$ are the weighted average calculated as specified in point (4).

Table 11 *How to assess the value of the DQR criteria for datasets with company-specific information*

Rating	P-EF and P-AD	TiR-EF and TiR-AD	TeR-EF and TeR-AD	GR-EF and GR-AD
1	Measured/calculated and externally verified	The data refers to the most recent annual administration period with respect to the EF report publication date. Data for cultivation should be the average of 3 years for annual plants or 3 full cultivations cycles.	The elementary flows and the activity data exactly reflect the technology of the newly developed dataset	The activity data and elementary flows reflects the exact geography where the process modelled in the newly created dataset takes place
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the EF report publication date. Data for cultivation should be the average of 3 years for annual plants or 3 full cultivations cycles.	The elementary flows and the activity data is a proxy of the technology of the newly developed dataset	The activity data and elementary flows) partly reflects the geography where the process modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the EF report publication date. Data for cultivation should be the average of 3 years for annual plants or 3 full cultivations cycles.	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

P-EF: Precision for elementary flows; **P-AD**: Precision for activity data; **TiR-EF**: Time Representativeness for elementary flows; **TiR-AD**: Time representativeness for activity data;; **TeR-EF**: Technology representativeness for elementary flows; **TeR-AD**: Technology representativeness for activity data**; GR-EF**: Geographical representativeness for elementary flows; **GR-AD:** Geographical representativeness for activity data.

5.4 Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific data (listed in 5.1) shall be evaluated using the Data Needs Matrix (see Table 12). The user of the PEFCR shall apply the DNM to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the user of the PEFCR (company) has on the specific process. The following three cases are found in the DNM and are explained below:

1. **Situation 1:** the process is run by the company applying the PEFCR;
2. **Situation 2:** the process is not run by the company applying the PEFCR but the company has access to (company-)specific information;
3. **Situation 3:** the process is not run by the company applying the PEFCR and this company does not have access to (company-)specific information.

Table 12 *Data Needs Matrix (DNM)[8]. *Disaggregated datasets shall be used.*

		Most relevant process	Other process
Situation 1: process run by the company using the PEFCR	Option 1	Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5)8F[9] Calculate the DQR values (for each criterion + total)	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR≤3.0) Use the default DQR values
Situation 2: process not run by the company using the PEFCR but with access to company-specific information	Option 1	Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5) Calculate the DQR values (for each criterion + total)	
	Option 2	Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤3.0)* Re-evaluate the DQR criteria within the product-specific context	
	Option 3		Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤4.0)* Use the default DQR values.
Situation 3: process not run by the company using the PEFCR and without access to company-specific information	Option 1	Use default secondary data set in aggregated form (DQR≤3.0) Re-evaluate the DQR criteria within the product-specific context	
	Option 2		Use default secondary data set in aggregated form (DQR≤4.0) Use the default DQR values

[8] The options described in the DNM are not listed in order of preference.
[9] Company-specific datasets shall be made available to the EC.

5.4.1 Processes in situation 1

For each process in situation 1 there are two possible options:

- The process is in the list of most relevant processes as specified in the PEFCR or is not in the list of most relevant process, but still the company wants to provide company-specific data (option 1);
- The process is not in the list of most relevant processes and the company prefers to use a secondary dataset (option 2).

Situation 1/Option 1
For all processes run by the company and where the user of the PEFCR applies company-specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.3.1.

Situation 1/Option 2
For the non-most relevant processes only, if the user of the PEFCR decides to model the process without collecting company-specific data, then the user shall use the secondary dataset listed in the PEFCR together with its default DQR values listed here.
If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the metadata of the original dataset.

5.4.2 Processes in situation 2

When a process is not run by the user of the PEFCR, but there is access to company-specific data, then there are three possible options:

- The user of the PEFCR has access to extensive supplier-specific information and wants to create a new EF compliant dataset (Option 1);
- The company has some supplier-specific information and want to make some minimum changes (Option 2);
- The process is not in the list of most relevant processes and the company wants to make some minimum changes (Option 3).

Situation 2/Option 1
For all processes not run by the company and where the user of the PEFCR applies company-specific data, the DQR of the newly developed dataset shall be evaluated as described in section 5.3.1.

Situation 2/Option 2
The user of the PEFCR shall use company-specific activity data for transport and shall substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets, starting from the default secondary dataset provided in the PEFCR.
Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.
The user of the PEFCR shall make the DQR context-specific by re-evaluating TeR and TiR using the Table 13. The criteria GR shall be lowered by 30%[10]111 and the criteria P shall keep the original value.

Situation 2/Option 3
The user of the PEFCR shall apply company-specific activity data for transport and shall substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets, starting from the default secondary dataset provided in the PEFCR.
Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.
In this case, the user of the PEFCR shall use the default DQR values. If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

[10] In situation 2, option 2 it is proposed to lower the parameter GeR by 30% in order to incentivise the use of company-specific information and reward the efforts of the company in increasing the geographic representativeness of a secondary dataset through the substitution of the electricity mixes and of the distance and means of transportation.

Table 13 *How to assess the value of the DQR criteria when secondary datasets are used*

	TiR	TeR	GR
1	The EF report publication date happens within the time validity of the dataset	The technology used in the EF study is exactly the same as the one in scope of the dataset	The process modelled in the EF study takes place in the country the dataset is valid for
2	The EF report publication date happens not later than 2 years beyond the time validity of the dataset	The technologies used in the EF study is included in the mix of technologies in scope of the dataset	The process modelled in the EF study takes place in the geographical region (e.g. Europe) the dataset is valid for
3	The EF report publication date happens not later than 4 years beyond the time validity of the dataset	The technologies used in the EF study are only partly included in the scope of the dataset	The process modelled in the EF study takes place in one of the geographical regions the dataset is valid for
4	The EF report publication date happens not later than 6 years beyond the time validity of the dataset	The technologies used in the EF study are similar to those included in the scope of the dataset	The process modelled in the EF study takes place in a country that is not included in the geographical region(s) the dataset is valid for, but sufficient similarities are estimated based on expert judgement.
5	The EF report publication date happens later than 6 years after the time validity of the dataset	The technologies used in the EF study are different from those included in the scope of the dataset	The process modelled in the EF study takes place in a different country than the one the dataset is valid for

5.4.3 Processes in situation 3

If a process is not run by the company using the PEFCR and the company does not have access to company-specific data, there are two possible options:

- It is in the list of most relevant processes (situation 3, option 1);
- It is not in the list of most relevant processes (situation 3, option 2).

Situation 3/Option 1
In this case, the user of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating TeR, TiR and GeR, using the table(s) provided. The criteria P shall keep the original value.

Situation 3/Option 2
For the non-most relevant processes, the user of the PEFCR shall apply the corresponding secondary dataset listed in the PEFCR together with its DQR values.
If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

5.5 Which datasets to use?

This PEFCR lists the secondary datasets to be applied by the user of the PEFCR. Whenever a dataset needed to calculate the PEF profile is not among those listed in this PEFCR, then the user shall choose between the following options (in hierarchical order):

- Use an EF compliant dataset available on one of the nodes of the Life Cycle Data Network http://eplca.jrc.ec.europa.eu/LCDN/.
- Use an EF compliant dataset available in a free or commercial source.
- Use another EF compliant dataset considered to be a good proxy. In such case this information shall be included in the 'limitations' section of the PEF report.
- Use an ILCD entry level (EL) compliant dataset. These datasets shall be included in the 'limitations' section of the PEF report. A maximum of 10% of the total environmental impact may be derived from ILCD-EL compliant datasets (calculated cumulatively from lowest to largest contribution to the total EF profile).
- If no EF compliant or ILCD-EL compliant proxy is available, it shall be excluded from the PEF study. This shall be clearly stated in the PEF report as a data gap and validated by the PEF study and PEF report verifiers.

5.6 How to calculate the average DQR of the study

To calculate the average DQR of the PEF study, the user of the PEFCR shall calculate separately the TeR, TiR, GeR and P for the PEF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single overall score. The calculation rules explained in Section 4.6.5.8 of the PEF method shall be used.

5.7 Allocation rules

If a process provides more than one function, i.e. it delivers several '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. In case of multifunctional processes allocation shall be applied according to the allocation rules specified in Table 14.

Table 14 *Allocation rules*

Process	Allocation rule	Modelling instructions	Allocation factor
Allocating organic fertiliser use and green manure in annual open field rotation systems	Manure/organic fertiliser is divided over all plant/flowers in a rotation scheme on the basis of share in area, except for the mineral N fraction which is allocated solely to the plant/flower of application.	If Organic fertiliser is applied in a crop rotation scheme, the following calculation rules apply for fertilisation of N (BSI, 2012). Formula 1 (Calculating N application to a plant/flower as part of a crop rotation scheme) Total N from Organic Fertiliser applied to the plot where plant/flower A stands = NmOA + NcrA +aA/aT x (NoOT+NcrT) • NmOA = Mineral nitrogen from organic fertiliser applied to plant/flower A (kg N/area unit) • NcrA = Nitrogen from residues of plant/flower A (kg N/area unit) • aA = area of plant/flower A (area unit) • aT = total area of rotation system (area unit) • NoOT = Organic nitrogen from organic fertiliser applied on all area (kg N/area unit) • NcrT = Nitrogen from crop residues of green manure on all area (kg N/area unit) • All other fertilising elements supplied using organic fertilisers, including green manure, is calculated by Formula 2: (Calculating Fertiliser application to a plant/flower as part of a rotation scheme) • Fapplied to plant/flower A = aA/aT x (FOT) Where • aA = area of A (area unit) • aT = total area of rotation system (area unit) • FOT = Organic fertiliser applied on all area (kg F/area unit)	
Organic fertilisers	Manure used in conventional farming is considered as a zero-burden product unless farmers need to pay a price for the manure that exceeds transport costs. Manure is then treated as a co-product where economic allocation shall be used. Economic allocation shall be applied for all other organic fertilisers originating from industrial processes.	For manure as a zero-burden product all activities needed after storage at the animal farm to application on the horticulture crop are included (thus including transport and processing if occurring). If manure has a price then the price will be based on the revenues for the animal farmer (excluding transport costs) or the price will be based on a shadow price derived from equivalent quantities of artificial fertiliser needed.	

Process	Allocation rule	Modelling instructions	Allocation factor
Energy use, cleaning and other generic operations in Greenhouse Cultivation	Land occupation and economic allocation depending on the situation.	When multiple plant products are grown in a protected (and heated) system, the relative land occupation of each plant product shall be applied to allocate the interventions related to the inputs for which it cannot be specified. When possible, the system should first be broken down in sub-systems, for instance into separated compartments within a greenhouse. Land occupation per product shall be obtained by specific data for the analysed time period (this will include any changes in land occupation due to differences with planning, differences in production, etc.). When not available, the average land occupation per plant product shall be used. This shall be calculated by adding together the land occupation per plant per phase using the following equation: LO = Sum over phases (p) (GTp * 1/PDp) With LO = Land occupation (yr*m^2) GTp = Growing time of phase p (yr) PDp = Plant density of phase p (numbers/m^2) There are cases known where potted plants are grown over a longer time period and leaves and/or flowers from those plants are sold as separate products during the cultivation period. The other way around is also possible: plants used for the production of cut flowers/leaves can be sold as potted plants after their useful life in flower/leaf production. In these cases, a final step of economic allocation between the pot plant and the cut leave/flower shall be used, after the step of allocation by land occupation.	
Combined heat and power systems (CHP) in Greenhouse Cultivation	Energy content (energy allocation)	The impact of CHP for the horticultural system shall be calculated by subdividing the heat and electricity produced, based on the energy produced through both. No environmental impact shall be attributed to the production of CO_2 output from the CHP. However the environmental impacts of the purification process shall be attributed to the CO_2. If CHP is turned on for electricity only, then heat should be attributed to the product. (see chapter 6.2.4.3)	
Transport (inbound and outbound)	Physical property defining load capacity	Allocation of transport emissions to transported products shall be done on the basis of physical causality, such as mass share, unless the density of the transported product is significantly lower than average so that the volume transported is less than the maximum load. Allocation of empty transport kilometres shall be done on the basis of the average load factor of the transport that is under study. If no supporting information is available, it shall be assumed that 100% additional transport is needed for empty return, which equals the utility rate of 50% (EC, 2021).	
Storage to single product	Volume and time	Only part of the emissions and resources emitted or used at storage systems shall be allocated to the product stored. This allocation shall be based on the space (in m^3) and time (in weeks) occupied by the product stored. For this the total storage capacity of the system shall be known, and the product-specific volume and storage time shall be used to calculate the allocation factor (as the ratio between product-specific volume*time and storage capacity volume*time). Further guidance on emission and resource allocation from storage can be found in (EC, 2021).	

5.8 Electricity modelling

The following electricity mix shall be used in hierarchical order:

a. Supplier-specific electricity product shall be used if for a country there is a 100% tracking system in place, or if:
   i. available, and
   ii. the set of minimum criteria to ensure the contractual instruments are reliable is met.
b. The supplier-specific total electricity mix shall be used if:
   iii. available, and
   iv. the set of minimum criteria to ensure the contractual instruments are reliable is met.
c. The 'country-specific residual grid mix, consumption mix' shall be used. Country-specific means the country in which the life cycle stage or activity occurs. This may be an EU country or non-EU country. The residual grid mix prevents double counting with the use of supplier-specific electricity mixes in a) and b).
d. As a last option, the average EU residual grid mix, consumption mix (EU-28 +EFTA), or region representative residual grid mix, consumption mix, shall be used.

Note: for the use stage, the consumption grid mix shall be used.
The environmental integrity of the use of supplier-specific electricity mix depends on ensuring that contractual instruments (for tracking) **reliably and uniquely convey claims to consumers**. Without this, the PEF lacks the accuracy and consistency necessary to drive product/corporate electricity procurement decisions and accurate consumer (buyer of electricity) claims. Therefore, a set of **minimum criteria** that relate to the integrity of the contractual instruments as reliable conveyers of environmental footprint information has been identified. They represent the minimum features necessary to use supplier-specific mix within PEF studies.

Set of minimum criteria to ensure contractual instruments from suppliers
A supplier-specific electricity product/mix may only be used if the user of the PEF method ensures that the contractual instrument meets the criteria specified below. If contractual instruments do not meet the criteria, then country-specific residual electricity consumption-mix shall be used in the modelling.
The list of criteria below is based on the criteria of the GHG Protocol Scope 2 Guidance – An amendment to the GHG Protocol Corporate Standard – Mary Sotos – World Resource Institute. A contractual instrument used for electricity modelling shall:

Criterion 1 – Convey attributes
- Convey the energy type mix associated with the unit of electricity produced.
- The energy type mix shall be calculated based on delivered electricity, incorporating certificates sourced and retired (obtained or acquired or withdrawn) on behalf of its customers. Electricity from facilities for which the attributes have been sold off (via contracts or certificates) shall be characterised as having the environmental attributes of the country residual consumption mix where the facility is located.

Criterion 2 – Be a unique claim
- Be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.
- Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).

Criterion 3 – Be as close as possible to the period to which the contractual instrument is applied

Modelling 'country-specific residual grid mix, consumption mix':
Datasets for residual grid mix, consumption mix, per energy type, per country and per voltage are made available by data providers.
If no suitable dataset is available, the following approach should be used:

Determine the country consumption mix (e.g. X% of MWh produced with hydro energy, Y% of MWh produced with coal power plant) and combine them with LCI datasets per energy type and country/region (e.g. LCI dataset for the production of 1MWh hydro energy in Switzerland).

- Activity data related to non-EU country consumption mix per detailed energy type shall be determined based on:
  - Domestic production mix per production technologies;
  - Import quantity and from which neighbouring countries;
  - Transmission losses;
  - Distribution losses;
  - Type of fuel supply (share of resources used, by import and/or domestic supply).

These data may be found in the publications of the International Energy Agency (IEA (www.iea.org).

- Available LCI datasets per fuel technologies. The LCI datasets available are generally specific to a country or a region in terms of:
  - fuel supply (share of resources used, by import and/or domestic supply);
  - energy carrier properties (e.g. element and energy contents);
  - technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.

Allocation rules:
Please refer to chapter 5.7.

If the consumed electricity comes from more than one electricity mix, each mix source shall be used in terms of its proportion in the total kWh consumed. For example, if a fraction of this total kWh consumed is coming from a specific supplier a supplier-specific electricity mix shall be used for this part. See below for on-site electricity use.

A specific electricity type may be allocated to one specific product in the following conditions:

a. If the production (and related electricity consumption) of a product occurs in a separate site (building), the energy type physical related to this separated site may be used.
b. If the production (and related electricity consumption) of a product occurs in a shared space with specific energy metering or purchase records or electricity bills, the product-specific information (measure, record, bill) may be used.
c. If all the products produced in the specific plant are supplied with a publicly available PEF study, the company wanting to make the claim shall make all PEF studies available. The allocation rule applied shall be described in the PEF study, consistently applied in all PEF studies connected to the site and verified. An example is the 100% allocation of a greener electricity mix to a specific product.

On-site electricity generation:
For the specific case of combined heat and power providing, electricity, heat and/or CO_2 to the farmer. This PEFCR provides specific modelling rules that are described in 6.2.4.
On site electricity generation using any other technology exclusive for electricity generation, shall be modelled following the steps described below.
If on-site electricity production is equal to the site own consumption, two situations apply:
No contractual instruments have been sold to a third party: the own electricity mix (combined with LCI datasets) shall be modelled.
Contractual instruments have been sold to a third party: the 'country-specific residual grid mix, consumption mix' (combined with LCI datasets) shall be used.
If electricity is produced in excess of the amount consumed on-site within the defined system boundary and is sold to, for example, the electricity grid, this system may be seen as a multifunctional situation. The system will provide two functions (e.g. product + electricity) and the following rules shall be followed:

- If possible, apply subdivision. Subdivision applies both to separate electricity productions or to a common electricity production where you may allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a windmill on its production site and exports 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the PEF study).

- If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[11].
- Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

5.9 Climate change modelling

The impact category 'climate change' shall be modelled considering three sub-categories:

1. **Climate change – fossil:** This sub-category includes emissions from peat and calcination/carbonation of limestone. The emission flows ending with '(fossil)' (e.g., 'carbon dioxide (fossil)' and 'methane (fossil)') shall be used, if available.

2. **Climate change – biogenic:** This sub-category covers carbon emissions to air (CO_2, CO and CH_4) originating from the oxidation and/or reduction of biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or aboveground plant residues, such as litter and dead wood. Carbon exchanges from native forests[12] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.

   A simplified modelling approach shall be used when modelling foreground emissions.
   'Only the emission 'methane (biogenic)' is modelled, while no further biogenic emissions and uptakes from atmosphere are included. If methane emissions can be both fossil or biogenic, the release of biogenic methane shall be modelled first and then the remaining fossil methane.'

3. **Climate change – land use and land use change**: This sub-category accounts for carbon uptakes and emissions (CO_2, CO and CH_4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (including soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest[13] and residues), while their CO_2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.
   For land use change, all carbon emissions and removals shall be modelled following the modelling guidelines of PAS 2050:2011 (BSI, 2011) and the supplementary document PAS2050-1:2012 (BSI, 2012) for horticultural products. PAS 2050:2011 (BSI, 2011): 'Large emissions of GHGs can result as a consequence of land use change. Removals as a direct result of land use change (and not as a result of long-term management practices) do not usually occur, although it is recognised that this could happen in specific circumstances. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forestland to cropland. All forms of land use change that result in emissions or removals are to be included. Indirect land use change refers to such conversions of land use as a consequence of changes in land use elsewhere. While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included. The GHG emissions and removals arising from direct land use change shall be assessed for any input to the life cycle of a product originating from that land and shall be included in the assessment of GHG emissions. The emissions arising from the product shall be assessed on the basis of the default land use change values provided in PAS 2050:2011 Annex C, unless better data is available. For countries and land use changes not included in this annex, the emissions arising from the product shall be assessed using the included GHG emissions and removals occurring as a result of direct land use change in accordance with the relevant sections of the IPCC (2006). The assessment of the impact of land use

[11] For some countries, this option is a best case rather than a worst case.
[12] Native forests – represents native or long-term, non-degraded forests. Definition adapted from Table 8 in Annex V C(2010)3751 to Directive 2009/28/EC.
[13] Following the instantaneous oxidation approach in IPCC 2013 (Chapter 2).

change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer). The total GHG emissions and removals arising from direct land use change over the period shall be included in the quantification of GHG emissions of products arising from this land on the basis of equal allocation to each year of the period[14].

1. Where it can be demonstrated that the land use change occurred more than 20 years prior to the assessment being carried out, no emissions from land use change should be included in the assessment.
2. Where the timing of land use change cannot be demonstrated to be more than 20 years, or a single harvest period, prior to making the assessment (whichever is the longer), it shall be assumed that the land use change occurred on 1 January of either:
   - the earliest year in which it can be demonstrated that the land use change had occurred; or
   - on 1 January of the year in which the assessment of GHG emissions and removals is being carried out.

The following hierarchy shall apply when determining the GHG emissions and removals arising from land use change occurring not more than 20 years or a single harvest period, prior to making the assessment (whichever is the longer):

1. where the country of production is known and the previous land use is known, the GHG emissions and removals arising from land use change shall be those resulting from the change in land use from the previous land use to the current land use in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);
2. where the country of production is known, but the former land use is not known, the GHG emissions arising from land use change shall be the estimate of average emissions from the land use change for that crop in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012);
3. where neither the country of production nor the former land use is known, the GHG emissions arising from land use change shall be the weighted average of the average land use change emissions of that commodity in the countries in which it is grown.

Knowledge of the prior land use can be demonstrated using a number of sources of information, such as satellite imagery and land survey data. Where records are not available, local knowledge of prior land use can be used. Countries in which a crop is grown can be determined from import statistics, and a cut-off threshold of not less than 90% of the weight of imports may be applied. Data sources, location and timing of land use change associated with inputs to products shall be reported.’

Soil carbon storage shall not be modelled, calculated and reported as additional environmental information.

