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Roline Broekema,[1]* Tommie Ponsioen,[2] Peter Vermeulen,[3] Paulina Gual Rojas,[4] Marisa Vieira,[5] Pietro Goglio,[1] Roel Helmes,[1] Irina Verweij-Novikova[1]

1 Wageningen Economic Research

2 FootPrinting

3 Peter Vermeulen research coaching & consulting

4 Blonk Consultants

5 PRé Sustainability

* corresponding author, contact e-mail: roline.broekema@wur.nl

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Disclaimer

This it is not a stand-alone document but should be read in parallel to the report 'Product Environmental Footprint Category Rules for Cut flowers and Potted plants', Wageningen, Report 2024-023, Wageningen Economic Research (Broekema et al., 2024). The purpose of this representative product study was to identify the most relevant impact categories, life cycle stages, processes and direct elementary flows and also to identify the data needs, all feeding into the methodology development. The study is conducted according to the most recent version of the Product Environmental Footprint Guidance – PEF Guidance (EC, 2021). The study reports on the data quality as required by the PEF Guidance. The study makes use of PEF compliant background data according to the EF 3.1 methodology for transport, energy, packaging and end-of-life. Full update to the EF 3.1 data has been made in this version.

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

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P.O. Box 29703, 2502 LS The Hague, The Netherlands, T +31 (0)70 335 83 30,
E communications.ssg@wur.nl, http://www.wur.eu/economic-research. Wageningen Economic Research is part of Wageningen University & Research.

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Contents

Preface

This document is offered to professionals who would like to learn more about the state of the art regarding the environmental footprint of cut flowers. The document has been prepared by a group of international experts in the framework of the PEFCR - Product Environmental Footprint Category Rules – development for Cut Flowers and Potted Plants (FloriPEFCR). The development of the methodology strictly follows the most recent Guidance for developing Product Environmental Category Rules (PEFCR) published by the European Commission and governed within the European Environmental Footprint Transition Phase. This rather technical document –Product Environmental Footprint Representative Product (PEF-RP) – is prepared with the following aims:

1. Identifying the most relevant impact categories;
2. Identifying the most relevant life cycle stages, processes and elementary flows;
3. Identifying data needs, data collection activities and data quality requirements; and
4. Helping to develop the FloriPEFCR.

This PEF-RP report follows the PEF-study template as provided in Annex II of (EC, 2021) and includes the characterised, normalised and weighted results. Being based on secondary data, there are no confidentiality issues. The report is accompanied by data tables in Excel that report inputs from three representative species of indoor flowering, indoor leaf and outdoor potted plants ('Life cycle inventory RP potted plants') and outputs ('Results RP potted plants') of the model.

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 thank consortium members Glastuinbouw Nederland, ABN AMRO Bank N.V., Rabobank, the Dutch Ministry of Agriculture and Nature and Food Quality for their contributions.

A word of thanks goes to several professionals that helped the team in reviewing and discussing the interim versions of this document. We would like to thank all the participants to the 1st and the 2nd Open Public Consultations who took the time to read and comment previous versions of this document). Also, we especially would like to thank the growers for providing sector-specific data and for reflecting on the results of the representative product studies that have been contributing to the methodology development, among which MPS and Royal FloraHolland.

The report was finalised after the 2nd Open Public Consultation that took place in June 2023. Stay tuned to the developments via the project website (link).

Prof.dr.ir. J.G.A.J. (Jack) van der Vorst
General Director Social Sciences Group (SSG)
Wageningen University & Research

Drs. Ing. A. (Albert) Haasnoot
Chair of the Technical Secretariat of the FloriPEFCR
Royal FloraHolland

Summary

Goal

This representative product study (RP study) was done in the context of the development of a methodology for calculating the environmental footprints of cut flowers and potted plants, the Product Environmental Category Rules for Cut Flowers and Potted Plants (FloriPEFCR, see Broekema et al., 2024). This RP study on potted plants is one of the two studies on representative products that have been selected based on a wide and economically relevant variety of applied technologies and origins of productions. The other study is on cut flowers (Helmes et al., 2024).

The goals of the study were to:

- Identify the most relevant impact categories, life cycle stages, processes and direct elementary flows;
- Calculate the benchmark results;
- Identify the secondary data needs; and
- Develop the ‘skeleton’ for all product-specific models.