The sum of the three sub-categories shall be reported.

The sub-category ‘Climate change-biogenic’ shall not be reported separately.

The sub-category ‘Climate change-land use and land transformation’ shall not be reported separately.

[14] In case of variability of production over the years, a mass allocation should be applied.

5.10 Modelling of end of life and recycled content

The end of life of products used during the manufacturing, distribution, retail, the use stage or after use shall be included in the overall modelling of the life cycle of the organisation. Overall, this should be modelled and reported at the life cycle stage where the waste occurs. This section provides rules on how to model the end of life of products as well as the recycled content.
The Circular Footprint Formula (CFF) is used to model the end of life of products as well as the recycled content and is a combination of 'material + energy + disposal', i.e.:

Material
$$(1-R_1)E_V + R_1 \times \left(AE_{recycled} + (1-A)E_V \times \frac{Q_{Sin}}{Q_p}\right) + (1-A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$$

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

With the following parameters
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. It shall be set to zero for all PEF studies.
Qsin: quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.
Qsout: quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.
Qp: quality of the primary material, i.e. quality of the virgin material.
R1: it is the proportion of material in the input to the production that has been recycled from a previous system.
R2: it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.
R3: it is the proportion of the material in the product that is used for energy recovery at EoL.
Erecycled (Erec): specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.
ErecyclingEoL (ErecEoL): specific emissions and resources consumed (per functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.
Ev: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material.
E*v: specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.
EER: specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, etc.).
ESE,heat and ESE,elec: specific emissions and resources consumed (per functional unit) that would have arisen from the specific substituted energy source, heat and electricity respectively.
ED: specific emissions and resources consumed (per functional unit) 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.

At several life cycle stages product losses and packaging waste occurs, while some materials are recycled or reused, as is elaborated per life cycle stage in chapter 6. The circular footprint formula applies in these situations.

This chapter does not apply to the end-of-life situation for use of organic fertilisers such as compost, use of purified CO2, manure application and reutilisation of growing media. In these specific cases the guidance in chapter 6.1.6.3, chapter 5.7 and chapter 6.2.9 of this PEFCR should be applied respectively.

The default parameters to use in modelling the circular footprint formula are provided in Annex C Transition Phase (https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) of the PEF method which have been summarised in Appendix 6, in Table 49 (A, R1 and R2), Table 50 (R3) and Table 51 (quality ratios). In case a specific A value is not in Annex C Transition Phase the following procedure shall be followed:

- Check in Annex C the availability of an application-specific A value which fits the PEFCR,
- If an application-specific A value is not available, the material-specific A value in Annex C shall be used,
- If a material-specific A value is not available, the A value shall be set equal to 0.5.

There are specific types of packaging for which default R1 values are provided:

- Single-use plastic trays: 90%
- Single-use plastic plant pots: 90%

This PEFCR refers to chapter 4.4.8.1 of the PEF guidance on The Circular Footprint Formula on how to deal with alternative parameters to the once provided in Annex C. Modelling recycled content (if applicable).
The following part of the Circular Footprint Formula is used to model the recycled content:

$$(1 - R_1)E_V + R_1 \times \left(AE_{recycled} + (1 - A)E_V \times \frac{Q_{Sin}}{Q_p}\right)$$

Equation 2

The R_1 values applied shall be supply-chain specific or default as provided in the table above, in relation with the DNM. Material-specific values based on supply market statistics are not accepted as a proxy and therefore shall not be used. The applied R_1 values shall be subject to PEF study verification.
When using supply-chain specific R_1 values other than 0, traceability throughout the supply chain is necessary. The following guidelines shall be followed when using supply-chain specific R1 values:

- The supplier information (through e.g., statement of conformity or delivery note) shall be maintained during all stages of production and delivery at the converter;
- Once the material is delivered to the converter for production of the end products, the converter shall handle information through their regular administrative procedures;
- The converter for production of the end products claiming recycled content shall demonstrate through its management system the [%] of recycled input material into the respective end product(s);
- The latter demonstration shall be transferred upon request to the user of the end product. In case a PEF profile is calculated and reported, this shall be stated as additional technical information of the PEF profile;
- Company-owned traceability systems may be applied as long as they cover the general guidelines outlined above.

[Industry systems may be applied as long as they cover the general guidelines outlined above. In that case, the text above may be replaced by those industry-specific rules. If not, they shall be supplemented with the general guidelines above.]

6 Life cycle stages

In the following subsections, the life cycle stages of products covered in the scope of this PEFCR are documented.

6.1 Raw material acquisition pre-processing and starting material

This section lists all technical requirements and assumptions for modelling raw material acquisition and starting material to be applied by the user of the PEFCR. This life cycle stage considers the materials acquired for the cultivation stage. Materials acquired are plant input material, growing media, capital goods in protected cultivation, water, plant protection products and biological pest control inputs, biological pest control, fertilisers (synthetic and mineral, organic and CO_2), and packaging.

All data are collected per gross area of farm plots being part of the study. By combining yields, allocation data (e.g. prices of co-products) and the other data points, the data are transferred to data per unit of product.

Capital goods (including depreciation and maintenance) necessary for cultivation (e.g. greenhouse) shall be considered in this life cycle stage.

6.1.1 Starting material

Plant input material can be seeds, seedlings, cuttings (or other) or young plants. For the plant input material, the following data shall be collected:

- number of seeds, seedlings and/or young plants needed per area,
- location of supplier, (to be able to calculate distance to supplier)
- transport mode, distance and mass of plant input materials, and
- amount and type packaging, container and growing media use.

For the transport of starting material secondary data may be used.

For the production of starting material secondary data may be used for cut flowers. For potted plants the duration of the production of the starting material is collected from the supplier as well as the duration of the cultivation of its own product from starting material to sales. This is needed to estimate the environmental impact of the starting material for potted plants (see chapter 3.8.2).

6.1.2 Growing media

For growing media, data shall be collected on (necessary information can be provided by the growing media producers):

- type of growing media,
- quantity of growing media in volume/weight,
- location of supplier, (to be able to calculate distance to supplier)
- transport mode, distance and mass of growing media,
- packaging material, and
- share of carbon in the growing media that is considered as fossil shall be collected (peat constituent carbon content).

The use of growing media materials shall be recorded per type of growing media on an annual basis. If growing media is used for a longer period than a year, the annual usage shall be defined by dividing the amount of growing media by the years of usage.

Growing media may contain nutrients. If that is the case the content shall be recorded. C, N, P, K, limestone, dolomite, urea content and density and moisture content shall be collected and shall be considered when modelling N and P emissions during cultivation (sections 6.2.7 and 6.2.9). We refer to GME (2021) as it contains a lot of the growing media specific data.

For the production and transport of growing media secondary data may be used.

6.1.3 Capital goods

According to the PEFCR Guidelines (EC, 2021), ‘capital goods (including infrastructures) and their end of life should be excluded, unless there is evidence from previous studies that they are relevant.’ Materials for greenhouses often have a large contribution to the environmental footprint of floriculture products (e.g. Helmes, Ponsioen, et al., 2021). For that reason, greenhouses used in protected cultivation systems shall be included by users of this PEFCR. Other capital goods used in cultivation, or parts of greenhouses not used for cultivation activities, do not need to be included in PEF studies adopting this PEFCR.

Often primary data on greenhouses is difficult to obtain. For that reason, this PEFCR provides default data to be used for a few greenhouse types.

Practitioner may collect primary data when available. An overview of the data that needs to be collected is provided in the supplementary documents (Memo on capital goods modelling, see (Kan, Daniël; Vieira, 2020)). In case no primary data is available, the practitioner shall use the default data provided in the EF3.1 data.

Capital goods depreciation shall be taken into account in all cases. Linear depreciation shall be used. The expected service life of the capital goods shall be taken into account. By combining the material bill of the greenhouse, the total size, and the expected lifetime of the greenhouse, the material use per greenhouse is established. If there is no specific information on the lifetime of the greenhouse, the default lifetime of 15 years (Montero et al., 2011) shall be assumed. To calculate the input of greenhouse per unit of product (one stem or one potted plant), the total yield shall be divided by the size of the greenhouse, the expected lifetime of the greenhouse and, in case of different crops grown after each other, the share of cropping time it takes to grow the product. For a multi tunnel greenhouse, the same calculation shall be made.

$$AGH_p = (AGH_T * CT_p / CT_T) / (LTGH * YGH)$$

In which:

- AGHp = the area of the greenhouse per stem/potted plant (ha/stem or potted plant)
- AGHT = the total area of the greenhouse (h)
- CTp = the cropping time (length of the cropping period) of crop p (weeks)
- CTT = the total cropping time (weeks)
- LTGH = the life time of the greenhouse (yr)
- YGH = the yield of the product for the entire greenhouse (stems or potted plants/yr)

When multiple crops are grown within one capital good, the bill of materials needs to be allocated between the crops using the allocation rules provided in Table 14.

6.1.4 Materials use

There can be a wide variety of material use at a farm. The following types shall be added in the inventory, if applicable:

6.1.4.1 Materials used for containing growing media

The use of a growing media goes along with material use for containing it. These can be foils or more rigid packaging such as containers for pot soil. Pots can come with the young plant material or can be added later during the growing phase. All materials used (both incoming with young plant material and added later) shall be recorded in weight units per hectare and/or per product.

6.1.4.2 Materials used for soil covering

Materials used for soil covering may be relevant in open field and protected farm systems. It concerns the use of natural materials such as mulch or straw and synthetic materials such as plastics.

6.1.4.3 Materials used for guiding plants

Some plants are led and supported. For this purpose, a wide variety of constructions are developed consisting of a range of materials, such as wood, steel and plastics.

6.1.4.4 Materials used for lifting plants to ease handling

Potted plants and plants grown in growing media systems are sometimes lifted from the ground to make handling easier (e.g. using sticks and/or strings). These materials shall also be included.

For all the materials used, the quantities shall be recorded in weight units per year per hectare orper unit of product if that is needed for the calculations to product units. The following data points shall be recorded:

- Type of material,
- Location of production,
- Share of recycled content, and
- Type of waste processing.

This information shall be used to match the most adequate secondary datasets for production of materials and waste processing.

6.1.5 Plant protection products

Plant protection products are ‘pesticides’ that protect crops or desirable or useful plants. They are primarily used in the agricultural sector but also in forestry, horticulture, amenity areas and in home gardens. They contain at least one active substance and have one of the following functions (EC, 2023):

- protect plants or plant products against pests/diseases, before or after harvest
- influence the life processes of plants (such as substances influencing their growth, excluding nutrients)
- preserve plant products
- destroy or prevent growth of undesired plants or parts of plants.

Company-specific data shall be collected on all use of plant protection products such as herbicides, insecticides, fungicides, biocides, soil fumigants in cultivation and storage, including also chemicals used in post-harvest handling. This data involves the specific active ingredient and its CAS number, the application rate in grams per year per area unit or per crop weight unit for the crop under study. The active ingredients can be organic or inorganic chemicals such as S and Cu compounds.

For the production of plant protection products secondary data may be used. Transport of plant protection products shall be omitted.

The rules for modelling of the emissions resulting from the application of plant protection products in the field is documented in Section 6.2.6.

Secondary data on biological pest control are not available. Biological pest control does not need to be considered in the analysis. If biological pest control is used, this shall be reported as additional technical information together with the type of biological pest control.

6.1.6 Fertilisers

6.1.6.1 Synthetic and mineral fertilisers

For synthetic and mineral fertilisers data shall be collected on the application of N, P, K, $CaCO_3$ and other Calcium compounds. Data on N fertilisers shall be split in ureum and other N compounds. For N, P, K compounds data shall also be collected on compounds use for more precise calculations. The data shall be specified in weight per area for the crop under study. Transport distance shall also be modelled.

Table 15 *Fertiliser use activity data collection table for default modelling*

Activity data	Unit per gross area per year	Quantity	Source and method of measurement
Fertiliser brand or type name and composition	Kg /ha		
Ureum	Kg N/ha		
Calculated N use	Kg N/ha		
Calculated P use	Kg P/ha		
Calculated K use	Kg K/ha		
CaO use	Kg CaO/ha		
$CaCO_3$ use	Kg $CaCO_3$/ha		

For the production of synthetic and mineral fertilisers secondary data can be used.

6.1.6.2 Organic fertilisers

Organic fertilisers are products originating from a wide range of sources, such as animal manure, co-products from industry and compost. The following data shall be collected on organic fertilisers:

- Fertiliser type (source (animal, compost, industry), animal type, from conventional or organic farming)
- Fertiliser composition: water, Total N, organic bound N, mineral N, P, K, Cd, Zn, Cu
- location of supplier, (to be able to calculate distance to supplier) and
- transport mode, distance and mass of fertilisers.

For the composition of N, P and K, fertiliser type and the transport distance primary data shall be used. For the production of organic fertiliser and the composition of trace elements Cd, Zn and Cu secondary data may be used.

6.1.6.3 CO_2 as a fertiliser

CO_2 is used as a fertiliser in greenhouses. It can either be produced by farmers themselves in a CHP or fuel boiler, or be purchased from a third party (e.g., OCAP). Guidance related to the production of CO_2 in a CHP can be found in Section 6.2.4.

If CO_2 is purchased at a third party supplier only the inputs required to capture, process (e.g., purifying), store and transport the CO_2 to the greenhouse shall be included. Data shall be collected on the quantity in weight unit per area unit for the area where the crop under study is grown. The resulting CO_2 emissions shall be allocated to the original process. The source of CO_2 used in greenhouse crops should be clearly defined in the PEF study. Data, sources and assumptions used for modelling the impact should be recorded and reported. In case no company-specific data is available, secondary data may be used.

CO_2 emissions resulting from the application of purchased CO_2 at greenhouse shall be omitted. The application and emissions of CO_2 during the production of potted plants and cut flowers is considered as a delayed emission of the providing industry and should be accounted by that industry.

6.1.7 Packaging

The raw material consumption of reusable packaging shall be calculated by dividing the actual weight of the packaging by the reuse rate.

The reuse rate affects the quantity of transport needed per FU. The transport impact shall be calculated by dividing the one-way trip impact by the number of times this packaging is reused.

Packaging materials, such as plant pots or sleeves, are needed to pack the products at farm. However, this often is not the final packaging arriving at consumer. For that reason, the following stages where new packaging is applied are considered:
- Added by the farmer (modelled in this life cycle stage)
- Added at the distribution centre (modelled in 6.3)
- Added at the auction/trade (modelled in 6.5)
- Added by the retailer (modelled in 6.6)

For packaging, data shall be collected on:
- material type,
- weight,
- location of supplier, (to be able to calculate distance to supplier) and
- transport mode, distance and mass of materials,
- recycled content per material type.

This information will be used to match the most adequate secondary datasets for production of packaging materials.

If packing is a separate operation the fuel and electricity use shall be collected. Electricity use data shall be collected according to the generic PEF methodology explained in 5.8, which implies that a specific consumption mix can be accounted for if the conditions on validation are met.

The use of packaging material for the products being distributed to the customer shall be quantified for primary packaging materials (having direct contact with the product). Data on secondary and tertiary packaging materials are collected in the distribution stage. The weight of material used to fulfil the functional unit, shall be collected.

Some types of packaging in the life cycle of cut flowers and potted plants are reused. Default reuse rates are provided for:
- Reusable flower buckets used for transporting cut flowers are used 125 times (10-15 times per year, during 10 years).
- Reusable trays are used 70 times (7 times per year during 10 years).
- Reusable trolleys used at auction (see chapter 6.3) are used 250 times.

If water is being used in containers for transport the amount of water should be collected here as well.

6.2 Cultivation

Use of crop type specific and country-, region- or climate-specific data for yield, water and land use, land use change, fertiliser (artificial and organic) amount (N, P amount) and pesticide amount (per active ingredient), per hectare per year.

The cultivation stage encompasses activities related to farming and harvesting of the horticultural product. These include plot preparation, planting/sowing, growing, harvesting and all activities related to the handling of cut flowers and potted plants products after harvesting. (e.g. sorting, washing, phytosanitary treatment).

6.2.1 Time period to consider for data collection of cultivation stage

For all cultivation data it is important to carefully define the average performance of the production system considering the variation in inputs and outputs related to climate variation. For perennial plants it is crucial to have a representative contribution of the different growth phases in the production system.

Cultivation data shall be collected over a period of time sufficient to provide an average assessment of the life cycle inventory associated with the inputs and outputs of cultivation that will offset fluctuations due to seasonal differences:

- For annual crops, an assessment period of at least three years shall be used (to level out differences in crop yields related to fluctuations in growing conditions over the years such as climate, pests and diseases, etc.). Where data covering a three-year period is not available i.e. due to starting up a new production system (e.g. new greenhouse, newly cleared land, shift to another crop), the assessment may be conducted over a shorter period, but shall be not less than 1 year. Crops/plants grown in greenhouses shall be considered as annual crops/plants, unless the cultivation cycle is significantly shorter than a year and another crop is cultivated consecutively within that year. Tomatoes, peppers and other crops which are cultivated and harvested over a longer period through the year are considered as annual crops.
- For perennial plants (including entire plants and edible portions of perennial plants) a steady state situation (i.e. where all development stages are proportionally represented in the studied time period) shall be assumed and a three-year period shall be used to estimate the inputs and outputs[15].
- Where the different stages in the cultivation cycle are known to be disproportional, a correction shall be made by adjusting the crop areas allocated to different development stages in proportion to the crop areas expected in a theoretical steady state. The application of such correction shall be justified and recorded. The life cycle inventory of perennial plants and crops shall not be undertaken until the production system actually yields output.
- For crops that are grown and harvested in less than one year (e.g. lettuce produced in 2 to 4 months) data shall be gathered in relation to the specific time period for production of a single crop, from at least three recent consecutive cycles. Averaging over three years may best be done by first gathering annual data and calculating the life cycle inventory per year and then determining the three years average.

For the farm plots where the crop(s) under study data are grown, data shall be collected on area use and on the history of the plot if a specific LUC calculation is done. If the farm (plots) have a proven history of no land use change for more than 20 years this means that there is no GHG impact of land use change.

6.2.2 Land occupation and land use change

Data on land use and direct land use change must be collected. This must be country-specific. Land use per FU is calculated from collected data on yield per hectare of land. If no specific information on type of land use is available, the following shall be used:

- Open field, in soil: occupation, annual or permanent crop
- Open field, outside soil: occupation, annual or permanent crop
- Protected, in soil: occupation, annual crop, greenhouse
- Protected, outside soil: occupation, annual crop, greenhouse

For land use change: all carbon emissions and removals shall be modelled following the modelling guidelines of PAS 2050:2011 (BSI, 2011) and the supplementary document PAS2050-1:2012 (BSI, 2012) for horticultural products.

[15] The underlying assumption in the cradle-to-gate life cycle inventory assessment of horticultural products is that the inputs and outputs of the cultivation are in a 'steady state', which means that all development stages of perennial crops (with different quantities of inputs and outputs) shall be proportionally represented in the time period of cultivation that is studied. This approach gives the advantage that inputs and outputs of a relatively short period can be used for the calculation of the cradle-to-gate life cycle inventory from the perennial crop product. Studying all development stages of a horticultural perennial crop can have a lifespan of 30 years and more (e.g. in case of fruit and nut trees).

6.2.3 Water

Data on the following water flows shall be collected and modelled in studies compliant with this PEFCR:
- Irrigation water
- Other blue water use
- Rain water, unless sourced via surface or groundwater resources, is not to be considered. Rain water captured at the roof of a greenhouse, stored (e.g. in a basin) and later used in the greenhouse is seen as irrigation water and shall be accounted for.

Irrigation water is crop-specific. The flow of irrigation water can be measured/estimated with several methods. This shall be recorded as well as the source of the irrigation water and the country in which used and extracted. All water use should be calculated back to the FU.

Table 16 *Water use activity data collection*

Activity data	Unit per gross area per year per crop	Quantity	Water source (well, canal/river, lake, tap water)	Country of use	Source and method of measurement
Irrigation water	m^3 per ha, kg crop or farm per year				
Other water use	m^3 per ha, kg crop or farm per year				
Water discharge	m^3 per ha, kg crop or farm per year				

6.2.4 Electricity, heat and purified CO_2

6.2.4.1 Purchased electricity

Electricity consumed during cultivation and post-harvest operations shall be collected according to the Electricity modelling in 5.8.

Electricity from a CHP system in a farm shall be modelled as described in the sub-section below, entitled Combined heat and power (CHP) systems (6.2.4.3). Electricity from a CHP system to a greenhouse of the same owner may be calculated from the CHP efficiency and electricity deliveries to the grid.

6.2.4.2 Purchased heat

For heat, data shall be collected on the energy use per hectare during cultivation and post-harvest operations. For purchased heat secondary data may be used.

For the production of heat from a CHP system located in a farm (own or neighbour), primary data of suppliers shall be used. Heat flows from a CHP to a greenhouse of the same owner may be calculated from the CHP efficiency and heat delivered to third parties.

6.2.4.3 Combined heat and power (CHP) systems

A combined heat and power (CHP) system can provide heat, electricity and purified CO_2 to a farm. In case a farmer has a CHP system, activity data from the operation inputs and outputs of the CHP system shall be gathered. A CHP system shall be modelled according to the following hierarchy:
1. By subdivision, i.e. by dividing the CHP unit to the smallest unit possible, being 1) the cultivation activities, 2) the CHP system and 3) the flue gas cleaning system.
2. If subdivision is not feasible, activity data shall be collected on the CHP including the flue gas cleaning system and the cultivation separately.
3. If subdivision between CHP and cultivation is not feasible, a theoretical subdivision shall be constructed by calculating all unknown energy inputs and output from the CHP from the known energy flows.

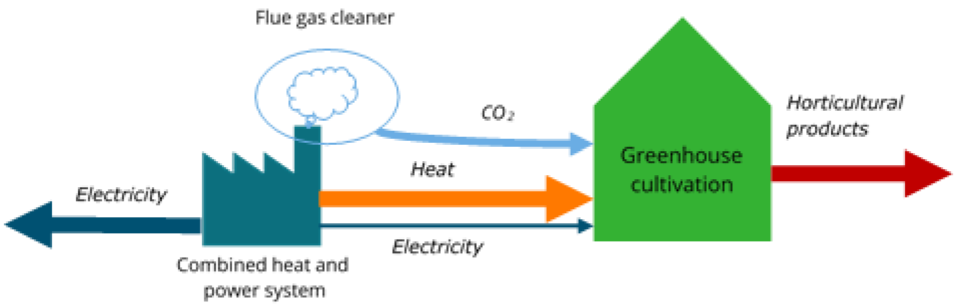

Figure 5 *Graphical representation of the heated greenhouse processes, subdivided into three unit process and the product flows*

Activity data for the CHP unit shall include:

i. The type and quantity of fuel used by the CHP per unit of electricity and heat produced. The amount and type of fuel shall be connected to appropriate secondary data for fuel production.

ii. The environmental interventions related to the CHP unit, shall be calculated. This shall be done by applying the following provisions:
   - Carbon dioxide (CO_2) emissions to air shall be determined in the following order of preference:
     - The emission shall be collected from direct measurement or a documented prior measurement of the CHP unit considered.
     - If direct measurement is not available, the emission shall be collected from a data source specific to the installation, such as a technical specification document.
     - If a technical specification is not available, a public source, clearly stating average emissions from CHPs in general representative for the country of cultivation shall be used.
     - If a public source is not available, secondary data from scientific papers or LCA databases are accepted.
   - All emissions for different cases within the same study shall be from the same type of data source. Note that CO_2 may be used in the cultivation process, however CO_2 is considered a direct emission of the CHP heat and electricity production and shall not be attributed to any other stage in the cultivation process. As per 6.1.6, if CO_2 is used as fertiliser, the flue gas cleaning activities for the purification of CO_2 can be attributed to the production of CO_2 and its use as fertiliser in the cultivation process.
   - Methane (CH_4) emissions to air from natural gas should be directly measured from CHP unit operation considering mg of C loss per m^3 of natural gas, assuming all C lost is CH_4. If no measurement is available, a default worst case scenario of 2.8% of fuel loss shall be assumed. Methane emissions from combustion of fuels other than natural gas shall be determined using the specific fuel heating value and carbon emission factors per energy unit.
   - Nitric oxide (NO_x) emissions to air shall be calculated using the EMEP/EEA Tier 1 approach mg emission per MJ of fuel.
   - Sulphur dioxide (SO_2) emitted to air shall be calculated using the EMEP/EEA Tier 1 approach mg emission per MJ of fuel.

iii. Electricity and heat output per unit of fuel used shall be recorded. The activity data and environmental interventions from CHP shall be allocated to the heat and electricity outputs as per indication provided in 6.1.6.

Urea used for flue gas cleaning shall be recorded in weight units per unit of fuel used by the CHP. The amount of urea used shall be connected to appropriate secondary data for fuel production. Default urea use for flue gas cleaning is based on expert judgment and considered to be 1.75 ml/kWh. This value shall be applied if no primary data is available.

Urea use shall be allocated to the heat and electricity outputs as per indication provided in section 6.1.6.

6.2.5 Fuels

Unless it is clearly documented that operations are carried out manually, field operations shall be accounted for through total fuel consumption and its combustion emissions or through inputs of specific machinery, transports to/from the field, energy for irrigation, etc.

For data on fuel use not captured in other activities with dedicated modelling, e.g. for use of machinery at farm, data shall be collected per area unit and shall include:
- Fuel type
- Energy content of the fuel specified in HHV or LHV
- Fuel mix (for instance if biogenic fuels are mixed in) in relative shares of fuels
- Quantity of the fuel in weight and energy units
- Sourcing country, if known
- Machine use (hours, type) (to be included if there is high level of mechanisation)

This information will be used to match the most adequate secondary datasets for production of fuels and combustion of fuels.

6.2.6 Emissions from use of plant protection products

Here, only the emissions resulting from the application of plant protection products in the cultivation area is described. The input of plant protection products in the field is documented in 6.1.5.

Pesticide emissions shall be modelled as specific active ingredients. As a default approach, pesticides applied on the field shall be modelled as 90% emitted to the agricultural soil compartment, 9% emitted to air and 1% emitted to water (EC, 2021).

If the active ingredient is not characterised in the EF method, the active ingredient shall be omitted and be listed separately as not characterised substance in the PEF report.

The impact of crop protection active ingredients depends on the farm system, climate conditions, the distance to surface area, the spraying technology etc. In this version of the PEFCR, no specific emission model is recommended that differentiates these parameters. The Technical Secretariat is aware of the Pest-LCI 2.0 (link) and Greenhouse Emission Model (link) approaches for respectively open field and protected cultivation, which are the most progressive to overcome the current limitations of the current modelling of pesticides here proposed.

6.2.7 Fertilisers

In this section, Carbon, Nitrogen and Phosphorus related emissions are calculated from C, N and P inputs as synthetic fertiliser, manure and other organic fertilisers. How much N and P inputs shall be allocated to a specific crop in case of a rotation scheme is described in a separate chapter in the PEFCR (chapter 5.7).

For this PEFCR a preference level approach shall be followed when modelling N and P emissions caused by the application of fertilisers. The preference will be determined by de data that can be made available by farms:
1. Direct measurement
2. Preferred modelling
3. Default PEFCR modelling

During the verification (compulsory for PEF studies) it needs to be checked whether an improved preference level could not be met.

Direct measurement of the emissions is the most accurate method to indicate the emissions provided that the measurement complies with given conditions.

The **preferred modelling** is based on calculation rules derived from existing models, whereas some principals are applied to select the most relevant model/method. These principals are:

- The calculation rule must be freely available from a model. Some models are not transparent in the use of calculation rules.
- The calculation rule should not be too complex, in other words data needed should be available on a level of regular management of a farmer/grower. This means that if data is needed on the basis of very frequent measurement (for instance daily basis), information is needed on parameters that are not in scope of regular management (for instance carbon content of the soil), or a big amount/high density of data on farm level is needed (for instance 10 soil samples per ha), the model is considered too complex to be used for the purpose of this PEFCR. The model must be representative on a global level.

The **default modelling** must be applied if the measurement and the preferred modelling cannot be performed. So, the most important criteria for the default modelling is that it should be applicable even if only minor information on cultivation is known.

This approach implies that comparability is more important than precision[16]. In other words, preferred modelling only uses one method, instead of several regional models, although this might imply less accurate results for certain regions. This means that by default PEFCR modelling prefers IPCC TIER 1 above the IPCC TIER 2 approach, because the TIER 1 approach results in a comparable approach for each situation, whereas when choosing for the IPCC TIER 2 approach, the method will differ between countries which results in less comparable results.

Fertiliser (and manure) emissions shall be differentiated per fertiliser type and cover as a minimum:

- NH_3 to air, i.e. ammonia volatilisation (from N fertiliser application)
- NO_x to air
- N_2O to air (direct and indirect) (from N fertiliser application)
- CO_2 to air (from lime, urea and urea-compounds application)
- NO_3 to water unspecified (leaching from N fertiliser application)
- PO_4 to water unspecified or freshwater (leaching and run-off of soluble phosphate from P fertiliser application)
- P to water unspecified or freshwater (soil particles containing phosphorous, from P fertiliser application)
- Please refer to Table 18 for an overview of the modelling underlying these emissions per preference level.

The LCI for N emissions shall be modelled as the amount of emissions after it leaves the field (soil) and ending up in the different air and water compartments per amount of fertilisers applied. N emissions to soil shall not be modelled. The nitrogen emissions shall be calculated from nitrogen applications of the farmer on the field and excluding external sources (e.g. rain deposition).

Table 17 *Parameters to be used when modelling nitrogen emission in soil*

Emission	Compartment	Value to be applied
N_2O (synthetic fertiliser and manure/organic fertiliser; direct and indirect)	Air	0.022 kg N_2O/kg N fertiliser applied *
NH_3 (synthetic fertiliser)	Air	kg NH_3 = kg N * FracGASF = 1*0.1* (17/14) = 0.12 kg NH_3/kg N fertiliser applied
NH_3 (manure/organic fertiliser)	Air	kg NH_3 = kg N*FracGASF = 1*0.2* (17/14) = 0.24 kg NH_3/kg N manure/organic fertiliser applied
NO_3^- (synthetic fertiliser and manure/organic fertiliser)	Water	kg NO_3^- = kg N*FracLEACH = 1*0.3*(62/14) = 1.33 kg NO_3^-/kg N applied
P based fertilisers	Water	0.05 kg P/kg P applied

FracGASF: fraction of synthetic fertiliser N applied to soils that volatilises as NH_3 and NOx. FracLEACH: fraction of synthetic fertiliser and manure/organic fertiliser lost to leaching and runoff as NO_3^-.

*This parameter combines direct and indirect N_2O emissions, which are separately explained in chapters 6.2.7.4 and 6.2.7.5.

[16] The use of the default approach, although allowing comparability, may not extend to specific country or region as no country-specific emission factors are applied. This is acknowledged as a limitation of the PEFCR approach as only comparability of applied N is possible.

Combining these three preference levels (direct measurement, preferred modelling, and default modelling) with the above-mentioned list of emissions related to fertilisers results in the overview as presented in Table 18. Note that for some combinations a distinction is made between soil and soilless[17] cultivation systems.

The remainder of this section is structured according to the overview in Table 18. Each of the following subsections describes the preference levels for emission modelling, including the formulas and corresponding parameters. The general parameters and constants that are relevant for several emissions are presented in Table 19.

Table 18 *Overview of emission modelling per preference level*

Section	Emission	Compart-ment	Measurement	Preferred modelling	Default modelling
6.2.7.1	**Ammonia (NH3)**	Air	Direct measurement	Model based on fertiliser use compliant to Bouwman et al 2002	IPCC Tier 1
6.2.7.2	**Nitrogen oxides (NOx)**	Air	Direct measurement	Model based on EEA 2016 (if no default modelling for NH3)	Default modelling for NH3 includes NOx
6.2.7.3	**Nitrate (NO3)**	Water	**Soilless**: direct measurement only for closed recirculation **Soil**: direct measurement not applicable	**Soilless**: not applicable **Soil**: model run-off to surface water and leaching to ground water (Miterra)	IPCC Tier 1
6.2.7.4	**Nitrous oxide (N2O)**	Air	Direct measurement not applicable (very complex)	IPCC Tier 1 (no supra national models available)	IPCC Tier 1
6.2.7.5	**Carbon dioxide (CO2)**	Air	Direct measurement not applicable	IPCC Tier 1 (no supra national models available)	IPCC Tier 1 for urea and lime
6.2.7.6	**Phosphate (PO4) and Phosphorus (P)**	Water	**Soilless**: direct measurement only for closed recirculation (all discharged water is monitored) **Soil**: direct measurement not applicable	No recommended model: use direct measurement or default modelling	PEFCR guide 6.3

Table 19 *Overview of general parameters and constants used in emission modelling*

Parameter	Unit	Description
N_{fert}	kg N	Total amount of N (kg) applied to soil or growing media as synthetic fertiliser
N_{org}	kg N	Total amount of N (kg) applied to soil or growing media as organic fertiliser (compost, animal manure, sewage sludge and other organic nitrogen)
$N_{applied}$	kg N	Total amount of N (kg) applied to soil or growing media as synthetic or organic fertiliser
17/14	-	Conversion constant from NH_3-N to NH_3
46/14	-	Conversion constant from NO_x-N to NO_x
62/14	-	Conversion constant from NO_3-N to NO_3
44/28	-	Conversion constant from N_2O-N to N_2O
44/12	-	Conversion constant from CO_2-C to CO_2

6.2.7.1 Ammonia (NH_3) volatilisation

The main source for ammonia (NH_3) emissions at horticulture systems is via application of nitrogen in synthetic and organic fertiliser (animal manure, compost, sewage sludge, etc.). Other sources of ammonia volatilisation as standing crops and crop residues are recognised but modelling these emissions as a robust and usable methodology covering various cultivation systems in different regions is not yet possible (EEA, 2016). Nevertheless in some situations these sources are modelled and included in inventories, as for

[17] We assume that a soilless system is a protected system (e.g., a greenhouse) or an open field situation where the soil is completely covered by a material that prevents water flowing to the soil and cultivation takes place in a growing medium on top of this material.

instance ammonia volatilisation from crop residues in The Netherlands which is included as source in the National Inventory (Vonk et al., 2018). In this methodology ammonia volatilisation from N-application through synthetic and organic fertiliser is being considered.

Ammonia airborne emissions have different characterisation factors for acidification and eutrophication, marine and terrestrial, per country. For this reason, the user of this PEFCR shall specify in which country the emissions take place.

Users of this PEFCR must follow the preferred modelling in case the data needed can be collected. If not, the default modelling based on IPCC, Tier 1 may be used instead (see Table 20).

Synthetic N-fertilisers solely based on nitrate do not have any volatilisation at application (EEA, 2016).

Table 20 *Preferred and default emission modelling for ammonia (NH_3) volatilisation*

Preferred modelling: Formula 1	**NH_3 (kg) = NH_3 rate * $N_{applied}$ * 17/14** **NH_3 rate = $Exp^{crop + fert + appl + pH + CEC + climate}$**	**Bouwman et al (2002)**
NH3 rate	NH3 fraction (0 – 1) of N application emitted as ammonia	Formula 1 (see above)
crop	Type of crop (upland/grass/flooded)	Choose ‘upland’ in Table 21
fert	Type of fertiliser (e.g., urea)	Primary data and Table 21 or country average[1]
appl	Type of application (e.g., broadcast)	Primary data and Table 21
pH	pH of the soil or the growing media	Primary data and Table 21
CEC	Cation-Exchange-Capacity of soil or growing media	Primary data and Table 21
climate	Climate (temperate or tropical)	Primary data and Table 21
Default modelling: Formula 2	**NH_3 (kg) = ($Frac_{vols}$ * N_{fert} + $Frac_{volo}$ * N_{org}) * 17/14**	**IPCC 2019 Tier 1**
$Frac_{vols}$	Fraction of N from synthetic fertiliser that volatilises as NH_3 and NO_x	$Frac_{vols}$ = 0.11
$Frac_{volo}$	Fraction of N from organic fertiliser (compost, animal manure, sewage sludge and other organic nitrogen) that volatilises as NH_3 and NO_x	$Frac_{volo}$ = 0.21

[1] In case that no information is available on which N-fertilisers are used (as described in Table 21) the weighted average value for N-fertiliser use determined per country (see Table 53 in Appendix 7) may be used as default.

Table 21 The values for the parameters to calculate the ammonia volatilisation rate according to (Bouwman et al., 2002)

parameter		**value**
crop type	upland	-0.045
	grass	-0.158
	flooded	0
fertiliser	Ammonium sulfate (AS)	0.429
	Urea	0.666
	Ammonium nitrate (AN)	-0.35
	Calcium Ammonium nitrate (CAN)	-1.064
	Anhydrous Ammonia (AA)	-1.151
	Other straight N	-0.507
	Nitrogen solutions	-0.748
	Ammonium phosphates (mono-ammonium and diammonium phosphate)	0.065
	other compound NP	0.0014
	compound NK	-1.585
	compound NPK	0.014
	Ammonium Bicarbonate	0.387
	Animal manure	0.995
application	broadcast	-1.305
	broadcast to floodwater	-1.305
	incorporated	-1.895
	solution	-1.292
	broadcast and then flooded	-1.844
	incorporated and then flooded	-1.844
	broadcast to floodwater at panicle initiation	-2.465
soil pH	< 5,5	-1.072
	5,5 > pH ≤ 7,3	-0.933
	7,3 > pH ≤ 8,5	-0.608
	> 8,5	0
soil CEC	≤ 16	0.088
in cmol/kg	16 < CEC ≤ 24	0.012
	24 < CEC ≤ 32	0.163
	> 32	0
Climate	Temperate < 20 ºC	-0.402
	Tropical ≥ 20 ºC	0

6.2.7.2 Nitrogen oxides (NO_x)

The preferred methodology for Nitrogen oxide (NO_x) emissions depends on the way ammonia volatilisation is calculated. If ammonia volatilisation is calculated using the fall back option (conform IPCC Tier 1, see 6.2.7.1), nitrogen oxide emissions are not relevant because in the IPCC ammonia approach (IPCC, 2006) the NO_x emissions are included. Table 22 provides an overview of preferred and default nitrogen oxides modelling.

Table 22 Preferred and default emission modelling for nitrogen oxides (NO_x)

Preferred modelling: Formula 3	**NO_x (kg) = $N_{applied}$ * EF_{nox} * 46/14**	**EEA (2019)**
EF_{nox}	Emission factor NO_x in kg NO_x per kg N applied	EF_{nox} = 0.04
	If NH_3 used default modelling: NO_x already included in IPCC Tier 1 so no need to account for these emissions	

Airborne emissions of nitrogen oxides have different characterisation factors for acidification and eutrophication, marine and terrestrial, per country. For this reason, the user of this PEFCR shall specify in which country the emissions take place.

6.2.7.3 Nitrate emissions (NO_3)

Nitrate emissions to groundwater and surface water originate from nitrogen surplus of external inputs from, for instance, fertiliser, nitrogen fixation, crop residues, deposition. Nitrate emissions shall be preferably calculated using either 'measurement' or the preferred modelling method. If insufficient data are available, then default rules documented in Section 4.4.1.5 of Annex 1 of the PEF Guidance (EC, 2021) may be applied. The choice of modelling shall be reported in the PEF study report. In the preferred method a distinction is made between run-off to surface water and leaching to ground water.

The ILCD impact methodology for marine eutrophication allows for making a distinction between N to soil and Nitrate to fresh water. Ground water is not an emission compartment as such and also the human toxicological effects of nitrate in ground water are not considered. We propose to consider both run off to surface water and leaching to ground water as a direct emission of nitrate to fresh water. Both emission pathways are separated in the emissions flows of the preferred modelling approach so that later on, when LCA methodology develops and separate impact factors become available, this can be applied easily.

The remainder of this subsection describes additional information on direct measurements, the preferred modelling approach, and the default modelling approach.

Direct measurements for soilless cultivation (For cultivation in soil: preferred or default modelling)

Nitrate emission measurements are only representative/accurate in completely closed water systems which are applied in soilless systems. In these systems all discharged water is monitored on nitrate content. In that case the nitrate emissions are calculated as volume discharged water times the measured nitrate concentration. This implies that for cultivations in the soil, regardless if it is protected, measurements of nitrate emissions are not applicable.

In some countries it is mandatory that for cultivation in greenhouses on growing media the annual amount of discharged water (to surface water or sewage system) and nitrate concentration is measured and reported to the authorities. This annual measured and reported quantity for nitrate in discharged water should be taken as nitrate emission. If it can be proven that the water recirculation system is closed, and no water is discharged at all, the nitrate leaching can be taken as zero. This zero-discharge of water must be confirmed by the relevant legal authority.

Preferred modelling for cultivation in soil (For soilless cultivation: measurement or default modelling)

The preferred modelling of nitrate emissions is based on the Miterra-Europe model (Velthof et al., 2009) (Velthof et al., 2007). This model has a proven track record in European studies (Velthof et al., 2014), (Leip et al., 2013), (Oenema et al., 2009), (De Vries et al., 2011), data needed for calculation of nitrate emissions should be rather easily available on farm level.

Two pathways for nitrate losses can be distinguished: runoff to surface water and leaching to groundwater (which indirectly can leach to surface water). Preferred emission modelling for both pathways is described in Table 23. Note that these formulas are only applicable to cultivation in soil. For soilless cultivation, direct measurements or default modelling is applicable.

Table 23 *Preferred emission modelling for nitrate (NO_3) runoff and leaching (only applicable to cultivation in soil)*

Preferred modelling		**Total NO_3 (kg) = (N_{runoff} + N_{leach}) * 62/14**	**See Formula 4 and 5**
Runoff to surface water: Formula 4		N_{runoff} (kg) = (N_{fert} + N_{org}) * LF_{runoff_max} * min(f_p, f_{rc}, f_s)	Velthof et al (2007, 2009)
LF_{runoff_max}		Maximum runoff fraction based on the slope of the soil	Primary data and Table 24
f_p, f_s, f_{rc}		Fractions based on precipitation surplus, soil type, and depth to rock	Primary data and Table 24
Leaching to groundwater: Formula 5		N_{leach} (kg) = LF * $correction_{dep}$ * $N_{soil\_surplus}$	Velthof et al (2007, 2009)
LF (leaching fraction)		= $LF_{soiltype\_max}$ * min(f_p, f_r, f_t, f_c)	
	$LF_{soiltype\_max}$	Maximum leaching fraction based on soil type	Primary data and Table 25
	f_p, f_r, f_t, f_c	Fractions based on precipitation surplus, rooting depth, temperature, and soil organic C content	Primary data and Table 25
$correction_{dep}$[1]		= 1 – (N_{dep} / (N_{fert} + N_{org} + N_{fix} + N_{dep})) Correction factor for share of N_{dep} in total N input	See parameters below
	N_{fix}	Amount of Nitrogen input from N-fixation in specific N fixating crops (e.g., legumes such as lupine) in kg N	N_{fix} = 0 (if N_{fert}+N_{org}≥N_{harv}) N_{fix} = N_{harv} (otherwise)
	N_{dep}	Amount of Nitrogen input from N-deposition (kg N)	Country specific data (e.g., via EMEP)
$N_{soil\_surplus}$		= (N_{fert} + N_{org} + N_{fix} + N_{dep}) minus (N_{harv} + NH_3-N + NO_x-N + N_{runoff} + direct N_2O-N) Difference of N inputs[2] and N outputs (kg N available to leach)	See parameters below
	N_{fix}, N_{dep}	See above as part of $correction_{dep}$	
	N_{harv}	Amount of Nitrogen in harvested crop (main and co-products) in kg N = N-content (kg N/tonne product) * $product_{harv}$ (tonne)	$Product_{harv}$: primary data N-content: primary data or Table 53 in Appendix 7
	NH_3-N	Amount of NH_3-N (kg) from synthetic and organic fertilisers	See Formula 1 or 2
	NO_x-N	Amount of NO_x-N (kg) from synthetic and organic fertilisers	See Formula 3
	N_{runoff}	Amount of N emitted as nitrate by runoff to surface water	See Formula 4
	Direct N_2O-N	Amount of N_2O-N (kg) from synthetic and organic fertilisers	See Formula 7

1 N_{dep} is included in $N_{soil\_surplus}$ but is considered as ‘background input’ for which the farmer is not directly accountable, although good farming practice is to take the deposition into account in the planning of fertilisation. Therefore, a correction is included, based on the share of N_{dep} in total N input.