Scope

The functional unit is to provide decoration, measured by 1 pot (inner pot only), for at least until the plant stays in the condition that fulfils its function with the minimum efforts from the user, with a quality standard according to the specifications of the producer or the retailer, and in accordance with the specific system boundary defined.

The following assumptions were made:

- Phalaenopsis cultivation in 12 cm Ø pots in the Netherlands is representative for indoor flowering pot plants sold in the EU;
- Dracaena cultivation in 17 cm Ø pots in the Netherlands is representative for indoor non-flowering indoor pot plants sold in the EU;
- Lavender cultivation in 12 cm Ø pots in the Netherlands is representative for outdoor pot plants sold in the EU;
- equal share of the three types of pot plants per pot is representative for their market shares, because no market data is available;
- a number of data and modelling assumptions on the lifetime of capital goods and the potted plants products, storage time and product losses during the different life cycle stages, emissions calculations; and
- use of proxy data.

Limitations: While the latest PEF Method (EC, 2021) stimulates developing the Category Rules for a virtual product category (calculated based on average European market sales-weighted characteristics of all existing technologies/materials covered by the product category or sub-category), the FloriPEFCR followed an approach using an equal share average of a number of products to represent the virtual product, which were selected based on their importance and representativeness of different production technologies/circumstances, and applications. The number of species, cultivation locations, and pot sizes is limited and the equal share approach deviates from an approach using market shares of each species, cultivation location and pot size. These limitations have been considered when determining which supporting studies need to be done The granularity of the agricultural emissions for greenhouse cultures and the country-specific characterisation of certain emissions and land use is also recognised as a limitation.

Despite the limited variety in cultivation practices and countries of origin, the absolute results will serve as a benchmark, being the nearest approximation of a reference impact. The general conclusions on the hotspots and the resulting data quality requirements will apply to the variety of potted plants as sold in Europe. The results have been used to see where potential hotspots are by looking at the most relevant impact categories, life cycle stages, processes and elementary flows.

The RP study is NOT intended to make statements about the product group impacts as such, nor is it intended to be used in the context of comparison or for comparative assertions to be disclosed to the public. The results can be used to see where potential hotspots are by looking at the most relevant impact categories, life cycle stages, processes and elementary flows.

System boundaries

The life cycle stages as defined in the FloriPEFCR are applied to define the system boundaries. In summary, the stages include Raw Material acquisition including plant starting material and capital goods, cultivation including all direct emissions and energy consumption, distribution including the secondary and tertiary packaging, storage, auction/trade, retail, use stage and end-of-life.

Results

The characterised, normalised, and normalised and weighted results are shown in **Table 1**.

Table 1 *Characterised, normalised, and normalised and weighted results of the virtual representative product per pot*

Damage category	Unit	Total (unit per pot)	Normalised result (Person-year per pot)	Normalised and weighted result (μPt per pot)
Acidification	mol H+ eq	3.80E-03	6.84E-05	4.2
Climate change	kg CO_2 eq	2.39	3.16E-04	66.5
Ecotoxicity, freshwater	CTUe	8.74	1.54E-04	3.0
Particulate matter	disease inc.	4.90E-08	8.23E-05	7.4
Eutrophication, marine	kg N eq	1.44E-03	7.35E-05	2.2
Eutrophication, freshwater	kg P eq	1.68E-05	1.05E-05	0.3
Eutrophication, terrestrial	mol N eq	0.0116	6.55E-05	2.4
Human toxicity, cancer	CTUh	3.83E-10	2.22E-05	0.5
Human toxicity, non-cancer	CTUh	6.20E-09	4.82E-05	0.9
Ionising radiation	kBq U-235 eq	0.0294	6.98E-06	0.3
Land use	Pt	18.2	2.22E-05	1.8
Ozone depletion	kg CFC11 eq	2.75E-10	5.26E-09	0.0
Photochemical ozone formation	kg NMVOC eq	3.52E-03	8.61E-05	4.1
Resource use, fossils	MJ	36.5	5.62E-04	46.7
Resource use, minerals and metals	kg Sb eq	6.29E-07	9.89E-06	0.7
Water use	m^3 depriv.	0.1512	1.32E-05	1.1

The hotspot analysis resulted in the following:

- The most important impact categories are:
  1. climate change
  2. resource use, fossil
  3. particulate matter
- The most relevant life cycle stages identified for the RP for potted plants are:
  - Stage 1. Raw materials (climate change, resource use; fossil and particulate matter)
  - Stage 2. Cultivation (climate change, resource use; fossil)
  - Stage 8. End-of-life (climate change)
- There were 11 most relevant processes identified for climate change, 7 for fossil resource use and 15 for particulate matter. Of these most relevant processes, the ones related to natural gas production and combustion are highly contributing, as well as materials for the greenhouse, landfill of biodegradable waste and electricity use.
- There is 1 most relevant elementary flow identified: carbon dioxide, fossil.

Data quality

The DQR of the PEF study is 1.55 out of 5. The most contributing processes have a DQR rating between 1 and 2.5 (heat, natural gas, plastics, greenhouse, and landfill of biowaste).

Conclusions

The goals of the study have been achieved: The most relevant impact categories, life cycle stages and processes have been identified. These inform the data requirements for the FloriPEFCR. The results serve as a nearest approximation of a reference impact, despite the large variety in cultivation practices and countries of origin. The DQRs of datasets from different sources (both EF data 3.1 and the required additional sources) show that the data quality level is sufficient and the study is expected to be fairly robust. The major recommendations are to improve secondary data by expanding the EF 3.1 dataset and to improve representativeness for the benchmark by broadening the number of plant species and countries of cultivation.

Abbreviations

Abbreviation	Explanation
CF	Characterisation factor
CHP	Combined Heat and Power
CPA	Classification of Products by Activity
EF	Environmental Footprint
EFTA	European Free Trade Association
EU	European Union
FU	Functional Unit
GHG	Greenhouse Gas
GR	Geographical Representativeness
ha	hectare
HDPE	high density polyethylene
FloriPEFCR	Floriculture Product Environmental Footprint Category Rules
HHV	higher heating value
ILCD	International Reference Life Cycle Data System
K	potassium
kg	kilogram
km	kilometre
kWh	kilowatt-hour
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LDPE	low-density polyethylene
LHV	lower heating value
LU	land use
m	metre
m^2	square metre
m^3	cubic metre
MJ	megajoule
N	nitrogen
P	phosphorus
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
Qty	quantity
TS	Technical Secretariat

Definitions

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

Activity data – This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). Examples of activity data include quantity of kilowatt-hours of electricity used, quantity of nitrogen used, output of a process (e.g. waste), number of hours the equipment is operated, distance travelled, floor area of a building, etc.

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

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.

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.

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 to 'primary data'. To determine the level of representativeness a sampling procedure can be applied.

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 or the comparison of one or more products against the benchmark, based on the results of a PEF study and supporting PEFCRs.

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

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

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

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

Elementary flow – 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.

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.

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

Growing media – 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.

Floriculture Product Environmental Footprint Category Rules (FloriPEFCR) – Life-cycle-based rules that complement general methodological guidance for PEF studies by providing further specification at the level of floriculture product categories: cut flowers and potted plants.

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.

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

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

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

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

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. An LCI dataset could be a unit process dataset, partially aggregated or an aggregated dataset.

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

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

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.

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 14040:2006).

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).

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.

Practitioner of study – Individual, organisation or group of organisations that performs the study in accordance with the FloriPEFCR.

Primary data[1] – This term refers to data from specific processes within the supply-chain of the company applying the study. Such data may take the form of activity data, or foreground elementary flows. 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 company applying the FloriPEFCR. In this Guidance, primary data is synonym of ‘company-specific data’ or ‘supply-chain specific data’.

Product category – Group of products (or services) that can fulfil equivalent functions (ISO 14025:2006).

Product Category Rules (PCRs) – Set of specific rules, requirements and guidelines for developing Type III environmental declarations for one or more product categories (ISO 14025:2006).

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.

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

Representative Product (RP) Study – A preliminary study carried out on the representative product(s) and intended to identify the most relevant life cycle stages, processes, elementary flows, impact categories and data quality needs to derive the preliminary indication about the definition of the benchmark for the product category/sub-categories in scope, and any other major requirement to be part of the final FloriPEFCR.

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.

Secondary data[3] – This refers to data not from specific process within the supply-chain of the company applying the FloriPEFCR. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third-party life-cycle-inventory 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 can 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.

Supply-chain – This term refers to all of the upstream and downstream activities associated with the operations of the company applying the PEFCR, including the use of sold products by consumers and the end-of-life treatment of sold products after consumer use.

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

Supporting study – Study carried out on specific products following the exact guidance of the FloriPEFCR. This study is meant to put the validity and applicability of the FloriPEFCR to test by completing a full study for a specific product.