2 Nitrogen in crop residues are no external inputs and considered as internal N-flows, so not included in N inputs.

Table 24 *The values for the parameters to calculate the runoff to surface water (Formula 4) according to (Velthof et al., 2007, 2009)*

Parameter		**value**
LF_{runoff_max}	Slope 0 to 8%	10%
	Slope 8 to 15%	20%
	Slope 15 to 25%	35%
	Slope > 25%	50%
f_p	Precipitation surplus > 300 mm	1
	Precipitation surplus 100 to 300 mm	0.75
	Precipitation surplus 50 to 100 mm	0.50
	Precipitation surplus < 50 mm	0.25
f_s	Mineral soils, clay content > 60%	1
	Mineral soils, clay content 35-60%	0.9
	Mineral soils, clay content 18-34%	0.75
	Mineral soils, clay content <18%	0.25
	Peat soils	0.25
f_{rc}	Depth soil to rock ≤ 25 cm	1
	Depth soil to rock > 25 cm	0.8

Table 25 *The values for the parameters to calculate the leaching to groundwater (Formula 5) according to (Velthof et al., 2007, 2009)*

Parameter		**value**
$LF_{soiltype\_max}$	Sandy soils	1
	Loamy soils	0.75
	Clay soils	0.5
	Peat soils	0.25
f_p, sand and loam	Precipitation surplus > 300 mm	1
	Precipitation surplus 100-300 mm	0.75
	Precipitation surplus 50-99 mm	0.50
	Precipitation surplus < 50 mm	0.25
f_p, clay and peat	Precipitation surplus > 300 mm	0.50
	Precipitation surplus 100-300 mm	1
	Precipitation surplus 50-99 mm	0.75
	Precipitation surplus < 50 mm	0.25
f_r	Rooting depth < 40 cm	1
	Rooting depth > 60 cm	0.75
f_t	Temperature < 5° C avg annual temp	1
	Temperature 5-15° C	0.75
	Temperature > 15° C	0.50
f_c	Soil organic C content < 1%	1
	Soil organic C content 1%-2%	0.90
	Soil organic C content 2%-5%	0.75
	Soil organic C content > 5%	0.50

Default modelling for cultivation in soil and for soilless cultivation

Nitrate emissions are calculated according to the 2019 Refinement to the 2006 IPCC Guidelines whereas 24% of the applied nitrogen is emitted as nitrate. The applied nitrogen is the sum of nitrogen applied with synthetic fertiliser, organic fertiliser (compost, animal manure, sewage sludge and other organic nitrogen additions to the soil), crop residues and nitrogen mineralised in organic soils or associated with land use change.

The fraction leached is 24% for situations where soil/growing media water-holding capacity is exceeded, as a result of an excess of rainfall compared to potential evaporation or where irrigation (excluding drip irrigation) is employed. For dry circumstances where evaporation exceeds rainfall or irrigation the 2019 Refinement to the 2006 IPCC Guidelines prescribe a leaching fraction of 0%, so no leaching takes place at all. This is, however, not in line with the preferred modelling where the reduction factor for a situation with a negative precipitation surplus is still more than 0% (25%, see Table 25). Therefore, in the default modelling the fraction leached is set to 24% for all situations. Table 26 describes the default emission modelling for total nitrate to water (without distinction between runoff and leaching). The default modelling approach is applicable to cultivation in soil and to soilless cultivation.

Table 26 *Default emission modelling for nitrate (NO_3) runoff and leaching (applicable to cultivation in soil and to soilless cultivation)*

Default modelling	**No distinction between runoff to surface water and leaching to ground water**	
Total nitrate to water: Formula 6	Total NO_3 (kg) = $Frac_{leach}$ * (N_{fert} + N_{org} + N_{cr} + N_{som}) * 62/14	IPCC 2019 Tier 1
$Frac_{leach}$	Fraction of added Nitrogen emitted as nitrate through leaching and runoff	$Frac_{leach}$ = 0.24
N_{cr}	Soil: total amount of Nitrogen in crop residues above and below ground (kg N) Soilless: negligible or not relevant[1]	Soil: N_{cr} from primary data or Table 55 in Appendix 7 Soilless: N_{cr} = 0
N_{min}	= N_{som} + N_{os}	See below
N_{som}	Soil: amount of Nitrogen mineralised in mineral soils associated with loss of soil Carbon from soil organic matter as a result of changes to land use or management Soilless: not applicable for fertiliser modelling in soilless cultivation	Soil: N_{som} calculated via IPCC 2019 equation 11.8 or choose N_{som} = 0 and acknowledge as limitation Soilless: N_{som} = 0
N_{os}	Amount of Nitrogen (kg N) mineralised from oxidation of organic matter in growing media. See Growing media in section 6.2.9.	N_{os} = 0 for fertiliser modelling

1 In soilless systems, crop residues are negligible or not relevant because the living crop is sold together with the growing media (potted plants) or after the cultivation period the crop is either removed together with growing media or the crop remains growing on the growing media for the next production cycle.

6.2.7.4 Nitrous oxide (N_2O) to air (direct and indirect)

The relationship of direct nitrous oxide emissions from N applied is described by the 2019 Refinement to the 2006 IPCC Guidelines. In this model the nitrous oxide emission is not depending on soil, climate, fertiliser type etc. A more specific modelling in which the relationship of N_2O emissions to those factors is taken into account on a supra national level is not available. For instance, in the Netherlands specific N_2O emission factors are available (depending on soil type, fertiliser type and application method) but these are not applicable for other (EU)countries. For this reason, both the preferred and the default modelling approach for direct and indirect nitrous oxide (N_2O) emissions are based on IPCC 2019 Tier 1 (see Table 27), without taking the N input from urine and dung from grazing animals into account. Indirect nitrous oxide emissions are determined by ammonia volatilisation and nitrate leached.

Table 27 *Preferred and default emission modelling for nitrous oxide (N2O) emissions (applicable to cultivation in soil and to soilless cultivation)*

Preferred and default modelling approach for direct N_2O emissions		
Direct N_2O: Formula 7	N_2O direct[1] (kg) = (N_{fert} + N_{org} + N_{cr}) * EF_1 * 44/28	IPCC 2019 Tier 1
N_{cr}	Soil: total amount of Nitrogen in crop residues above and below ground (kg N) Soilless: negligible or not relevant[2]	Soil: N_{cr} from primary data or Table 55 in Appendix 7 Soilless: N_{cr} = 0
EF_1	Emission factor for direct N_2O emissions from Nitrogen inputs in kg N_2O-N per kg N	EF_1 = 0.01
Preferred and default modelling approach for indirect N_2O emissions		
Indirect N_2O: Formula 8	N_2O indirect (kg) = ($EF_{ammonia}$ * NH_3-N + $EF_{nitrate}$ * NO_3-N) * 44/28	IPCC 2019 Tier 1
NH3-N (kg)	Amount of Nitrogen volatilisation and redeposition as ammonia and nitrogen oxides (kg NH_3-N + kg NO_x-N)	See Formulas 1, 2, 3
NO3-N (kg	Amount of Nitrogen leached an runoff as nitrate (kg NO_3-N)	See Formulas 4, 5, 6
$EF_{ammonia}$	Emission factor for N_2O emissions from atmospheric deposition of Nitrogen on soils and water surfaces in kg N_2O-N/(kg NH_3-N+kg NO_x-N)	$EF_{ammonia}$ = 0.01
$EF_{nitrate}$	Emission factor for N_2O emissions from Nitrogen leaching and runoff in kg N_2O-N per kg N leached and runoff	$EF_{nitrate}$ = 0.011

1 Note that direct N_2O emissions also result from Nitrogen mineralised in mineral soils associated with loss of soil Carbon from soil organic matter as a result of change in land use or management and from Nitrogen mineralised from organic soils and growing media. These direct N_2O emissions shall be accounted for in section 6.2.2 on Land occupation and land use change, in section 6.2.9 on Growing media.

2 In soilless systems, crop residues are negligible or not relevant because the living crop is sold together with the growing media (potted plants) or after the cultivation period the crop is either removed together with growing media or the crop remains growing on the growing media for the next production cycle.

6.2.7.5 Carbon dioxide (CO2) to air from lime, urea, and urea-compounds application

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g., calcic limestone ($CaCO_3$), or dolomite ($CaMg(CO_3)_2$) leads to CO_2 emissions as the carbonate limes dissolve and release bicarbonate ($2HCO_3^-$), which evolves into CO_2 and water (H_2O).

Adding urea to soils during fertilisation leads to a loss of CO_2 that was fixed in the industrial production process. This source category is included because the CO_2 removal from the atmosphere during urea manufacturing is estimated in the Industrial Processes and Product Use Sector (IPPU Sector).

Both the preferred and the default modelling approach for CO_2 emissions from lime and urea follow the 2019 IPCC Refinement to the 2006 IPCC Guidelines as described in Table 28 below.

Table 28 *Preferred and default emission modelling for CO_2 from lime and urea application*

Preferred and default modelling approach for CO_2 emissions from lime application		
CO_2 from lime: Formula 9	CO_2 (kg) = (limestone (kg) * EF_{lime} + dolomite (kg) * EF_{dolo})* 44/12	IPCC 2019 Tier 1
Limestone	Amount of calcic limestone ($CaCO_3$) applied in kg	Primary data
Dolomite	Amount of dolomite ($CaMg(CO_3)_2$) applied in kg	Primary data
EF_{lime}	Emission factor for limestone in kg C per kg limestone	EF_{lime} = 0.12
EF_{dolo}	Emission factor for dolomite in kg C per kg dolomite	EF_{dolo} = 0.13
Preferred and default modelling approach for CO_2 emissions from urea application		
CO_2 from urea: Formula 10	CO_2 (kg) = urea (kg) * EF_{urea} * 44/12	IPCC 2019 Tier 1
Urea	Amount of urea fertilisation in kg	Primary data
EF_{urea}	Emission factor for urea in kg C per kg urea	EF_{urea} = 0.20

6.2.7.6 Phosphate (PO4) to water

The LCI for P emissions should be modelled as the amount of P emitted to water after run-off and the emission compartment 'water' shall be used. When this amount is not available, the LCI may be modelled as the amount of P applied on the agricultural field (through manure or fertilisers) 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.

In the case of measured amounts of phosphate (PO4) discharged in wastewater to surface water or sewage system, the first option shall be used. Comparable with nitrate, phosphate measurements are only representative/accurate in completely closed recirculation systems, where all discharged water is monitored on phosphate content. In that case the phosphate emissions are calculated as volume of discharged water times the measured phosphate concentration. This implies that for cultivations in the soil, regardless if it is protected, measurements of phosphate emissions are not applicable.

Table 29 describes the preferred and default emission modelling approach for Phosphorus (P) related emissions according to the product environmental footprint category rules (PEFCR) guide 6.3.

Table 29 *Preferred and default emission modelling for Phosphorus related emissions*

P emissions: Formula 11	***P (kg) = P_{rate} * $P_{applied}$***	***PEFCR guide 6.3***
$P_{applied}$	*Amount of Phosphorus (P) applied in kg*	*Primary data*
P_{rate}	*Fraction (0 – 1) of Phosphorus application emitted to water*	*P_{rate} = 0.05*

6.2.7.7 Nitrogen and Phosphorous balance

To get the full picture of N and P use, the fate of the nutrients and the environmental impact modelling, a balance per area unit shall be made according to Table 30.

Table 30 *N and P nutrient application balance per area unit*

	Nutrient application on the field during cultivation of the crop	Nutrient application due to crop rotation related fertiliser application	Nutrient uptake by the crop (main product plus co-product)	Nutrient uptake by crop residues	Nutrients discharged to surface or sewage water system after recirculation	Remaining nutrients
N						
P						

Refer to Appendix 7 for default modelling parameters.

If a recirculation system is in place farm system emissions to surface water shall be calculated directly from the discharged quantities.

Additionally, the input N from crop residues that stay on the field or are burned (kg residue + N content/ha) shall be included. How to address green manure is a topic raised by the TS for discussion at the Agricultural modeling working group. We will wait for their guidance, until then, green manure is only considered for the N&P balance.

6.2.8 Heavy metal emissions

Heavy metal emissions from field inputs shall be modelled as emission to soil and/or leaching or erosion to water. The inventory to water shall specify the oxidation state of the metal (e.g., Cr+3, Cr+6). As crops assimilate part of the heavy metal emissions during their cultivation, clarification is needed on how to model crops that act as a sink. The following modelling approach shall be used:

The final fate of the heavy metals elementary flows are not further considered within the system boundary: the inventory does not account for the final emissions of the heavy metals and therefore shall not account for the uptake of heavy metals by the crop. For example, heavy metals in agricultural crops cultivated for human consumption end up in the plant. Within the EF context human consumption is not modelled, the final fate is not further modelled and the plant acts as a heavy metal sink. Therefore, the uptake of heavy metals by the crop shall not be modelled.

6.2.9 Growing media

The production of all growing media (e.g. clay pellets, Rockwool cubes, vermiculite, peat moss, perlite) shall be accounted for. Carbon content of peat (constituents), N, P, K content, limestone, dolomite and urea content and density and moisture content shall be reported for the growing media used in cultivation. This shall be based on primary data.

Oxidation of peat carbon into CO_2 shall be calculated by considering a default rate of 5% per year, until growing media is transferred to the next user (reuse). All emissions due to oxidation of peat carbon shall be modelled as fossil CO_2, in the life cycle stage for cultivation.

The remaining peat C content in growing media shall be considered during end-of-life (6.8).

6.2.10 Peat soils

The input of peat to soil (kg/ha + C/N ratio) shall be included.

Drained peat soils shall include carbon dioxide emissions on the basis of a model that relates the drainage levels to annual carbon oxidation.

Please refer to chapter 6.2.9

6.2.11 Waste

The waste of products used during the manufacturing shall be included in the modelling.

All waste resulting from the cultivation stage at farm shall be modelled in this life cycle stage.

Farm waste consists of plant and crop remains (organic) and of wasted materials. The modelling of emissions from crop residues left on the field is explained in 6.2.7. Other organic waste should be accounted for and modelled as composting. For materials waste the waste scenario is included in the Circular footprint formula detailed in 5.10.

6.2.12 Storage at farm

Electricity use for climate control is the main activity data that shall be collected. If applicable data on amount of leakage of refrigerants (per type) and use of other energy sources (per type) shall also be collected.

Electricity use data shall be collected according to rules provided in 5.8 which implies that a specific consumption mix can be accounted for if the conditions on validation are met. If the storage operation takes place at the farm no specific electricity use data needs to be collected if already captured in electricity usage compiled in 6.2.4.

6.3 Distribution

Transport from farm to final client (including consumer transport) shall be modelled within this life cycle stage. The final client is defined as consumer of the cut flowers or potted plants. According to the PEF Guidance (EC, 2021), 'the distribution stage includes the transport from factory gate to warehouse/ retail, storage at warehouse/ retail, and transport from warehouse/ retail to consumer home.'

In case supply-chain-specific information is available for one or several transport parameters, they may be applied following the Data Needs Matrix.

The waste of products during distribution and retail shall be included in the modelling.

The default loss rate for distribution is based on expert judgement and considered to be 2.5%. The default waste treatment scenarios per material are displayed in Table 39. The default amount of waste generated in distribution is:
- Potted plants per 12cm pot: PP – 0.397g and biowaste – 7.15g
- Potted plants per 17cm pot: PP – 1.06g and biowaste – 20.75g
- Cut flowers per stem: PP – 2.13g, PE – 0.063g, aluminium – 0.097g, steel – 0.0051g and biowaste – 1.875g.

The waste disposal at the distribution centre and at retail place (6.6) is modelled according to Annex F of the PEF Guidance (EC, 2021), unless specific information is available:
- Cut flowers and potted plants wasted at distribution, during transport and at retail centre are assumed to be 100% composted.
- Waste at distribution centre, during transport and at retail place: all waste is assumed to be 100% recycled.
- Other waste generated at the distribution centre, during transport and at the retailer (except food and product losses) such as repacking/unpacking are assumed to follow the same EoL treatment as for home waste.

- Liquid waste, e.g. from the water used for the cut flowers, is assumed to be poured in the sink and therefore treated in the wastewater treatment plant. European average waste water treatment, i.e. not country-specific, is considered for water losses in distribution, storage, auction and retail.

Outbound transport, from location of cultivation to first destination in Europe, is a mandatory company-specific process.
This may be done with different levels of accuracy, as indicated in the hierarchy below from the most accurate to the least accurate, depending on data availability:
1. Fuel consumption for producer, means of delivery and transport to user.
2. Producer-specific delivery distance and means of transportation.
3. Average fuel consumption per m^3 delivered and means of transport.
4. Average distance from cultivation to final user and transport means.

If actual fuel use data of outbound transport can be collected, because there is a suitable accounting system in place, these data shall be used. Fuel use data shall be connected to secondary data of fuel production and combustion, considering multiple stretches of transport and various transport modalities used. Actual fuel use data shall be collected following Table 31.

Table 31 *Data collection table for fuel use in outbound transport (when fuel data available)*

Activity data	Unit *	Quantity	Technology (e.g. EURO class, barge/bulk/container)	Source and method of measurement
Fuel (type 1)	unit/tonne delivered product (specify unit)			
Fuel (type 2)	unit/tonne delivered product			
Fuel (type 3)	unit/tonne delivered product			
Fuel (type 4)	unit/tonne delivered product			
Refrigerant	Unit/tonne delivered product (in case of cooled transport)			

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

If no supply-chain-specific information is available on outbound transport, the default scenario outlined in Table 32 shall be used.

Table 32 *Default transport scenario*

From	To	Distance (in km)	Secondary dataset to be used
Supplier	Farm	50	Articulated lorry transport, Total weight 20-26 t, mix Euro 0-5 {ROW w/o EU-28+3} | diesel driven, Euro 0-5 mix, cargo | consumption mix, to consumer | 20-26t gross weight/17.3t payload capacity | LCI result
Farm	Auction/trader (i.e. first destination in Europe)		This is a mandatory company-specific data point. If no primary data is available and used, it is not possible to conduct a PEF study compliant with this PEFCR.
Auction/trader (i.e. first destination in Europe)	Retail DC	800	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result
Retail DC	Retail	250	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result
Retail	Consumer	5 (62%)	Passenger car, average {GLO} | technology mix, gasoline and diesel driven, Euro 3-5, passenger car | consumption mix, to consumer | engine size from 1,4l up to >2l | LCI result
		5 round trip (5%)	Articulated lorry transport, Euro 4, Total weight <7.5t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | up to 7.5t gross weight/3.3t payload capacity | LCI result
		0 (33%)	No impact modelled

The product volume (including packaging and empty spaces) shall be used to allocate the transport burdens between the products transported for transport from retail to final client. The allocation factor shall be calculated as the volume of the product transported divided by 0.2 m^3. Default volumes per functional unit are provided which can be used for transport from retail to final client:

- Cut flowers – 0.00081 m^3
- Potted plants – 0.018225 m^3

For products larger than 0.2 m^3 the full car transport impact shall be considered. To simplify the modelling, all other types of consumer transport shall be modelled as above.

The use of packaging material for products being distributed to the customer shall be quantified for secondary (packing the packed products for transport) and tertiary packaging (materials used for transporting, e.g. trolleys) materials. The weight of material used to fulfil the functional unit, shall be collected. If data on secondary and tertiary packaging are not available, default data for the secondary and tertiary packaging materials are provided for cut flowers and for potted plants.

Table 33 *Information about the trolley used at auction*

	unit	amount		Source of data
wt_trolley_steel	kg/trolley	23.62	weight of the steel in a steel trolley	Hortiinnovations.nl (2021)
wt_trolley_wood	kg/trolley	17.2	weight of the wood plates in a steel trolley	Hortiinnovations.nl (2021)

To calculate the amount of materials for the trolly for potted plants the example below can be used. The assumption was made that a trolley is reused (reuse_trolley) 250 times. The amount of plants per trolly is dependent on the type of plant. Phalaenopsis come in pots with a diameter of 12 cm and have a height of 55 cm. This means that for Phalaenopisis 3 levels of 40 plants (ph_plants_trolley = 120 plants) fit on one trolley.

A trolley has the following measurements (length x width x heigth): 135 cm x 56.5 cm x 180 cm.

Table 34 *Example on how to calculate the amount of material per FU for the trolley for potted plants*

Trolley steel	g	0.787	Steel hot dip galvanised {EU-28+EFTA} | steel sheet hot dip galvanisation | single route, at plant | 1.5 mm sheet thickness, 0.02 mm zinc thickness | LCI result	wt_trolley_steel/ph_plants_trolley/reuse_trolley*1000
Wood	g	0.573	Plywood, outdoor use {EU-28+EFTA} | attaching veneer layers | production mix, at plant | 5% moisture | LCI result	wt_trolley_wood/ph_plants_trolley/reuse_trolley*1000

For cut flowers default data are provided per stem (Table 35), for specific conditions. If packed in a box, paper and carton are used, as well as an auction trolley. The following background processes apply:

- Paper bag {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying | production mix, at plant | uncoated Kraft Paper | LCI result
- Carton box {EU+EFTA+UK} | Kraft Pulping Process, pulp pressing and drying, box manufacturing | production mix, at plant | 280 g/m^2, R1=47% | LCI result

If packed in a bucket, a bucket and water is used, as well as an auction trolley, and the following background process apply:

- Plastic tray {EU+EFTA+UK} | raw material production, plastic extrusion | production mix, at plant | From PP, 0.91 g/cm^3, 42.08 g/mol per repeating unit | LCI result
- Tap water {EU+EFTA+UK} | average technology mix | consumption mix, at consumer | Technology mix for supply of drinking water to users | LCI result

For air transport a steel flat container is used and the following background process applies:

- Steel hot dip galvanised {EU-28+EFTA} | steel sheet hot dip galvanisation | single route, at plant | 1.5 mm sheet thickness, 0.02 mm zinc thickness | LCI result

Table 35 *Default data for secondary and tertiary packaging for cut flowers*

Packaging class	Material	Condition	Amount (g/stem)
secondary	Paper (secondary packaging)	IF in box	1.96E+00
secondary	Carton (secondary packaging)	IF in box	1.71E+01
tertiary	Auction Trolley (Aluminium)	IF in box in EU	4.40E-02
tertiary	Auction Trolley (Steel)	IF in box in EU	2.32E-03
tertiary	Steel flat container for air transport	IF air transport	4.44E-02
secondary	Bucket	IF in bucket in EU	7.29E-01
secondary	Water	IF in bucket in EU	4.25E+01
tertiary	Auction Trolley (Aluminium)	IF in bucket in EU	8.07E-02
tertiary	Auction Trolley (Steel)	IF in bucket in EU	4.25E-03

Storage activities consume energy and refrigerant gases. The following default data shall be used, unless better data is available:

- **Energy consumption at distribution centre:** the storage energy consumption is 30 kWh/m^2·year and 360 MJ bought (= burnt in boiler) or 10 Nm^3 natural gas/m^2·year (if using the value per Nm^3, do not forget to consider emissions from combustion and not only production of natural gas). For centres that contain cooling systems, the additional energy use for the chilled or frozen storage is 40 kWh/m^3·year (with an assumed height of 2 m for the fridges and freezers). For centres with both ambient and cooled storage: 20% of the area of the DC is chilled or frozen. Note: the energy for chilled or frozen storage is only the energy to maintain the temperature.
- **Refrigerant gases consumption and leakages at DCs with cooling systems**: gas content in fridges and freezers is 0.29 kg R404A per m^2 (retail OEFSR). A 10% annual leakage is considered (Palandre et al., 2003). The environmental impact of the portion of refrigerant gases remaining in the equipment at end of life is assumed to be negligible, 5% is emitted at end of life and the remaining fraction is treated as hazardous waste.

Only part of the emissions and resources emitted or used at storage systems shall be allocated to the product stored. This allocation shall be based on the space (in m^3) and time (in weeks) occupied by the product stored. For this the total storage capacity of the system shall be known, and the product specific volume and storage time shall be used to calculate the allocation factor (as the ratio between product-specific volume*time and storage capacity volume*time).

In case company-specific data on the product specific volume and storage time is not available, the reference values in Table 36 shall be used.

Table 36 *Reference values for storage for cut flowers and potted plants*

Storage area potted plants per pot	cm^2 144
Storage area cut flowers per stem	cm^2 12.2

The default storage time at the distribution centre is based on expert judgement and considered to be 4 days.

The waste disposal at the distribution centre is modelled as described in 5.10.

6.4 Storage

Storage meant here is all storage between cultivation and auction/trade and prior to storage at retail. Storage at auction/trade is covered under 6.5. Storage at retail is covered under 6.6. The waste of products during storage shall be included in the modelling.

Losses during storage are modelled in the distribution stage (6.3) and retail stage (6.6) and are included in the default loss rates given in that chapter.

6.5 Auction and trade

The auction involves the trading of the product and includes the use of energy and materials required for this life cycle stage. Some products do not go under the actual auction hammer, but do go through the auction facilities, in which case the auction life cycle stage is also applicable.

Most floriculture products are sold via an auction. For a PEF study, the user shall indicate the fraction of product being sold via the auction. The default data for the auction documented in this section can be used. The default data have been derived from Royal FloraHolland for the year 2019 and corrected for the amount of electricity from solar panels in 2021. These data are deemed representative for this life cycle stage. For cut flowers the data per average flower stem is provided. For potted plants the energy and water consumption needs to be calculated by dividing the default use by the amount of potted plants, including pot and plant, per kg.

Table 37 *Default data to be used for the auction and trade*

Resource	**Unit**	**Per kg of product**	**Per average flower stem***
Electricity from Natural Gas	kWh	4.31E-02	4.65E-03
Electricity from Solar Panels	kWh	3.04E-03	3.28E-04
Diesel consumed for fork lift trucks	L	4.71E-05	5.08E-06
Natural gas consumed for heat	m^3	6.02E-03	6.49E-04
Water	m^3	1.75E-06	1.89E-07

* including all packaging (flower + pack = 108 gr).

Losses during storage at auction and trade are modelled in the distribution stage (6.3) and are included in the default loss rates given in that chapter.

6.6 Retail

Activity data for the retail stage can be modelled using default data as provided in the PEF Guidance (EC, 2021). If retailer-specific data is available, the data needs matrix applies (see 5.4).

As per the PEF Guidance (EC, 2021), storage activities consume energy and refrigerant gases. The following default data shall be used, unless site-specific storage data is available:

- Energy consumption at retail: A general energy consumption of 300 kWh/m^2·year for the entire building surface shall be considered as default. For retail specialised in non-food/non-beverage products a 150 kWh/m^2·year for the entire building surface shall be considered. For retail specialised in food/beverage products a 400 kWh/m^2·year for the entire building surface plus energy consumption for chilled and frozen storage of 1,900 kWh/m^2·year and 2700 kWh/m^2·year respectively is to be considered (Palandre et al., 2003).
- An average retail place is assumed to store 2000 m^3 of products (assuming 50% of the 2000 m^2 building is covered by shelves of 2 m high) during 52 weeks, i.e. 104,000 m^3 * weeks/year.
- Default volumes per stem and per pot are provided: Cut flowers 0.00081 m^3, Potted plants 0.018225 m^3.

Table 38 *Retail (capitals indicate those processes expected to be run by the company)*

Name of the process	Unit of measurement (output)	Default (per FU)	Default dataset to be used	Dataset source (node and data stock)	UUID	Default DQR				Most relevant [Y/N]
						P	TiR	GR	TeR	
Electricity use potted plants (12 cm)	Wh	**41.4**	Electricity grid mix 1kV-60kV {EU+EFTA+UK} | technology mix | consumption mix, to consumer | 1kV-60kV | LCI result		34960d4d-af62-43a0-aa76-adc5fcf57246	1	1	1	1	N
Electricity use potted plants (17 cm)	Wh	**83.1**	idem		Idem					
Electricity use cut flowers	kWh	**7.02E-3**	idem		idem					

The waste of products during retail shall be included in the modelling.

The default loss rate for retail is based on expert judgement and considered to be 5%. The waste disposal at the retail place is modelled as described in 5.10. The default waste treatment scenarios per material are displayed in Table 39.
The default amount of waste generated in retail is:

- Potted plants per 12cm pot: PP – 0.7935g and biowaste – 14.3g
- Potted plants per 17cm pot: PP – 2.12g and biowaste – 41.5g
- Cut flowers per stem: PP – 0.07g and biowaste – 2.7g

The default storage time at retail is based on expert judgement and considered to be 3 days.

6.7 Use stage

The electricity and heating used indoor, which maintains a good climate for the plant, is not attributed to the plant. The use phase is highly dependent on user behaviour, climate and other variable circumstances. The executor of the PEF study does not have impact nor insight into consumer stage and it is extremely difficult to construct a scenario to deal with all variables that can be included. In the Representative Product studies, use phase (incl. water use) was not found to be relevant with respect to the total environmental impact. Due to irrelevancy and high variability water use and fertilisation in the use phase are excluded.

Transport from retail to consumer home shall be excluded from the use stage and shall be included in the distribution stage.

6.8 End of life

The end of life stage (EoL) begins when the product in scope and its packaging is discarded by the user and ends when the product is returned to nature as a waste product or enters another product's life cycle (i.e. as a recycled input). In general, it includes the waste of the product in scope, such as the flower/plant waste, and primary packaging. Other waste (different from the product in scope) generated during the manufacturing, distribution, retail, use stage or after use shall be included in the life cycle of the product and modelled at the life cycle stage where it occurs.

The EoL of the horticultural product shall consider all activity data related to the management of the horticultural product as waste, including transport for collection, utility use and emissions related to incineration, landfill, composting or recycling, based on the local waste management system.

The EoL of the pots and used materials of cut flowers and potted plants shall be modelled for EU average scenario for municipal waste. The following fractions shall be used as default for the share between landfill and incineration of municipal waste. As default, incineration shall be considered with energy recovery.

- Landfill of waste curbside collection is by default 55% Incineration of waste curbside collection is by default 45%

The horticultural product itself is partly composted. Average composting of waste curbside collection is by default 40% (link). The remaining horticultural product is treated via the EU average scenario for municipal waste.
The default waste treatment scenarios per material are displayed in Table 39. The default amount of waste generated in EoL is:

- Potted plants per 12cm pot: PP – 15.9g and biowaste – 286g
- Potted plants per 17cm pot: PP – 42.2g and biowaste – 830g
- Cut flowers per stem: PP – 1.48g and biowaste – 54g

Table 39 *End of life waste treatment scenarios per material*

Name of the process	Unit of measurement (output)	Default (per FU)	Default dataset to be used	Dataset source (node and data stock)	UUID	Default DQR				Most relevant [Y/N]
						P	TiR	GR	TeR	
Waste treatment scenarios for potted plants and cut flowers										
Waste scenario PP, PS, PE										
Lorry transport	Kgkm	***30***	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result			*1*	*1*	*1*	*1*	*N*
Incineration	Kg	***0.4573***	Waste incineration of plastics (unspecified) {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | unspecified plastic waste | LCI result			*2*	*1*	*1*	*1*	*N*
Landfill	Kg	***0.5427***	Landfill of plastic waste {EU-28+EFTA} | landfill including leachate treatment and with transport without collection and pre-treatment | production mix (region specific sites), at landfill site | The carbon and water content are respectively of 62%C and 0% Water (in weight %) | LCI result			*2*	*2*	*2*	*2*	*N*
Lorry transport	Kgkm	***30***	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result			*1*	*1*	*1*	*1*	*N*
Avoided virgin material	Kg	***0.543***	Unbleached kraft pulp, softwood {EU+EFTA+UK} | technology mix | production mix, at plant | dry mass 0.89, carbon content, non-fossil 0.494 | LCI result			*1*	*1*	*1*	*1*	*N*
Incineration	Kg	***0.116***	Waste incineration of paper and board {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | paper waste | LCI result			*2*	*1*	*1*	*1*	*N*
Recycling	Kg	***0.597***	Recycling paper and cardboard, waste management, technology mix, at plant {EU+EFTA+UK} | collection, sorting, transport, recycling | production mix, at plant | paper waste, efficiency 90,9% | LCI result			*2*	*2*	*2*	*2*	*N*
Landfill	Kg	***0.138***	Landfill of paper and paperboard waste {EU+EFTA+UK} | LCI result			*2*	*2*	*2*	*2*	*N*
Waste scenario concrete										
Lorry transport	Kgkm	***30***	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result			*1*	*1*	*1*	*1*	*N*

Name of the process	Unit of measurement (output)	Default (per FU)	Default dataset to be used	Dataset source (node and data stock)	UUID	Default DQR				Most relevant [Y/N]
						P	TiR	GR	TeR	
Incineration	Kg	***0.4573***	Waste incineration of inert material {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | inert material waste | LCI result			*2*	*1*	*1*	*1*	*N*
Landfill	Kg	***0.5427***	Landfill of inert (construction materials) {EU+EFTA+UK} | landfill including leachate treatment and with transport without collection and pre-treatment | production mix (region specific sites), at landfill site | LCI result			*2*	*2*	*2*	*2*	*N*
Waste scenario wood										
Lorry transport	Kgkm	***30***	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result			*1*	*1*	*1*	*1*	*N*
Avoided virgin material	Kg	***0.06***	Wood chips, softwood {EU+EFTA+UK} | production mix | at plant | per kg wood | LCI result			*1*	*1*	*1*	*1*	*N*
Incineration	Kg	***0.32***	Waste incineration of untreated wood {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | wood waste | LCI result			*3*	*2*	*2*	*3*	*N*
Landfill	Kg	***0.38***	Landfill of processed wood {EU-28+EFTA} | landfill including leachate treatment and with transport without collection and pre-treatment | production mix (region specific sites), at landfill site | The carbon and water			*3*	*2*	*2*	*3*	*N*
Waste scenario biowaste										
Lorry transport	Kgkm	***30***	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result			*1*	*1*	*1*	*1*	*N*
Incineration	Kg	***0.4573***	Waste incineration of textile, animal and plant based {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | textile waste | LCI result			*2*	*1*	*1*	*1*	*N*
Landfill	Kg	***0.5427***	Landfill of biodegradable waste {EU+EFTA+UK} | LCI result			*2*	*2*	*2*	*2*	*N*
Waste scenario steel										
Lorry transport	Kgkm	***30***	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result			*1*	*1*	*1*	*1*	*N*

Name of the process	Unit of measurement (output)	Default (per FU)	Default dataset to be used	Dataset source (node and data stock)	UUID	Default DQR				Most relevant [Y/N]
						P	TiR	GR	TeR	
Avoided virgin material	Kg	***0.641***	Steel (BF) {GLO} | primary production | single route, at plant | carbon steel | LCI result			*2*	*3*	*3*	*2*	*N*
Incineration	Kg	***0.0686***	Waste incineration of ferro metals {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | ferro metal waste | LCI result			*2*	*1*	*1*	*1*	*N*
Recycling	Kg	***0.68***	Recycling of steel into steel billet {EU+EFTA+UK} | collection, transport, pretreatment, remelting | production mix, at plant | steel waste, efficiency 95% | LCI result			*3*	*3*	*3*	*2*	*N*
Landfill	Kg	***0.0814***	Landfill of inert (steel) {EU+EFTA+UK} | landfill including leachate treatment and with transport without collection and pre-treatment | production mix (region specific sites), at landfill site | LCI result			*2*	*2*	*2*	*2*	*N*
Waste scenario aluminium										
Lorry transport	Kgkm	***30***	Articulated lorry transport, Euro 4, Total weight 28-32t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | 28-32t gross weight/22t payload capacity | LCI result			*1*	*1*	*1*	*1*	*N*
Avoided virgin material	Kg	***0.674***	Aluminium ingot mix (high purity) {EU+EFTA+UK} | primary production, aluminium casting | single route, at plant | 2.7 g/cm^3, >99% Al | LCI result			*2*	*2*	*2*	*2*	*N*
Incineration	Kg	***0.0686***	Waste incineration of inert material {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | inert material waste | LCI result			*2*	*1*	*1*	*1*	*N*
Recycling	Kg	***0.68***	Recycling of aluminium into aluminium ingot - from pre-consumer {EU+EFTA+UK} | collection, transport, pretreatment, remelting | production mix, at plant | aluminium waste, efficiency 99% | LCI result			*3*	*3*	*3*	*2*	*N*
Landfill	Kg	***0.0814***	Landfill of inert (aluminium) {EU+EFTA+UK} | landfill including leachate treatment and with transport without collection and pre-treatment | production mix (region specific sites), at landfill site | LCI result			*2*	*2*	*2*	*2*	*N*

The user of the PEFCR shall report the DQR values (for each criterion + total) for all the datasets used.

The end of life shall be modelled using the Circular Footprint Formula and rules provided in chapter 'End of life modelling' (see chapter 5.10) of this PEFCR and in the PEF method, together with the default parameters listed in Annex C Transition Phase (https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) of the PEF method which have been summarised in Table 50,Table 51 and Table 52 of Appendix 6.

Before selecting the appropriate R_2 value, the user of the PEFCR shall carry out an evaluation for recyclability of the material. The PEF study shall include a statement on the recyclability of the materials/ products. The statement on recyclability shall be provided together with an evaluation for recyclability that includes evidence for the following three criteria (as described by (ISO, 1999)), Section 7.7.4 'Evaluation methodology'):

1. The collection, sorting and delivery systems to transfer the materials from the source to the recycling facility are conveniently available to a reasonable proportion of the purchasers, potential purchasers and users of the product;
2. The recycling facilities are available to accommodate the collected materials;
3. Evidence is available that the product for which recyclability is claimed is being collected and recycled.

Point 1 and 3 can be proven by recycling statistics (country specific) derived from industry associations or national bodies. Approximation to evidence at point 3 can be provided by applying for example the design for recyclability evaluation outlined in EN 13430 Material recycling (Annexes A and B) or other sector-specific recyclability guidelines if available[18].

Following the evaluation for recyclability, the appropriate R_2 values (supply-chain specific or default) shall be used. If one criterion is not fulfilled or the sector-specific recyclability guidelines indicate limited recyclability, an R_2 value of 0% shall be applied.

Company-specific R_2 values (measured at the output of the recycling plant) shall be used, if available. If no company-specific values are available and the criteria for the evaluation of recyclability are fulfilled (see below), application-specific R_2 values shall be used as listed in the table below.

- If an R_2 value is not available for a specific country, the European average shall be used.
- If an R_2 value is not available for a specific application, the R2 values of the material shall be used (e.g. materials average).
- In case no R_2 values are available, R_2 shall be set equal to 0 or new statistics may be generated in order to assign an R_2 value in the specific situation.
- The applied R_2 values shall be subject to the PEF study verification.

The reuse rate determines the quantity of packaging material (per product sold) to be treated at the end of life. The amount of packaging treated at the end of life shall be calculated by dividing the actual weight of the packaging by the number of times this packaging was reused.

The post-consumer waste-related activities of the product studied shall be included and reported in the EoL lifecycle stage. The waste generated in other lifecycle stages is treated per lifecycle stage. All modelled EoL processes shall be connected to the appropriate secondary data for municipal waste management processes, according to Table 39.

Emissions of peat C shall be modelled based on remaining C content of peat after transferring to EoL, in which case full oxidation of remaining C from peat shall be modelled.

[18] E.g. the EPBP design guidelines (http://www.epbp.org/design-methodlines), or Recyclability by design (http://www.recoup.org/).

7 PEF results

7.1 Benchmark values

Benchmarks are provided as characterised results, normalised results and weighted results, as requested in the PEFCR Guidance. One benchmark was calculated for each sub-category: Cut flowers and Potted plants. A standard or point of reference against which any comparison may be made. In the context of PEF, the term ‘benchmark’ refers to the average environmental performance of the representative product sold in the EU market.

As a matter of principle, the TS does not question the merits of a benchmark approach as a tool among others to enable final consumers to assess the environmental footprint of products placed on the market. However, the TS considers that, at the current stage of development of the PEF methodology, a mandatory and stringent benchmark approach would be premature, and its immediate implementation might give an inaccurate perception to consumers and a wrong incentive to the industry, due to the diversity of crops and cropping systems used in the floriculture sector. The results of the supporting studies provide more insight into this diversity. The benchmark values listed below should therefore be seen as an indicative guide only.