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.

Unit process dataset – Smallest element considered in the life cycle inventory analysis for which input and output data are quantified (ISO 14040:2006). In LCA practice, both physically not further separable processes (such as unit operations in production plants, then called 'unit process single operation') and also whole production sites are covered under 'unit process', then called 'unit process, black box' (ILCD Handbook).

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

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

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

1 General

This representative product (RP) study was done in the context of developing the methodology for calculating environmental footprints of cut flowers and potted plants, the Product Environmental Category Rules for Cut Flowers and Potted Plants (FloriPEFCR, see Broekema et al, 2024). This RP study on potted plants is one of the two RP studies that have been selected based on economically relevant applied technologies and origins of productions. The other study is on cut flowers (Helmes et al., 2024).

For the RP of potted plants, a virtual product is chosen, because there are large differences between plant species, pot and plant sizes, type of growing media, flowering or leaf plants, indoor or outdoor use, countries and regions of cultivation, etc. It was decided to define three main groups of potted plants:

- flowering plants,
- leaf plants, and
- outdoor plants.

For each group, a typical species grown in a typical pot size with a typical type of growing media, cultivated in a typical country for this plant was selected, based on market analysis (AIPH & Union Fleurs, 2022). This approach virtually covers all potted plants products in the product classification (CPA) included in the FloriPEFCR. The environmental footprint of the representative product was calculated based on an equal share of each group (flowering plants, leaf plants and outdoor plants) instead of basing on the market shares. The general information for this potted plants RP study is shown in Table 2.

Table 2 *General information*

Information	Description
Name of the product	Virtual representative product for potted plants
Product identification (e.g. model number),	Not applicable
Product classification (CPA) based on the latest CPA list version available,	In the CPA category 01.30.10 (Planting material: live plants, bulbs, tubers and roots, cuttings and slips; mushroom spawn), the following codes are included: • 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 90 Unrooted cuttings and slips (excl. vines) • 0602 30 00 Rhododendrons and azaleas, grafted or not • 0602 40 00 Roses, whether or not grafted • 0602 90 45 Outdoor rooted cuttings and young plants of trees, shrubs and bushes (excl. fruit, nut and forest trees) • 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)
Product is based on	Typical/average data for 1/3 of flowering plants, 1/3 leaf plants, and 1/3 outdoor plants (grown outside): • For flowering plants: Phalaenopsis (*Phalaenopsis sp)* in a 12 cm diameter pot with bark growing media (Figure 1, left) • For leaf plants: Dracaena (*Dracaena sp)* in a 17 cm diameter pot plants in coco growing media (Figure 1, middle) • For outdoor plants: Lavender (*Lavandula sp*) in 12 cm pot with peat growing media (Figure 1, right)
Date of publication of the PEF study	February 2024 (final)
Geographic validity of the PEF study	European Union
Compliance with the PEF method	Externally verified, see Chapter 7
Conformance to other documents, additional to the PEF method	Final FloriPEFCR (publication date February 2024, see Broekema et al., 2024)
Name and affiliation of the verifier(s)	See chapter 7

Figure 1 *Photos of potted Phalaenopsis (left), Dracaena (middle) and Lavender (right)*

2 Goal of the study

The goal of the study is to perform a representative product study for potted plants in the context of the FloriPEFCR development as described in Table 3.

Table 3 *Goal of the study*

Information	Description
Intended application(s)	Becoming the ‘skeleton’ for all product-specific models
Methodological limitations	See paragraph 3.6 for an overview and paragraph 4.2 for an elaboration
Reasons for carrying out the study	Study the representative product for potted plants and help in developing the FloriPEFCR by: • Identifying the most relevant impact categories, life cycle stages, processes and direct elementary flows; • Calculating the benchmark results; • Identifying the secondary data needs.
Target audience	LCA experts, growers, exporters, retailers and consumers or representations of them.
Commissioner of the study	Technical Secretariat PEFCR cut flowers & potted plants
Identification of the verifier	See Chapter 7

3 Scope of the study

The scope of the study identifies the analysed system in detail and addresses the overall approach used to establish:

i) description of the representative product
ii) functional unit and reference flow
iii) system boundary
iv) list of EF impact categories
v) additional information (environmental and technical)
vi) assumptions and limitations.