7.1.1 Benchmark values for RP cut flowers

Table 40 *Characterised benchmark values for Representative Product Cut flower*

Impact category	Unit	Life cycle excl. use stage	Total life cycle
Acidification	mol H+ eq	2.10E-03	2.10E-03
Climate change	kg CO2 eq	5.57E-01	5.57E-01
Ecotoxicity, freshwater	CTUe	6.06E+00	6.06E+00
Particulate matter	disease inc.	1.91E-08	1.92E-08
Eutrophication, marine	kg N eq	8.60E-04	8.60E-04
Eutrophication, freshwater	kg P eq	1.03E-05	1.03E-05
Eutrophication, terrestrial	mol N eq	8.29E-03	8.29E-03
Human toxicity, cancer	CTUh	1.62E-10	1.63E-10
Human toxicity, non-cancer	CTUh	3.14E-09	3.15E-09
Ionising radiation	kBq U-235 eq	1.18E-02	1.18E-02
Land use	Pt	4.65E+00	4.65E+00
Ozone depletion	kg CFC11 eq	9.12E-10	9.15E-10
Photochemical ozone formation	kg NMVOC eq	1.79E-03	1.79E-03
Resource use, fossils	MJ	7.65E+00	7.65E+00
Resource use, minerals and metals	kg Sb eq	2.69E-07	2.70E-07
Water use	m^3 depriv.	9.33E-02	9.66E-02

Table 41 *Normalised benchmark values for Representative Product Cut flower*

Impact category	Life cycle excl. use stage	Total life cycle
Acidification	3.78E-05	3.78E-05
Climate change	7.37E-05	7.37E-05
Ecotoxicity, freshwater	1.07E-04	1.07E-04
Particulate matter	3.22E-05	3.22E-05
Eutrophication, marine	4.40E-05	4.40E-05
Eutrophication, freshwater	6.41E-06	6.43E-06
Eutrophication, terrestrial	4.69E-05	4.69E-05
Human toxicity, cancer	9.37E-06	9.44E-06
Human toxicity, non-cancer	2.44E-05	2.45E-05
Ionising radiation	2.79E-06	2.79E-06
Land use	5.67E-06	5.67E-06
Ozone depletion	1.74E-08	1.75E-08
Photochemical ozone formation	4.39E-05	4.39E-05
Resource use, fossils	1.18E-04	1.18E-04
Resource use, minerals and metals	4.23E-06	4.24E-06
Water use	8.14E-06	8.43E-06

Table 42 *Weighted benchmark values for Representative Product Cut flower*

Impact category	Unit	Life cycle excl. use stage	Total life cycle
Total	Pt	4,02E-05	4,02E-05
Acidification	Pt	2,34E-06	2,34E-06
Climate change	Pt	1,55E-05	1,55E-05
Ecotoxicity, freshwater	Pt	2,05E-06	2,05E-06
Particulate matter	Pt	2,88E-06	2,88E-06
Eutrophication, marine	Pt	1,30E-06	1,30E-06
Eutrophication, freshwater	Pt	1,79E-07	1,80E-07
Eutrophication, terrestrial	Pt	1,74E-06	1,74E-06
Human toxicity, cancer	Pt	2,00E-07	2,01E-07
Human toxicity, non-cancer	Pt	4,49E-07	4,51E-07
Ionising radiation	Pt	1,40E-07	1,40E-07
Land use	Pt	4,50E-07	4,50E-07
Ozone depletion	Pt	1,10E-09	1,10E-09
Photochemical ozone formation	Pt	2,10E-06	2,10E-06
Resource use, fossils	Pt	9,79E-06	9,79E-06
Resource use, minerals and metals	Pt	3,20E-07	3,20E-07
Water use	Pt	6,92E-07	7,17E-07

7.1.2 Benchmark values for RP potted plants

Table 43 *Characterised benchmark values for Representative Product Potted plants*

Impact category	Unit	Life cycle excl. use stage	Total life cycle
Acidification	mol H+ eq	3.81E-03	3.80E-03
Climate change	kg CO2 eq	2.39E+00	2.39E+00
Ecotoxicity, freshwater	CTUe	8.74E+00	8.74E+00
Particulate matter	disease inc.	4.91E-08	4.90E-08
Eutrophication, marine	kg N eq	1.44E-03	1.44E-03
Eutrophication, freshwater	kg P eq	1.68E-05	1.68E-05
Eutrophication, terrestrial	mol N eq	1.16E-02	1.16E-02
Human toxicity, cancer	CTUh	3.84E-10	3.83E-10
Human toxicity, non-cancer	CTUh	6.22E-09	6.20E-09
Ionising radiation	kBq U-235 eq	2.96E-02	2.94E-02
Land use	Pt	1.82E+01	1.82E+01
Ozone depletion	kg CFC11 eq	2.76E-10	2.75E-10
Photochemical ozone formation	kg NMVOC eq	3.52E-03	3.52E-03
Resource use, fossils	MJ	3.66E+01	3.65E+01
Resource use, minerals and metals	kg Sb eq	6.30E-07	6.29E-07
Water use	m^3 depriv.	0.15E+00	0.15E+00

Table 44 *Normalised benchmark values for Representative Product Potted plants*

Impact category	Life cycle excl. use stage	Total life cycle
Acidification	6.85E-05	6.84E-05
Climate change	3.16E-04	3.16E-04
Ecotoxicity, freshwater	1.54E-04	1.54E-04
Particulate matter	8.24E-05	8.23E-05
Eutrophication, marine	7.36E-05	7.35E-05
Eutrophication, freshwater	1.05E-05	1.05E-05
Eutrophication, terrestrial	6.56E-05	6.55E-05
Human toxicity, cancer	2.22E-05	2.22E-05
Human toxicity, non-cancer	4.83E-05	4.82E-05
Ionising radiation	7.01E-06	6.98E-06
Land use	2.22E-05	2.22E-05
Ozone depletion	5.27E-09	5.26E-09
Photochemical ozone formation	8.62E-05	8.61E-05
Resource use, fossils	5.63E-04	5.62E-04
Resource use, minerals and metals	9.90E-06	9.89E-06
Water use	1.32E-05	1.32E-05

Table 45 Weighted benchmark values for Representative Product Potted plants

Impact category	Unit	Life cycle excl. use stage	Total life cycle
Total	Pt	1,42E-04	1,41E-04
Acidification	Pt	4,25E-06	4,24E-06
Climate change	Pt	6,66E-05	6,65E-05
Ecotoxicity, freshwater	Pt	2,96E-06	2,96E-06
Particulate matter	Pt	7,38E-06	7,38E-06
Eutrophication, marine	Pt	2,18E-06	2,18E-06
Eutrophication, freshwater	Pt	2,93E-07	2,93E-07
Eutrophication, terrestrial	Pt	2,43E-06	2,43E-06
Human toxicity, cancer	Pt	4,74E-07	4,73E-07
Human toxicity, non-cancer	Pt	8,89E-07	8,86E-07
Ionising radiation	Pt	3,51E-07	3,50E-07
Land use	Pt	1,76E-06	1,76E-06
Ozone depletion	Pt	3,32E-10	3,32E-10
Photochemical ozone formation	Pt	4,12E-06	4,12E-06
Resource use, fossils	Pt	4,68E-05	4,67E-05
Resource use, minerals and metals	Pt	7,47E-07	7,47E-07
Water use	Pt	1.12E-06	1.12E-06

7.2 PEF profile

The user of the PEFCR shall calculate the PEF profile of its product in compliance with all requirements included in this PEFCR. The following information shall be included in the PEF report:

- full life cycle inventory;
- characterised results in absolute values, for all impact categories (as a table);
- normalised results in absolute values, for all impact categories (as a table);
- weighted result in absolute values, for all impact categories (as a table);
- the aggregated single overall score in absolute values.

Together with the PEF report, the user of the PEFCR shall develop an aggregated EF compliant dataset of its product in scope. This dataset shall be made available to the European Commission. The disaggregated version may remain confidential.

For comparability reasons non-plant decorative elements, wrapping paper or foil added in retail are not part of this PEFCR. Retailers are advised to make clear that the PEF result is applicable to the horticultural product, excluding these elements.

7.3 Classes of performance

This PEFCR should become an instrument to inform stakeholders – e.g., growers, traders, retailers, and consumers – regarding the product environmental footprint of cut flowers and potted plants. In this context, communicating PEF impact assessment results is not sufficient. Stakeholders need a 'compass' to give them an indication whether the PEF results they obtain are good or bad.

Communication on environmental performance needs to serve two goals:

- Provide relevant stakeholders with useful insights to make more sustainable decisions.
- Provide relevant stakeholders with the possibility to shift to lower classes, which will stimulate them to work on reduction of impact.

In this section, we distinguish two approaches considered to provide such communication means:

- **Short-term solution (interim):** these are not classes of performance but rather additional benchmark results; it can be done with the information available during development of the PEFCR.

- **Long-term solution (recommended):** the optimal way to determine classes of performance but which requires many PEF results to be carried out and their results to be collected first.

The long-term solution is further explained in Appendix 9.

7.3.1 Short-term solution (interim)

Until the long-term solution described in Appendix 9 can be adopted, growers and other stakeholders need some type of reference as a first guidance. Per default, according to the PEF method, one set of benchmark results is available for cut flowers and potted plants each. Additionally, we provide the results of the reference crop products that were used to model the representative products i.e.:

- For cut flowers:
  - Representative rose
  - Representative chrysanthemum
  - Representative tulip
- Potted plants:
  - Representative Dracaena
  - Representative Lavender
  - Representative Phalaenopsis

For the representative crop-specific products above, the single score results per life cycle stage as well the total single score is provided in Appendix 8.

8 Verification

Currently, there are several actors developing and updating their tools to adopt the rules for product environmental footprinting documented in this PEFCR. Tools can ease the effort and significantly reduce the costs involved in calculating PEF results. In this context, it is important to guarantee that tools claiming compliance with this PEFCR meet a list of requirements. Other verification requirements are product/PEF study specific.
'The International EPD® System[19] allows the use of pre-verification of LCA and EPD tools to facilitate the development of EPDs. The application of these tools leads to a simplified verification process since certain elements of the LCA cannot be further influenced by those developing the EPD and verification of these elements is needed only once. Please note that while using a pre-verified tool simplifies the procedure for developing an EPD, it does not replace the need for fulfilling verification requirements (…).'[20] The TS took inspiration from the pre-verified tools for EPD development of the International EPD® Systems and identified the verification and validation requirements that can be met by the integration of a specific PEFCR in a software tool. Having this as a pre-requisite would significantly reduce the efforts and costs for verification of specific studies/assessments.
For this reason, in this section we consider two situations:

- The PEF assessment is **not conducted with a pre-verified tool** (see section 8.1); and
- The PEF assessment is **conducted in a pre-verified tool** (see section 8.2).

The verification of a PEF study/report carried out in compliance with this PEFCR shall be done according to all the general requirements included in section A.8 of the Annex of the PEF guidance on verification and validation of PEF studies, reports and communication vehicles, and the requirements listed below.

The verifier(s) shall verify that the PEF study is conducted in compliance with this PEFCR.

In case policies implementing the PEF method define specific requirements regarding verification and validation of PEF studies, reports and communication vehicles, the requirements in said policies shall prevail. The data checks shall include, but should not be limited to, the activity data used, the selection of secondary sub-processes, the selection of the direct elementary flows and the CFF parameters. For example, if there are 5 processes and each one of them includes 5 activity data, 5 secondary datasets and 10 CFF parameters, then the verifier(s) has to check at least 4 out of 5 processes (70%) and, for each process, (s)he shall check at least 4 activity data (70% of the total amount of activity data), 4 secondary datasets (70% of the total amount of secondary datasets), and 7 CFF parameters (70% of the total amount of CFF parameters), i.e. the 70% of each of data that could be subject to a check.

The verification of the PEF report shall be carried out by randomly checking enough information to provide reasonable assurance that the PEF report fulfils all the conditions listed in section A.8 of Annex of the PEF guidance on verification and validation of PEF studies, reports and communication vehicles, and the requirements listed below.

[19] The International EPD® System is a global programme for Environmental Declarations. Environmental Product Declarations (EPD) present transparent, verified and comparable information about the life-cycle environmental impact of products and services.
[20] https://www.environdec.com/all-about-epds/lca-and-epd-tools

8.1 Verification requirements PEF assessments not conducted in a pre-verified tool

The verifier(s) shall validate the accuracy and reliability of the quantitative information used in the calculation of the study. As this can be highly resource intensive, the following requirements shall be followed:

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 with140. This may also be done indirectly, for example:

   a. Export the EF-compliant datasets from the LCA software used to do the PEF study and run them in Look@LCI141 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.
   b. 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.

5. Cut-off applied (if any) fulfils the requirements at section 4.6.4 of Annex I.
6. All datasets used shall be checked against the data requirements (sections 4.6.3 and 4.6.5. of Annex I).
7. For at least 80% (in number) of the most relevant processes (as defined in section 6.3.3 of Annex I), 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 as specified in section 6.3.3 of Annex I;
8. For at least 30% (in number) of all other processes (corresponding to 20% of the processes as defined in section 6.3.3 of Annex I) 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;
9. 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.

8.2 Verification requirements for PEF assessments conducted in a pre-verified tool

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. A real product or a virtual product or the recalculated RP model in the tool, may be used for the first verification.

The tool verification shall be documented by the verifier in a tool verification report and shall be made available to tool users. Verification of the first EPD developed by a tool shall be part of the pre-verified tool verification.

The verification section of the PEFCR template of the most recent version of the PEF method was taken as a starting point (text highlighted in grey is the text currently included in the PEFCR report template). These were further categorised in: ‘Pre-verification of the tool’ vs ‘Additional verification requirements to be met by specific PEF studies conducted using a pre-verified tool’ (see Table 47).

Table 46 *Verification requirements. Adapted from section B.8 of the PEF method*[21]

Original bullet in chapter B.8 of the PEFCR template	Pre-verification of the tool	Additional verification requirements to be met by specific PEF studies conducted using a pre-verified tool
Bullet 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 with.24F[22] This may also be done indirectly, for example: a) Export the EF-compliant datasets from the LCA software used to do the PEF study and run them in Look@LCI25F[23] 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.	This may also be done indirectly, for example: b) 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.
Bullet 2		cut-off applied (if any) fulfils the requirements at section 4.6.4 of Annex I.
		The verifier shall check if a maximum of 10% of the single overall score is derived from ILCD entry-level compliant datasets.
Bullet 3	all secondary datasets included by default in the tool shall be checked against the data requirements (sections 4.6.3 and 4.6.5. of Annex I).	all other datasets i.e., secondary datasets not originally included in the tool and all newly created datasets, shall be checked against the data requirements (sections 4.6.3 and 4.6.5. of Annex I).
	The tool shall require the user to populate fields related to the list of mandatory-specific data required in this PEFCR.	The verifiers shall validate all related activity data and datasets used to model 100% of the mandatory company-specific data required in this PEFCR (see section XX).
Bullet 4	CFF parameters included in Annex C and added to the model as default values and datasets used to model them shall also be validated.	For 100% of the most relevant processes (as defined in section 6.3.3 of Annex I), the verifier(s) shall validate all related activity data26F[24] and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them that are either not documented or different from those included in Annex C, shall also be validated in the same way.
Bullet 5		For at least 30% (in number) of all other processes (corresponding to 20% of the processes as defined in section 6.3.3 of Annex I) the verifier(s) shall validate all related activity data27F[25] and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them that are either not documented or different from those included in Annex C, shall also be validated in the same way.

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021H2279
[22] Available at: http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml
[23] https://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml
[24] Data validation can be done by data auditors that parties already work with.
[25] Data validation can be done by data auditors that parties already work with.

Original bullet in chapter B.8 of the PEFCR template	Pre-verification of the tool	Additional verification requirements to be met by specific PEF studies conducted using a pre-verified tool
Bullet 6		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.
		In particular, verifier(s) shall verify if the DQR of the process satisfies the minimum DQR as specified in the DNM for the selected processes.
	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.	

Some of the activity data requested – to enter by the user of the PEFCR, and to validate by the verifier – is already collected and audited by standards included in the FSI basket of standards. If the basket of standards can extend the list of data to be audited to cover for all data points required in a PEF study compliant with this PEFCR, then the verifier will not need to additionally validate the activity data entered in the tool because this is part of data already audited.

In the context of the verification requirements to be met by a PEFCR-compliant tool, only the PEF study will be subject of verification and validation. The verification and validation of the PEF report and of the technical content of the communication vehicles are not covered.

Without changes to the pre-verified tool, the verification of the tool shall be valid for a maximum of 5 years, and not exceed the validity of this PEFCR.

Any change to the tool beyond the variation of user-defined input parameters shall result in a new version of the tool (so tool versioning is required). All changes that may affect numeric results of the PEF calculation require a reverification of the tool. The reverification may be limited to the parts of the tool that were modified. Only verified versions of the tool can be applied. Older versions of the tool shall be stored and be accessible, for a minimum of 5 years after their modification.

8.3 Verifier(s)

The independence of the verifiers shall be guaranteed (i.e. they shall fulfil the intentions in the requirements of EN ISO/IEC 17020:2012 regarding a 3rd party verifier, they shall not have conflicts of interests on concerned products and cannot include members of the Technical Secretariat or of the consultants involved in previous part of the work – PEF-RP studies, supporting studies, PEFCR review, etc.).

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Appendix 1 List of EF normalisation and weighting factors

Global normalisation factors are applied within the EF. The normalisation factors as the global impact per person are used in the EF calculations.
Normalisation and weighting factors are available at: http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

Table 47 *Normalisation factors for Environmental Footprint (EF) 3.1*

Impact categories	Unit	NF
Acidification	mol H+ eq./person	5.56E+01
Climate change	kg CO_2 eq./person	7.55E+03
Ecotoxicity, freshwater	CTUe/person	5.67E+04
EF-particulate matter	disease incidences/person	5.95E-04
Eutrophication, freshwater	kg P eq./person	1.61E+00
Eutrophication, marine	kg N eq./person	1.95E+01
Eutrophication, terrestrial	mol N eq./person	1.77E+02
Human toxicity, cancer	CTUh/person	1.73E-05
Human toxicity, non-cancer	CTUh/person	1.29E-04
Ionising radiation	kBq U-235 eq./person	4.22E+03
Land use	pt/person	8.19E+05
Ozone depletion	kg CFC-11 eq./person	5.23E-02
Photochemical ozone formation	kg NMVOC eq./person	4.09E+01
Resource depletion, fossils	MJ/person	6.50E+04
Resource depletion, minerals and metals	kg Sb eq./person	6.36E-02
Water use	m^3 water eq of deprived water/person	1.15E+04

Table 48 *Weighting factors for Environmental Footprint (EF) 3.1*

Impact categories	WF [%]
Acidification	6.20%
Climate change	21.06%
Ecotoxicity, freshwater	1.92%
EF-particulate matter	8.96%
Eutrophication, freshwater	2.80%
Eutrophication, marine	2.96%
Eutrophication, terrestrial	3.71%
Human toxicity, cancer	2.13%
Human toxicity, non-cancer	1.84%
Ionising radiation	5.01%
Land use	7.94%
Ozone depletion	6.31%
Photochemical ozone formation	4.78%
Resource depletion, fossils	8.32%
Resource depletion, minerals and metals	7.55%
Water use	8.51%

Appendix 2 PEF study template

This is the checklist from the PEF study template as provided in part E of the Annex II of the PEF guidance (EC, 2021), including any additional chapters required.

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Appendix 3 Review reports of the PEFCR and PEF-RP(s)

The review reports of the PEFCR and PEF-RPs have been provided to the European Commission, EF-Subgroup and Technical Advisory Board in separate Excel files:

1) Review report_PEFCR_RPs 1st draft (aug 2021)
2) Review report_PEFCR_RPs 2nd draft (june 2023)
3) Review report_PEFCR_RPs final draft (sept 2023)

Appendix 4 Validation statement

Title of the PEF study: Product Environmental Footprint Category Rules for Cut flowers and Potted plants

Version/ date of the PEF study: Draft Final version, September 2023

Commissioner of the PEF study: Technical Secretariat of the FloriPEFCR

User of the PEF method: Zampori L, Pant R., 2019. Suggestions for updating the Product Environmental Footprint (PEF) method. JRC Technical reports, EUR 29682 EN
Technical Secretariat: After final review the transition was made to PEF Guidance version 2021 (EC, 2021), at request of EC.

Team members of the review panel:

- René Corsten/ Jeroen van Buren, Delphy (lead)
- Johannes Lijzen/ Elias de Valk, RIVM
- Judith Brouwer, Milieu Centraal

We, the review panel, declare not to have conflicts of interest with respect to concerned products and any involvement in previous work (PEFCR development, Technical Secretariat membership, consultancy work carried out for the user of the PEF method) during the last three years.

The objective of this verification/ validation is to check whether the study 'Product Environmental Category Rules for Cut flowers and Potted plants' has been carried out in compliance with the most updated version of the PEF method and that the information and data included in the study 'Product Environmental Category Rules for Cut flowers and Potted plants' are reliable, credible and correct.

We, the review panel following the review procedure consider:

- This PEFCR report has been developed in accordance with the latest JRC PEFCR guideline
- Company specific and secondary datasets are appropriate.
- The hotspot analysis is applied and reported upon correctly.
- The identified LCA data and additional environmental information give a description of the significant environmental aspects associated with this product.
- It gives suggestions for improvements and limitations of the PEFCR study itself and the studies on two representative products.
- The comments given on the draft PEFCR-study were seriously worked on leading to changes or explanations. Overall, the Technical Secretariat of the FloriPEFCR has addressed all concerns raised by the review panel with clear and sufficient responses.
- Points of attention and/or limitations of the verification are:
  - We support the addition of the impact category ecotoxicity for cut flowers and potted plants (in addition to the impact categories adding up to 80%), because for many products this will be an important category and the impact might be underestimated because of the lack of data for individual crop protection products.
  - EF background data does not support accurate company-specific modelling of crop protection products (horizontal issue).
  - As is stated in the PEFCR, biodiversity impact cannot yet be taken into account. It is important to improve this in the future.
  - 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. It should be noted the that electronic equipment (capital goods) can be an important costs, additional to the greenhouse itself. The need to include the impact of other capital goods, including electronic installations, should be incorporated in the FloriPEFCR once it is clear that their impact is relevant.

- Considering the fact that the benchmark is now largely based on non-existent, virtual products, the benchmark will improve over time, as more studies will have been performed. Only then, the real range of impacts will become clear. As insights develop, FloriPEFCR should adapt to the emerging benchmark accordingly.
- We understand that it is currently difficult to give a good assessment of the impact of pesticides, but recommend to come to a better assessment of these products as soon as methods have been developed. In our opinion, there is sufficient knowledge available to at least consider part of the impact of pesticides on ecotoxicity. It is important to start collecting this information, and to improve methods over time.

Date of this validation statement: 27th of September 2023

Signatures:

Milieu Centraal	Judith Brouwer
RIVM	Johannes Lijzen / Elias de Valk
Delphy	René Corsten / Jeroen van Buren

Appendix 5 Definition of the models of the Representative products

The models of the representative products are defined in the representative product reports.

Helmes, R., Broekema, R., Ponsioen, T., Vermeulen, P., Gual Rojas, P., Vieira, M., Goglio, P., Snoek, J., Verweij-Novikova, I. (2024). Product Environmental Footprint of the Representative Product for Cut Flowers. Wageningen, Wageningen Economic Research, Report 2024-022.

Broekema, R., Ponsioen, T., Vermeulen, P., Gual Rojas, P., Vieira, M., Goglio, P., Helmes, R., Verweij-Novikova, I. (2024). Product Environmental Footprint of the Representative Product for Potted Plants. Wageningen, Wageningen Economic Research, Report 2024-021.

Appendix 6 Parameters to the circular footprint formula

The parameters to be used by the applicant to implement the CFF are all default values from the PEF Guidance, Annex C. We refer to the Annex C Transition Phase (https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) for the full list of default parameters, where country specific parameters are also available for R2. In this appendix we provide most of the parameters from Annex C, except for the country specific R2 values and any additional information provided in Annex C.

Table 49 *A, R1 and R2 parameters to use in the circular footprint formula*

Category	Material	Application	Parameters			
			A	R1	R2	
					Europe (post consumer)	Comments
Metals	Steel	MATERIAL	0.2	0	0.85	
		building – sheet	0.2	0.18	0.95	
		building – stainless steel parts in copper alloy fittings	0.2	0.63	0	
		appliances – sheet	0.2	0.18	0.90	
		packaging	0.2	0.58	0.80	including bottom ashes
		photovoltaic panel – not specified	0.2	0.37	0	
		photovoltaic panel – mounting structure; electric installation	0.2	0.37	0.95	
		steel hangers and screws	0.2	0.107	0.95	
		building – water supply pipes – stainless steel in PPSU fittings	0.2	0.63	0	
		building – water supply pipes – stainless steel in copper fittings	0.2	0.63	0	
		building – water supply pipes – galvinzed steel – clamps	0.2	0.10	0.95	
		uninterruptible power supply (UPS)	0.2	0	0.93	R2 value is valid for all steel types used in UPS
	Aluminium	MATERIAL	0.2	0	0.85	
		automotive	0.2	0	0.90	R1 shall refer to application-specific values. Material specific values are not valid.
		Building – sheet	0.2	0	0.95	R1 shall refer to application-specific values. Material specific values are not valid.
		Building – e.g. doors, windows	0.2	0	0.90	R1 shall refer to application-specific values. Material specific values are not valid.