3.1 Description of the representative product

As mentioned in section 1, a virtual product is chosen for the representative product (RP) of potted plants. The basis for the virtual product is the distinction between three groups of potted plants, which represent the entire category of potted plants:

1. flowering plants
2. leaf plants and
3. outdoor plants

Within each of these groups, there is still a large variation of plant species, pot and plant sizes, type of growing media, and countries and regions of cultivation. However, if we only consider the products that are dominating the market, this variation is much smaller. We selected for each group only one species based on market analysis (AIPH & Union Fleurs, 2022), and can be considered similar in the way it is cultivated to other market dominating species within each group.

Flowering plants
For flowering plants, the orchid Phalaenopsis was chosen. Phalaenopsis is actually not a single species, but a genus of many species. Phalaenopsis is one of the most popular potted orchid plants to keep indoors, because the tropical plant can be cultivated in controlled conditions in greenhouses in Europe, and, because of breeding advancements, Phalaenopsis is well adapted to home conditions and needs only basic care by the consumer. A Phalaenopsis plant has several leaves and can flower for up to three months after which it stays vegetative for several months. If it is then kept it can flower again, but generally consumers dispose of the plants when it loses its flowers.

The Phalaenopsis plants are mainly cultivated for the European consumer market in the Netherlands in heated greenhouses. The most typical pot size is 12 cm diameter with two stems. The pot in generally filled with bark and peat growing media. The starting material is grown by specialised growers in controlled conditions. The starting material is grown then in plugs in trays and when it reaches a certain size, it is transplanted to a bigger pot with additional growing media. When the plant starts flowering, it is packed and transported to the auction or directly to the retailer.

Leaf plants
For leaf plants, Dracaena was chosen. Dracaena is also a genus of many species. Only a few species are common for use as indoor leaf plants. The Dracaena plants need humidity and some watering, but do not need as high temperatures as Phalaenopsis for cultivating them. Still, they are cultivated in greenhouses in Europe to keep them in a protected environment and prevent them from exposure to low temperatures.

For the European market, the Dracaena plants are mainly grown in the Netherlands in heated greenhouses. The most typical pot size is 17 cm diameter. The pot in generally filled with bark and peat growing media. The cultivation and rest of the supply chain is very similar to the supply chain of Phalaenopsis. The starting material is grown by specialised growers in controlled conditions. The starting material is then grown then in plugs in trays and when it reaches a certain size, it is transplanted to a bigger pot with additional growing media. When the plant reaches a sellable size, it is transplanted as a single, double or triple plant pot and so packed and transported to the auction or directly to the retailer.

Outdoor plants
For outdoor plants lavender is selected. Lavender is also a genus of several species, but the most common is the common lavender *Lavandula angustifolia.* It is grown in gardens all over the world and can propagate itself beyond the gardens. The most ideal conditions for lavender are relatively dry, well-drained, sandy soils in full sun.

The Netherlands is an important country for growing lavender plants in greenhouses for the European market, but it is also cultivated for the market at scale in Portugal, Spain and Italy. The most typical pot size is 12 cm diameter. The pot in generally filled with peat growing media. The starting material is grown by specialised growers in controlled conditions. The starting material is grown then in plugs in trays and when it reaches a certain size, it is transplanted to a bigger pot with additional growing media. When the plant reaches a certain size, it is put outside by the grower to acclimatise. After several weeks of acclimatisation, the plants are packed and transported to the auction or directly to the retailer.

Virtual product
The three real products represent the three main groups of potted plants, but they are combined in a single virtual product by multiplying the data of each product per unit of product by a weighting factor to be able to calculate the environmental footprint of the RP of potted plants. The environmental footprint of the representative product was calculated based on an equal share of each group (flowering plants, leaf plants and outdoor plants) instead of basing on the market shares.