Category	Material	Application	Parameters			
			A	R1	R2	
					Europe (post consumer)	Comments
		Appliances – sheet	0.2	0	0.90	R1 shall refer to application-specific values. Material specific values are not valid.
		Other packaging – food cans, closures, trays	0.2	0	0.60	R1 shall refer to application-specific values. Material specific values are not valid.
		Packaging – liquid beverage carton	0.2	0	0.43*	Values in the R2 cells refer to the recycling input rate, and they refer to liquid beverage carton (including paper, plastics and aluminium). The conversion to the recycling output rate (R2) for the three materials is included in the EF -compliant dataset for the recycling of liquid beverage carton.
		Packaging – beverage can body (final product)	0.2	0.55	0.75	
		packaging – beverage can end (final product)	0.2	0.03	0.75	
		photovoltaic panel – not specified	0.2	0.32	0	
		photovoltaic panel – mounting structure; electric installation	0.2	0.32	0.95	
		building – water supply pipes – Pol/Al/Pol pipe	0.2	0	0	R1 shall refer to application-specific values. Material specific values are not valid.
		Building – water supply pipes – copper alloy fittings	0.2	0	0	R1 shall refer to application-specific values. Material specific values are not valid.
		Building – water supply pipes – production waste	0.2	0	1.00	R1 shall refer to application-specific values. Material specific values are not valid.
		Sheet – uniterruptible power supply (UPS)	0.2	0	0.90	R2 value is valid for all steel types used in UPS
	Aluminum alloys	AlMg3 – photovoltaic panel	0.2	0.77	0	
	Copper	MATERIAL	0.2	0	0	
		building – sheet	0.2	0.79	0.95	R1 is calculated using the formula R1,2clean + [(1-R1,2clean)* R1,1 sec cathode. R1sec cathode =0.3; R1,2 clean = 0.7

Category	Material	Application	Parameters			
			A	R1	R2	
					Europe (post consumer)	Comments
		building – pipes	0.2	0.79	0.95	R1 is calculated using the formula R1,2clean + [(1-R1,2clean)* R1,1 sec cathode. R1sec cathode =0.3; R1,2 clean = 0.7
		electronic applications	0.2	0.72	0.80	R1 is calculated using the formula R1,2clean + [(1-R1,2clean)* R1,1 sec cathode. R1sec cathode =0.3; R1,2 clean = 0.6
		electrical applications (cables)	0.2	0.30	0.95	R1 is calculated using the formula R1,2clean + [(1-R1,2clean)* R1,1 sec cathode. R1sec cathode =0.3; R1,2 clean =0
		mechanical applications	0.2	0.79	0.80	R1 is calculated using the formula R1,2clean + [(1-R1,2clean)* R1,1 sec cathode. R1sec cathode =0.3; R1,2 clean = 0.7
		photovoltaic panel – PV modules or not specified	0.2	0.44	0	
		photovoltaic panel – mounting structure; electric installation	0.2	0.44	0.95	
		building – water supply pipes	0.2	0.79	0.95	
		tube/sheet in uniterruptible power supply (UPS)	0.2	0	0.93	R2 value is valid for all steel types used in UPS
	Copper alloys	building – water supply pipes	0.2	0.80	0.95	
		CuZn38 cast – uninterruptible power supply (UPS)	0.2	0	0.93	R2 value is valid for all steel types used in UPS
	Copper telluride	photovoltaic panel	0.2	0	0	
	Lead	MATERIAL	0.2	0	0	
		building – sheet	0.2	1	0.95	
		lead-acid batteries	0.2	0.80	0.99	
	Antimony	MATERIAL	0.2	0	0	
		lead-acid batteries	0.2	0.79	0.99	
	Cadmium	MATERIAL	0.2	0	0	
		photovoltaic panel	0.2	0	0	
	Ferrite	MATERIAL	0.2	0	0	
		uniterruptible power supply (UPS)	0.2	0	0	
Paper	Paper	MATERIAL	0.2	0	0.62	
		graphic paper	0.5	0.21	n.a	

Category	Material	Application	Parameters			
			A	R1	R2	
					Europe (post consumer)	Comments
		packaging – corrugated – pads/box/inserts	0.2	0.88	0.75	
		packaging – paper sack	0.2	0	0.75	
		packaging – paper bag	0.2	0	0.75	
		packaging – carton board/inserts	0.2	0.47	0.75	
		packaging – solid board box	0.2	0.47	0.75	
		packaging – solid board box – bleached	0.2	0.47	0.75	
		packaging – liquid beverage carton	0.2	0	0.43*	Values in the R2 cells refer to the recycling input rate, and they refer to liquid beverage carton (including paper, plastics and aluminium). The conversion to the recycling output rate (R2) for the three materials is included in the EF -compliant dataset for the recycling of liquid beverage carton.
		Tissue paper	0.5	0.25	0	
Plastics	PET	MATERIAL	0.5	0	0	
		packaging – bottle	0.5	0	0.42	
	ABS	MATERIAL	0.5	0	0	
		uninterruptible power supply (UPS)	0.5	0	0.7	
	PE	MATERIAL	0.5	0	0	
		building – water supply pipes	0.5	0	0	
		PE-LD building and construction	0.5	0	0.275	
		PE-HD building and construction	0.5	0	0.225	
		PE-LD uninterruptible power supply (UPS)	0.5	0	0.70	
		PE-HD uninterruptible power supply (UPS)	0.5	0	0.70	
	PMMA	MATERIAL	0.5	0	0	
		uninterruptible power supply (UPS)	0.5	0	0.7	
	PP	MATERIAL	0.5	0	0	
		building and construction	0.5	0	0.183	
		Lead-acid batteries	0.2	0	0.000	
	PS	MATERIAL	0.5	0	0	
		building and construction	0.5	0	0.067	
	EPS	building and construction	0.5	0	0.067	
	PVC	building and construction	0.5	0	0.321	
		uninterruptible power supply (UPS)	0.5	0	0.00	

Category	Material	Application	Parameters			
			A	R1	R2	
					Europe (post consumer)	Comments
	PA polyamide	building – water supply pipes	0.5	0	0	
		uninterruptible power supply (UPS)	0.5	0	0.7	
	PVDF	building – water supply pipes	0.5	0	0	
	PPSU	building – water supply pipes	0.5	0	0	
	Polycarbonate PC	packaging – water	0.5	0	0.29	R2 values refer to Generic plastics 'packaging-generic'
		uninterruptible power supply (UPS)	0.5	0	0.7	
	Generic plastics	packaging – generic	0.5	0	0.29	
		packaging – liquid beverage carton	0.5	0	0.43*	Values in the R2 cells refer to the recycling input rate, and they refer to liquid beverage carton (including paper, plastics and aluminium). The conversion to the recycling output rate (R2) for the three materials is included in the EF -compliant dataset for the recycling of liquid beverage carton.
Glass	Glass	MATERIAL	0.2	0	0	
		packaging – container glass unspecified colour	0.2	0.52	0.66	
		packaging – container glass colourless (flint)	0.2	0.40	0.66	
		packaging – container glass green colour	0.2	0.80	0.66	
		packaging – container glass amber colour	0.2	0.50	0.66	
		Lead-acid batteries	0.2	0	0	
		photovoltaic panel	0.2	0	0	
Wood	Wood	packaging – pallet	0.8	0	0.3	
Batteries	unspecified	cordless power tool (CPT)	see comments box	0	0.45*	Values in the R2 cells refer to the collection rate, and they refer to the whole product. The conversion to the recycling output rate (R2) for the different materials is included in the EF -compliant dataset. A values of the different materials apply.

Category	Material	Application	Parameters			
			A	R1	R2	
					Europe (post consumer)	Comments
		Information and communication technology (ICT)	see comments box	0	0.45*	Values in the R2 cells refer to the collection rate, and they refer to the whole product. The conversion to the recycling output rate (R2) for the different materials is included in the EF -compliant dataset. A values of the different materials apply.
		e-mobility	see comments box	0	0.95*	Values in the R2 cells refer to the collection rate, and they refer to the whole product. The conversion to the recycling output rate (R2) for the different materials is included in the EF -compliant dataset. A values of the different materials apply.
Chemicals	Chromium	leather tanning	0.5	0	0.24	
	Powder coating	uninterruptible power supply (UPS)	0.5	0	0	
	sulphuric acid	Lead-acid batteries	0.5	0	0	
Thermal insulation						
	Wood	pitched roof – rafters	0.8	0	0.38	
	Bitumen	vapour barrier flat roof	0.5	0	0	
	Bitumen	flat roof – fixing	0.5	0	0	
	Glass	vapour barrier flat roof	0.2	0	0	
	PU glue	flat roof – fixing	0.5	0	0	
	PP	pitched roof – sublayer	0.5	0	0	
	Wood	pitched roof – extensions oriented standard board (OSB)	0.8	0	0.38	
	PE	pitched roof – Vapour barrier (+ tape for fixing/closing holes)	0.5	0	0	
	Steel	pitched roof – screws	0.2	0	0.95	
	Cellulose	insulation	0.5	1	0	
	Glass wool	insulation	0.5	0.407	0	
	Stone wool	insulation	0.5	0.25	0	
	Wood fibre	insulation	0.8	0	0	
	Cellular glass	insulation	0.5	0.49	0	
	EPS	insulation	0.5	0.02	0.067	
	PU	insulation – PU insulation	0.5	0	0	
	Aluminium	insulation – Al facing in PU insulation product	0.2	0	0	
	Glass	insulation – glass facing in PU insulation product	0.5	0	0	
	XPS	insulation	0.5	0	0	
Olive oil	olive oil	exhausted olive oil	0.5	0	0.3	
Rubbers	EPDM	building – water supply pipes; copper alloy fitting in pipes	0.5	0	0	

Category	Material	Application	Parameters			
			A	R1	R2	
					Europe (post consumer)	Comments
Textiles		t-shirts	0.8	0	0.11	R2 is defined based on collection rate and the percentage of recycling after sorting.
Resins	Epoxy	uninterruptible power supply (UPS)	0.5	0	0	
Fibers	E-glass fiber	MATERIAL	0.5	0	0	
		uninterruptible power supply (UPS)	0.5	0	0	
	Aramid	MATERIAL	0.5	0	0	
		uninterruptible power supply (UPS)	0.5	0	0	
Fillers	Talc filler	MATERIAL	0.5	0	0	
		uninterruptible power supply (UPS)	0.5	0	0	

Table 50 *R_3 parameters to use in the circular footprint formula on municipal waste by waste operation*

	Landfill Absolute values	Incineration Absolute values	Landfill share	Incineration share
European Union (28 countries)	74561	61634	55%	45%
European Union (27 countries)	73148	61633	54%	46%
Belgium	46	2180	2%	98%
Bulgaria	2167	49	98%	2%
Czech Republic	1815	631	74%	26%
Denmark	65	2270	3%	97%
Germany	109	17559	1%	99%
Estonia	53	214	20%	80%
Ireland	1028	427	71%	29%
Greece	4507	0	100%	0%
Spain	12606	2038	86%	14%
France	9886	11845	36%	64%
Croatia	1413	1	100%	0%
Italy	10914	5970	65%	35%
Cyprus	423	0	100%	0%
Latvia	521	0	100%	0%
Lithuania	798	92	90%	10%
Luxembourg	62	123	34%	66%
Hungary	2415	336	88%	12%
Malta	196	1	99%	1%
Netherlands	131	4305	3%	97%
Austria	199	1716	10%	90%
Poland	5979	766	99%	1%
Portugal	2320	1091	68%	32%
Romania	4248	0	100%	0%
Slovenia	224	4	98%	2%
Slovakia	1152	174	87%	13%
Finland	672	1137	37%	63%
Sweden	28	2192	1%	99%
United Kingdom	10584	6514	62%	38%
Iceland	55	7	89%	11%
Norway	52	1446	3%	97%
Switzerland	0	2798	0%	100%
Montenegro	278	0	100%	0%
Former Yugoslav Republic of Macedonia, the	793		100%	
Serbia	1920	0	100%	0%
Turkey	25267		100%	
Bosnia and Herzegovina	898		100%	
Kosovo (under United Nations Security Council Resolution 1244/99)				

Values in Table 52 are applicable only to packaging materials.

Table 51 *Qsin/Qp and Qsout/Qp values to use in the circular footprint formula*

	Default value (Qsin/Qp)	**Default value (Qsout/Qp)**
Glass	1	1
Steel	1	1
Aluminium	1	1
Other metals	1	1
Paper and cardboard This value shall be used when the recycling process doesn’t consider fibre losses	0.85	0.85
Paper and cardboard This value shall be used when the recycling process considers fibre losses	1	1
PET – SSP recycling	1	1
PET mechanical recycling	0,9	0,9
PS	0.9	0.9
PP	0.9	0.9
HDPE	0.9	0.9
LDPE film	0.75	0.75

Appendix 7 Parameters fertiliser modelling

The main parameters to be used by the applicant regarding fertiliser modelling are described in the corresponding section (6.2.7). For an increased readability of this section, some parameter lists are included in this Appendix.

Table 52 *Per country the weighted average value for the parameter fertiliser ('fert') in the equation for ammonia volatilisation (Formula 1), based on the N-fertiliser use given by FAO*

	Country	***Value fertiliser***		**country**	***Value fertiliser***
1	Afghanistan	0.637	60	Libya	0.476
2	Albania	0.318	61	Lithuania	-0.160
3	Algeria	0.383	62	Macedonia	-0.150
4	Argentina	0.264	63	Malaysia	0.245
5	Armenia	-0.269	64	Mauritius	0.014
6	Australia	0.311	65	Mexico	0.153
7	Austria	-0.461	66	Moldova Republic of	-0.082
8	Azerbaijan	-0.251	67	Morocco	0.028
9	Bangladesh	0.613	68	Myanmar	0.546
10	Belarus	-0.017	69	Nepal	0.574
11	Belgium	-0.771	70	Netherlands	-0.800
12	Bosnia-Herzegovina	-0.399	71	New Zealand	0.579
13	Brazil	0.346	72	Nicaragua	0.030
14	Bulgaria	-0.163	73	Nigeria	0.514
15	Cameroon	0.488	74	Norway	-0.219
16	Canada	0.030	75	Pakistan	0.504
17	Chile	0.451	76	Paraguay	0.210
18	China	0.251	77	Peru	0.407
19	Colombia	0.373	78	Philippines	0.493
20	Costa Rica	0.136	79	Poland	-0.119
21	Croatia	-0.031	80	Portugal	-0.427
22	Cuba	0.310	81	Qatar	0.574
23	Cyprus	0.097	82	Romania	-0.068
24	Czech Rep.	-0.373	83	Russian Federation	-0.209
25	Czechoslovakia (former)	NA	84	Saudi Arabia	0.491
26	CÃ´te d'Ivoire	0.490	85	Senegal	0.014
27	Denmark	-0.639	86	Serbia	0.056
28	Dominican Republic	0.512	87	Slovak Rep.	-0.371
29	Ecuador	0.460	88	Slovenia	-0.651
30	Egypt	0.396	89	South Africa	0.055
31	El Salvador	0.442	90	Spain	-0.102
32	Estonia	-0.301	91	Sri Lanka	0.632
33	Ethiopia	0.416	92	Sudan	0.615
34	Finland	-0.366	93	Sweden	-0.650
35	Former FSU	NA	94	Switzerland	-0.519
36	France	-0.340	95	Syria	0.413
37	Georgia	-0.285	96	Taiwan China	0.436
38	Germany	-0.373	97	Tajikistan	0.266
39	Greece	-0.044	98	Tanzania	0.293
40	Guatemala	0.478	99	Thailand	0.458
41	Hungary	-0.626	100	Trinidad & Tobago	0.635
42	Iceland	-0.097	101	Tunisia	-0.269

	Country	Value fertiliser		country	Value fertiliser
43	India	0.557	102	Turkey	0.065
44	Indonesia	0.559	103	Turkmenistan	0.233
45	Iran	0.578	104	Ukraine	-0.188
46	Iraq	0.606	105	United Kingdom	-0.259
47	Ireland	-0.415	106	United States	-0.385
48	Israel	0.004	107	Uruguay	0.419
49	Italy	0.264	108	Uzbekistan	-0.158
50	Japan	0.151	109	Venezuela	0.472
51	Jordan	-0.099	110	Viet Nam	0.500
52	Kazakhstan	-0.192	111	Yugoslavia (former)	NA
53	Kenya	-0.013	112	Zambia	0.247
54	Korea DPR	0.341	113	Zimbabwe	-0.186
55	Korea Republic	0.210	114	Others Africa	0.155
56	Kuwait	0.593	115	Others East Asia	0.292
57	Kyrgyzstan	-0.303	116	Others Latin America and the Caribbean	0.469
58	Latvia	-0.114	117	Others Oceania	0.042
59	Lebanon	0.192	118	Others West Asia	0.523

Table 53 *Nitrogen content in harvested products*

Type of cultivation	Proxy	N-content harvested (kg N/tonne fresh product)	Source
Bulb cultivation in soil	Onion	2.2	https://edepot.wur.nl/526774, Annex B, page 13
Cut flowers in soil	Flowers	5	https://edepot.wur.nl/30636, Table 3.2, page 22
Soilless cultivation (e.g., potted plants)	Parameter N_{harv} is only applicable in formulas for cultivation in soil.		

Table 54 *Nitrogen in crop residues above and below ground*

Type of cultivation	Proxy	Crop residues above and below ground (kg N/ha)	Source
Bulb cultivation in soil (e.g., tulips)	Onion	60	https://edepot.wur.nl/290558, Appendix III, page III-2 and III-3
Permanent plants in soil (e.g., roses)	Asparagus	33	https://edepot.wur.nl/526774 Annex A, page 12
Other cut flowers in soil	Endive	46	https://edepot.wur.nl/526774, Annex A, page 12
Soilless cultivation (e.g., potted plants)	Crop residues not applicable in cultivation stage: it ends up in the use and end-of-life stage where it is judged negligible.		

Appendix 8 Reference results for classification

Table 55 *Weighted results for potted plants RP Dracaena*

Damage category	Unit	Total	Stage 1. Raw materials RP potted plants	Stage 2. Cultivation RP potted plants	Stage 3. Distribution RP potted plants	Stage 4. Storage RP potted plants	Stage 5. Auction RP potted plants	Stage 6. Retail RP potted plants	Stage 7. Use stage RP potted plants	Stage 8. End-of-life RP potted plants
Total	Pt	**1,30E-04**	3,54E-05	6,32E-05	2,08E-05	1,77E-07	1,55E-06	8,99E-06	x	-6,44E-08
Acidification	Pt	3,86E-06	1,43E-06	1,34E-06	6,32E-07	5,08E-09	2,12E-08	3,11E-07	x	1,22E-07
Climate change	Pt	5,94E-05	1,08E-05	3,32E-05	7,86E-06	8,25E-08	8,11E-07	3,89E-06	x	2,74E-06
Ecotoxicity, freshwater	Pt	2,89E-06	1,45E-06	1,73E-07	1,04E-06	1,74E-09	2,13E-09	1,98E-07	x	2,20E-08
Particulate matter	Pt	6,43E-06	4,23E-06	1,28E-06	7,54E-07	6,56E-09	2,24E-08	4,89E-07	x	-3,47E-07
Eutrophication, marine	Pt	2,14E-06	5,39E-07	7,33E-07	2,63E-07	1,61E-09	1,08E-08	1,37E-07	x	4,57E-07
Eutrophication, freshwater	Pt	4,79E-07	7,11E-08	2,50E-08	2,73E-08	3,81E-11	4,37E-11	2,52E-08	x	3,30E-07
Eutrophication, terrestrial	Pt	2,66E-06	8,07E-07	8,13E-07	4,01E-07	2,41E-09	1,66E-08	1,78E-07	x	4,46E-07
Human toxicity, cancer	Pt	7,19E-07	3,38E-07	1,36E-07	1,87E-07	4,23E-10	6,00E-09	4,31E-08	x	8,95E-09
Human toxicity, non-cancer	Pt	1,26E-06	4,80E-07	1,21E-07	2,14E-07	5,91E-10	1,28E-09	7,99E-08	x	3,68E-07
Ionising radiation	Pt	3,00E-07	3,34E-07	1,57E-07	1,56E-07	5,27E-09	1,76E-09	1,91E-07	x	-5,45E-07
Land use	Pt	1,80E-06	1,41E-06	1,83E-07	1,01E-07	4,42E-10	3,03E-10	1,04E-07	x	-1,92E-09
Ozone depletion	Pt	1,27E-10	1,38E-10	-1,69E-12	1,29E-11	4,45E-13	2,76E-14	2,20E-11	x	-4,42E-11
Photochemical ozone formation	Pt	4,06E-06	1,27E-06	1,27E-06	6,09E-07	3,96E-09	2,75E-08	2,70E-07	x	6,06E-07
Resource use, fossils	Pt	4,17E-05	1,16E-05	2,36E-05	7,66E-06	6,33E-08	6,21E-07	2,86E-06	x	-4,70E-06
Resource use, minerals and metals	Pt	1,05E-06	2,27E-07	6,83E-08	6,48E-07	3,94E-10	1,02E-09	6,31E-08	x	4,32E-08
Water use	Pt	1,35E-06	4,02E-07	1,49E-07	2,51E-07	2,61E-09	4,24E-09	1,56E-07	x	3,87E-07

Table 56 *Weighted results for potted plants RP Lavendula*

Damage category	Unit	Total	Stage 1. Raw materials RP potted plants	Stage 2. Cultivation RP potted plants	Stage 3. Distribution RP potted plants	Stage 4. Storage RP potted plants	Stage 5. Auction RP potted plants	Stage 6. Retail RP potted plants	Stage 7. Use stage RP potted plants	Stage 8. End-of-life RP potted plants
Total	Pt	**5,83E-05**	2,86E-05	5,97E-06	8,02E-06	8,82E-08	5,43E-07	3,59E-06	x	1,15E-05
Acidification	Pt	1,86E-06	1,08E-06	3,16E-07	2,57E-07	2,53E-09	7,45E-09	1,52E-07	x	4,16E-08
Climate change	Pt	2,73E-05	6,99E-06	3,33E-06	2,88E-06	4,11E-08	2,85E-07	1,25E-06	x	1,25E-05
Ecotoxicity, freshwater	Pt	4,21E-06	3,45E-06	2,83E-08	4,77E-07	8,66E-10	7,49E-10	2,37E-07	x	7,39E-09
Particulate matter	Pt	7,15E-06	6,18E-06	2,28E-07	4,08E-07	3,27E-09	7,87E-09	4,41E-07	x	-1,22E-07
Eutrophication, marine	Pt	1,05E-06	4,73E-07	2,34E-07	1,09E-07	8,02E-10	3,79E-09	6,75E-08	x	1,59E-07
Eutrophication, freshwater	Pt	1,95E-07	5,12E-08	7,37E-09	1,09E-08	1,90E-11	1,54E-11	1,04E-08	x	1,15E-07
Eutrophication, terrestrial	Pt	1,18E-06	6,44E-07	1,29E-07	1,63E-07	1,20E-09	5,83E-09	8,12E-08	x	1,55E-07
Human toxicity, cancer	Pt	2,67E-07	1,64E-07	9,18E-09	7,13E-08	2,11E-10	2,11E-09	1,69E-08	x	3,08E-09
Human toxicity, non-cancer	Pt	5,88E-07	3,13E-07	2,22E-08	8,62E-08	2,95E-10	4,48E-10	3,77E-08	x	1,28E-07
Ionising radiation	Pt	1,62E-07	1,77E-07	1,67E-08	6,00E-08	2,62E-09	6,20E-10	9,56E-08	x	-1,91E-07
Land use	Pt	1,62E-06	1,21E-06	2,58E-07	6,42E-08	2,20E-10	1,06E-10	8,81E-08	x	-6,96E-10
Ozone depletion	Pt	6,82E-10	6,36E-10	-3,31E-13	1,99E-11	2,22E-13	9,71E-15	4,18E-11	x	-1,55E-11
Photochemical ozone formation	Pt	1,44E-06	7,80E-07	1,00E-07	2,36E-07	1,97E-09	9,64E-09	1,05E-07	x	2,11E-07
Resource use, fossils	Pt	9,63E-06	6,14E-06	1,24E-06	2,78E-06	3,15E-08	2,18E-07	8,67E-07	x	-1,65E-06
Resource use, minerals and metals	Pt	4,44E-07	9,87E-08	8,36E-09	2,94E-07	1,97E-10	3,59E-10	2,75E-08	x	1,51E-08
Water use	Pt	1,23E-06	8,37E-07	4,04E-08	1,14E-07	1,30E-09	1,49E-09	1,06E-07	x	1,35E-07

Table 57 *Weighted results for potted plants RP Phaleanopsis*

Damage category	Unit	Total	Stage 1. Raw materials RP potted plants	Stage 2. Cultivation RP potted plants	Stage 3. Distribution RP potted plants	Stage 4. Storage RP potted plants	Stage 5. Auction RP potted plants	Stage 6. Retail RP potted plants	Stage 7. Use stage RP potted plants	Stage 8. End-of-life RP potted plants
Total	Pt	**2,39E-04**	2,70E-05	1,86E-04	1,26E-05	8,82E-08	2,53E-07	1,28E-05	x	6,54E-07
Acidification	Pt	7,04E-06	1,38E-06	4,83E-06	3,80E-07	2,53E-09	4,61E-09	3,97E-07	x	4,08E-08
Climate change	Pt	1,13E-04	8,50E-06	9,19E-05	5,19E-06	4,11E-08	1,31E-07	5,93E-06	x	1,64E-06
Ecotoxicity, freshwater	Pt	1,79E-06	8,70E-07	3,82E-07	4,20E-07	8,66E-10	6,36E-10	1,06E-07	x	7,24E-09
Particulate matter	Pt	8,60E-06	4,34E-06	3,44E-06	4,43E-07	3,27E-09	6,01E-09	4,88E-07	x	-1,21E-07
Eutrophication, marine	Pt	3,35E-06	4,77E-07	2,38E-06	1,64E-07	8,02E-10	2,14E-09	1,77E-07	x	1,57E-07
Eutrophication, freshwater	Pt	2,07E-07	6,08E-08	1,13E-08	1,12E-08	1,90E-11	1,31E-11	1,00E-08	x	1,14E-07
Eutrophication, terrestrial	Pt	3,46E-06	7,34E-07	2,16E-06	2,17E-07	1,20E-09	3,28E-09	1,87E-07	x	1,53E-07
Human toxicity, cancer	Pt	4,37E-07	1,67E-07	1,68E-07	7,54E-08	2,11E-10	5,42E-10	2,35E-08	x	3,03E-09
Human toxicity, non-cancer	Pt	8,17E-07	3,63E-07	1,90E-07	9,17E-08	2,95E-10	3,20E-10	4,52E-08	x	1,27E-07
Ionising radiation	Pt	5,94E-07	1,69E-07	4,28E-07	7,04E-08	2,62E-09	5,87E-10	1,12E-07	x	-1,89E-07
Land use	Pt	1,88E-06	1,36E-06	3,58E-07	7,07E-08	2,20E-10	9,28E-11	9,21E-08	x	-6,92E-10
Ozone depletion	Pt	1,89E-10	1,69E-10	1,18E-11	8,24E-12	2,22E-13	9,46E-15	1,44E-11	x	-1,53E-11
Photochemical ozone formation	Pt	6,88E-06	1,05E-06	4,88E-06	3,65E-07	1,97E-09	5,72E-09	3,65E-07	x	2,08E-07
Resource use, fossils	Pt	8,93E-05	7,04E-06	7,44E-05	4,68E-06	3,15E-08	9,80E-08	4,73E-06	x	-1,63E-06
Resource use, minerals and metals	Pt	7,49E-07	2,01E-07	1,91E-07	3,01E-07	1,97E-10	2,36E-10	4,03E-08	x	1,49E-08
Water use	Pt	7,87E-07	3,00E-07	1,72E-07	1,03E-07	1,30E-09	3,05E-10	7,69E-08	x	1,34E-07

__Table 58__ Weighted results for cut flowers RP Chrysanthumum

Damage category	**Unit**	**Total**	**Stage 1 Raw Material Acquisition RP cut flowers**	**Stage 2 Cultivation RP cut flowers**	**Stage 3 Distribution RP cut flowers**	**Stage 4 Storage RP cut flowers**	**Stage 5 Auction RP cut flowers**	**Stage 6 Retail RP cut flowers**	**Stage 7 Use RP cut flowers**	**Stage 8 End of Life RP cut flowers**
Total	Pt	**4,51E-05**	4,20E-06	1,71E-05	2,12E-05	3,46E-09	2,07E-07	2,35E-06	4,10E-08	-6,68E-08
Acidification	Pt	2,54E-06	2,12E-07	8,80E-07	1,31E-06	6,98E-11	2,91E-09	1,30E-07	6,31E-10	8,19E-09
Climate change	Pt	1,83E-05	1,31E-06	7,88E-06	7,96E-06	1,79E-09	9,23E-08	9,49E-07	4,69E-09	8,81E-08
Ecotoxicity, freshwater	Pt	1,58E-06	9,54E-08	3,16E-07	1,08E-06	2,19E-11	9,58E-10	7,93E-08	7,40E-10	1,55E-09
Particulate matter	Pt	2,94E-06	9,12E-07	7,53E-07	1,14E-06	8,18E-11	3,80E-09	1,54E-07	1,49E-09	-1,96E-08
Eutrophication, marine	Pt	1,23E-06	7,02E-08	2,97E-07	7,73E-07	3,13E-11	1,56E-09	6,10E-08	3,98E-10	2,76E-08
Eutrophication, freshwater	Pt	2,27E-07	4,47E-08	1,17E-07	3,40E-08	1,53E-12	5,50E-10	1,09E-08	5,77E-10	1,97E-08
Eutrophication, terrestrial	Pt	1,75E-06	1,20E-07	4,32E-07	1,08E-06	4,62E-11	2,06E-09	8,69E-08	2,57E-10	2,70E-08
Human toxicity, cancer	Pt	2,78E-07	3,06E-08	1,38E-07	9,15E-08	9,41E-12	2,03E-09	1,37E-08	1,36E-09	5,75E-10
Human toxicity, non-cancer	Pt	5,01E-07	1,27E-07	1,56E-07	1,67E-07	1,11E-11	2,03E-09	2,51E-08	2,00E-09	2,20E-08
Ionising radiation	Pt	1,71E-07	2,70E-08	8,45E-08	6,86E-08	3,05E-11	4,39E-10	2,23E-08	2,65E-10	-3,17E-08
Land use	Pt	7,96E-07	1,54E-07	9,60E-08	5,07E-07	1,16E-11	-7,42E-12	3,91E-08	-3,77E-11	-1,00E-10
Ozone depletion	Pt	9,28E-10	7,42E-10	4,25E-12	1,33E-10	9,80E-16	3,14E-12	4,53E-11	3,32E-12	-2,57E-12
Photochemical ozone formation	Pt	2,25E-06	1,37E-07	4,30E-07	1,53E-06	7,32E-11	3,59E-09	1,13E-07	6,32E-10	3,69E-08
Resource use, fossils	Pt	1,16E-05	6,82E-07	5,41E-06	5,05E-06	1,25E-09	6,97E-08	6,13E-07	2,54E-09	-2,72E-07
Resource use, minerals and metals	Pt	3,49E-07	2,01E-07	4,24E-08	8,39E-08	6,09E-12	8,13E-10	1,74E-08	6,58E-10	2,57E-09
Water use	Pt	6,48E-07	8,11E-08	9,48E-08	3,64E-07	2,49E-11	2,39E-08	3,68E-08	2,48E-08	2,28E-08

Table 59 *Weighted results for cut flowers RP Rose*

Damage category	Unit	Total	Stage 1 Raw Material Acquisition RP cut flowers	Stage 2 Cultivation RP cut flowers	Stage 3 Distribution RP cut flowers	Stage 4 Storage RP cut flowers	Stage 5 Auction RP cut flowers	Stage 6 Retail RP cut flowers	Stage 7 Use RP cut flowers	Stage 8 End of Life RP cut flowers
Total	Pt	**4,57E-05**	3,31E-06	1,79E-05	2,19E-05	3,46E-09	2,07E-07	2,38E-06	4,10E-08	-6,68E-08
Acidification	Pt	2,85E-06	1,79E-07	1,08E-06	1,44E-06	6,98E-11	2,91E-09	1,45E-07	6,31E-10	8,19E-09
Climate change	Pt	1,72E-05	7,86E-07	6,70E-06	8,66E-06	1,79E-09	9,23E-08	8,99E-07	4,69E-09	8,81E-08
Ecotoxicity, freshwater	Pt	2,35E-06	1,62E-07	8,26E-07	1,24E-06	2,19E-11	9,58E-10	1,16E-07	7,40E-10	1,55E-09
Particulate matter	Pt	3,02E-06	7,17E-07	1,24E-06	9,21E-07	8,18E-11	3,80E-09	1,57E-07	1,49E-09	-1,96E-08
Eutrophication, marine	Pt	1,77E-06	6,28E-08	7,71E-07	8,25E-07	3,13E-11	1,56E-09	8,69E-08	3,98E-10	2,76E-08
Eutrophication, freshwater	Pt	1,75E-07	3,01E-08	9,94E-08	1,63E-08	1,53E-12	5,50E-10	8,41E-09	5,77E-10	1,97E-08
Eutrophication, terrestrial	Pt	2,23E-06	1,00E-07	7,66E-07	1,22E-06	4,62E-11	2,06E-09	1,10E-07	2,57E-10	2,70E-08
Human toxicity, cancer	Pt	1,87E-07	4,81E-08	3,01E-08	9,59E-08	9,41E-12	2,03E-09	9,43E-09	1,36E-09	5,75E-10
Human toxicity, non-cancer	Pt	4,07E-07	9,12E-08	9,94E-08	1,70E-07	1,11E-11	2,03E-09	2,06E-08	2,00E-09	2,20E-08
Ionising radiation	Pt	1,85E-07	1,34E-08	1,24E-07	5,55E-08	3,05E-11	4,39E-10	2,29E-08	2,65E-10	-3,17E-08
Land use	Pt	2,94E-07	2,46E-07	1,27E-07	-9,41E-08	1,16E-11	-7,42E-12	1,52E-08	-3,77E-11	-1,00E-10
Ozone depletion	Pt	1,73E-09	1,51E-09	5,05E-12	1,27E-10	9,80E-16	3,14E-12	8,36E-11	3,32E-12	-2,57E-12
Photochemical ozone formation	Pt	2,51E-06	1,04E-07	5,39E-07	1,70E-06	7,32E-11	3,59E-09	1,25E-07	6,32E-10	3,69E-08
Resource use, fossils	Pt	1,10E-05	4,59E-07	4,75E-06	5,40E-06	1,25E-09	6,97E-08	5,86E-07	2,54E-09	-2,72E-07
Resource use, minerals and metals	Pt	3,33E-07	2,08E-07	2,65E-08	7,78E-08	6,09E-12	8,13E-10	1,67E-08	6,58E-10	2,57E-09
Water use	Pt	1,12E-06	1,01E-07	7,50E-07	1,43E-07	2,49E-11	2,39E-08	5,94E-08	2,48E-08	2,28E-08

Table 60 *Weighted results for cut flowers RP Tulip*

Damage category	Unit	Total	Stage 1 Raw Material Acquisition RP cut flowers	Stage 2 Cultivation RP cut flowers	Stage 3 Distributio n RP cut flowers	Stage 4 Storage RP cut flowers	Stage 5 Auction RP cut flowers	Stage 6 Retail RP cut flowers	Stage 7 Use RP cut flowers	Stage 8 End of Life RP cut flowers
Total	Pt	**3,00E-05**	2,54E-05	1,45E-06	1,32E-06	3,46E-09	2,07E-07	1,63E-06	4,10E-08	-6,68E-08
Acidification	Pt	1,65E-06	1,42E-06	5,24E-08	8,38E-08	6,98E-11	2,91E-09	8,81E-08	6,31E-10	8,19E-09
Climate change	Pt	1,11E-05	8,70E-06	1,14E-06	4,84E-07	1,79E-09	9,23E-08	6,07E-07	4,69E-09	8,81E-08
Ecotoxicity, freshwater	Pt	2,24E-06	2,04E-06	4,18E-09	7,50E-08	2,19E-11	9,58E-10	1,11E-07	7,40E-10	1,55E-09
Particulate matter	Pt	2,70E-06	2,43E-06	3,93E-08	1,05E-07	8,18E-11	3,80E-09	1,42E-07	1,49E-09	-1,96E-08
Eutrophication, marine	Pt	9,07E-07	7,79E-07	5,72E-09	4,68E-08	3,13E-11	1,56E-09	4,56E-08	3,98E-10	2,76E-08
Eutrophication, freshwater	Pt	1,38E-07	1,06E-07	2,86E-10	3,82E-09	1,53E-12	5,50E-10	6,65E-09	5,77E-10	1,97E-08
Eutrophication, terrestrial	Pt	1,25E-06	1,07E-06	1,94E-08	6,92E-08	4,62E-11	2,06E-09	6,30E-08	2,57E-10	2,70E-08
Human toxicity, cancer	Pt	1,39E-07	1,20E-07	1,36E-09	5,95E-09	9,41E-12	2,03E-09	7,10E-09	1,36E-09	5,75E-10
Human toxicity, non-cancer	Pt	4,46E-07	3,78E-07	1,91E-09	1,73E-08	1,11E-11	2,03E-09	2,25E-08	2,00E-09	2,20E-08
Ionising radiation	Pt	6,39E-08	7,02E-08	5,35E-09	2,18E-09	3,05E-11	4,39E-10	1,72E-08	2,65E-10	-3,17E-08
Land use	Pt	2,62E-07	2,29E-07	9,59E-09	1,06E-08	1,16E-11	-7,42E-12	1,37E-08	-3,77E-11	-1,00E-10
Ozone depletion	Pt	6,51E-10	5,92E-10	1,87E-13	2,30E-11	9,80E-16	3,14E-12	3,21E-11	3,32E-12	-2,57E-12
Photochemical ozone formation	Pt	1,55E-06	1,34E-06	9,93E-09	7,69E-08	7,32E-11	3,59E-09	7,90E-08	6,32E-10	3,69E-08
Resource use, fossils	Pt	6,85E-06	6,20E-06	1,58E-07	3,04E-07	1,25E-09	6,97E-08	3,88E-07	2,54E-09	-2,72E-07
Resource use, minerals and metals	Pt	2,80E-07	2,41E-07	9,79E-10	2,00E-08	6,09E-12	8,13E-10	1,41E-08	6,58E-10	2,57E-09
Water use	Pt	3,81E-07	2,67E-07	4,58E-09	1,47E-08	2,49E-11	2,39E-08	2,41E-08	2,48E-08	2,28E-08

Appendix 9 Long-term classification solution (recommended)

The example to determine classes of performance provided in section A.5.2. of the Annex 1-2 of the Commission Recommendation (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organizations method was considered but it was considered inadequate for floriculture products. There is wide variability of crops and production techniques used. It is likely that a certain crop type would have large PEF impact assessment regardless of the sustainable measures a producer would take, simply because of the characteristics on the crop and what it needs to grow. We believe that the system used for classification has to encourage producers to improve their footprint.
A communication scheme is best developed when more product-specific PEF studies have been performed (a growth model). That way, data of a specific fraction of the market can be used to build it. Therefore, defining classes of performance requires the collection of PEF results on a large amount of floriculture products which considers the wide variability it has. For this reason, the definition of classes of performance shall cover as a minimum PEF results of real floriculture products covering the following requirements, per sub-category:

- **Coverage of minimum 80% of the crops (on basis of market share):** Sorting from the largest to the shortest market share, 80% of the cumulative market share of cut flowers (22 in total) and 50% of the cumulative market share of potted plants (26 in total) is to be covered[26];
- **3 per continent:** regions where the crop is grown so it accounts for the climate and distance from EU + EFTA + UK (destination market in scope of the PEFCR);
- **1 per production systems**: the cultivation techniques e.g., open field, greenhouse, hydroponics, etc. have different activities that affect the environmental performance of growing a crop; and
- combinations of all of the above, whenever applicable[27].

The data sample required to define classes of performance would include PEF results for crops that are sold in the EU market:

- 22 cut flower crops x 3 x 6 continents x 4 production systems i.e., a maximum of 1584 PEF results for cut flowers; and
- 26 potted plant crops x 3 x 6 continents x 4 production systems i.e., a maximum of 1872 PEF results for potted plants.

Apart from that, PEF results shall indicate the stem and pot size of the product for which the assessment is done.
Following the example of rose (Rosa): it is currently produced in Africa and in South America in 3 production systems (open field, shade nets, and multi-tunnel greenhouses), and in Europe in all 4 production systems. So, that becomes a total of 30 (= 3x2x3 + 3x1x4) PEF results for roses.

[26] Market share of Royal FloraHolland is considered representative so this is used to identify the crops to cover, based on those with the largest revenue.
[27] Not all combinations are possible e.g. there will be crops that cannot grow in a polar climate so this needs to be considered.

Table 61 *Aspects for data sample required to define classes of performance*

Subcategory	Crop	Continent20F[28]	*Production systems*
Cut flowers	Rosa	Asia	Open field
	Chrysanthemum Spray	Africa	Shade nets
	Tulipa	North America	(Plastic) multi-tunnel greenhouses
	Lilium	South America	(Glass) Venlo greenhouses
	Eustoma russellianum	Europe	
	Gerbera	Australia	
	Chrysanthemum Disbudded		
	Hydrangea		
	Paeonia		
	Dianthus		
	Gypsophila		
	Freesia		
	Cymbidium		
	Alstroemeria		
	Limonium		
	Hippeastrum		
	Hypericum		
	Chamelaucium		
	Eucalyptus		
	Helianthus		
	Delphinium		
	Zantedeschia		
Potted plants	Phalaenopsis		
	Anthurium		
	Kalanchoe		
	Rosa		
	Ficus		
	Chrysanthemum		
	Dracaena		
	Spathiphyllum		
	Hydrangea		
	Zantedeschia		
	Helleborus		
	Calathea		
	Hydrangea		
	Hyacinthus		
	Zamioculcas		
	Monstera		
	Dendrobium		
	Sansevieria		
	Lavandula		
	Hippeastrum		
	Dianthus		
	Cyclamen		
	Euphorbia pulcherrima		
	Hedera		
	Dypsis		
	Mandevilla		

[28] Antarctica is not considered as a viable region for growing crops. Hence, this is not considered.

This classification system will encompass two separate classification schemes, one for cut flowers and one for potted plants. The final classification schemes may also require more than five classes to provide producers with the right perspective for improvement. However, this can only be known once sufficient product-specific PEF impact assessment results have been gathered (according to the requirements set above) and a specific analysis has been done for the data sample.
Various attempts have been made to define appropriate classes of performance that fit the overarching goals set above. The final choice depends on an analysis of what suits best the sample of PEF impact results. However, at least the following elements should be considered:

- the mathematical distribution; and
- amount of classes.

Existing work indicates that, for similar data samples, 8 classes and using either an exponential approach or an equal amount of products per class are the most suitable. At least these are to be explored in the future for floriculture products.
The classification scheme must store data to allow for classification both for single score results as well as for impact assessment results for each most relevant impact category.
There must be a framework in place to ensure that such data will be collected.

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