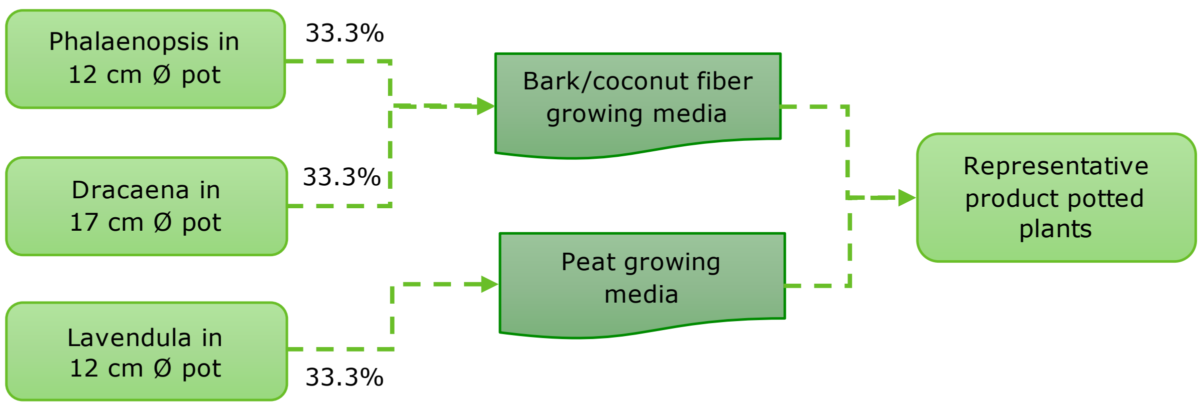

Figure 2 *Phalaenopsis, Dracaena and Lavendula represent the virtual product representative for potted plants in this study*

3.2 Functional unit and reference flow

The functional unit, defining the four aspects, is described in Table 4.

Table 4 *The functional unit, defining the four aspects*

Aspect	Information	Description
'what'	The function(s)/service(s) provided	To provide decoration
'how much'	The extent of the function or service	1 pot (inner pot only)
'how long'	The duration/life time of the product	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)
'how well'	The expected level of quality	According to the specifications of the producer or the retailer

The reference flow of the representative product is 1 pot.

There is a significant difference between the duration/lifetime of the product, depending on the use phase conditions and the type of plant and species. If a reference flow of 1 pot-year would be used, the impact results of Phalaenopsis would get a 4 times higher weight per pot when assuming the lifetime of Phalaenopsis is at least 3 months and that of Dracaena and lavender at least 12 months, where the estimated duration is debatable. The question is which reference flow would give a good proxy for the market shares of the three different types of potted plants with equal weighting in the virtual representative product. In our judgement this is with a reference flow of 1 pot.

3.3 System boundary

The life cycle stages in Table 5 have been identified for all floriculture products in scope. Depending on the product subcategory, different activity data is applicable per life cycle stage. In the case of all potted plants, the production of starting material is included as a substage in life cycle stage 1 Raw Materials. All phases of the starting material production are included in this life cycle stage.

In the case of Phalaenopsis and Dracaena the cultivation stage includes 2 substages:
- 1a Young plant cultivation
- 1b Large plant cultivation

In case of lavender the cultivation stage includes 3 substages:
- 1a Young plant cultivation
- 1b Large plant cultivation
- 1c Acclimatisation (outdoor)

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 of the FloriPEFCR (Broekema et al, 2024). Also transport shall be included. Capital goods (including 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 waste which occurs.
Use stage	Use stage includes the use of water for watering the cut flower or potted plant.
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.

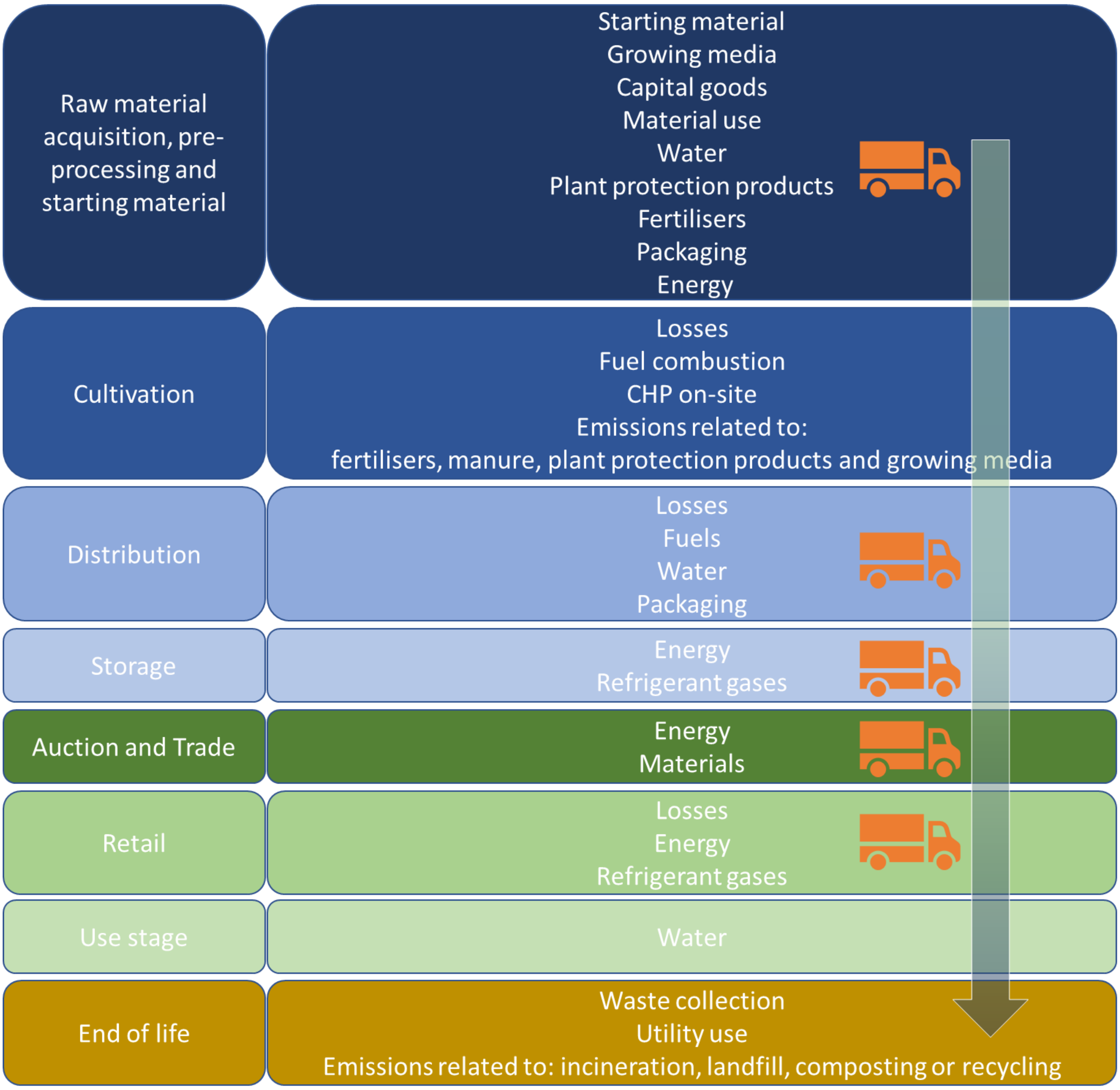

Figure 3 *Product system processes and elementary flows*

3.4 Environmental Footprint impact categories

The list of EF 3.1 impact categories, units, and EF reference package used is shown in Table 6.

Table 6 *EF impact categories with respective impact category indicators and characterisation models. The CFs that shall be used are available at: http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.*

EF impact category	Impact category indicator	Unit
Climate change[1]	Radiative forcing as Global Warming Potential (GWP100)	kg CO_2 eq
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 eq
Human toxicity, cancer	Comparative Toxic Unit for humans (CTUh)	CTUh
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTUh)	CTUh
Particulate matter	Impact on human health	disease incidence
Ionising radiation, human health	Human exposure efficiency relative to U-235	kBq U-235 eq
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC eq
Acidification	Accumulated Exceedance (AE)	mol H^+ eq
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N eq
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P eq
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N eq
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTUe)	CTUe
Land use	• Soil quality index • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Dimensionless (pt) • kg biotic production • kg soil • m^3 water • m^3 groundwater
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 world eq
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb eq
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ

3.5 Additional information

A large variety of potted plants are available on the market, which raises questions in terms of comparability of outcomes of analyses using the FloriPEFCR. One pot plant has been selected for FU (see section 3.3). 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
- Expected lifetime of the plant, in weeks

3.6 Assumptions and limitations

The following assumptions were made regarding the case composition for the virtual representative product:

- Phalaenopsis cultivation in 12 cm Ø pots in the Netherlands is representative for indoor flowering pot plants sold in the EU
- Dracaena cultivation in 17 cm Ø pots in the Netherlands is representative for indoor non-flowering indoor pot plants sold in the EU

[1] 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.

- Lavender cultivation in 12 cm Ø pots in the Netherlands is representative for outdoor pot plants sold in the EU
- Equal share of the three types of pot plants per pot is representative for their market shares, because no market data is available

Full details on all cultivation methods, and on how the three potted plant types weigh into the total RP model are provided in Annex I LCI data tables. All modelling choices are listed in paragraph 4.2, and the assumptions and expert estimates affecting the most relevant processes as listed in paragraph 5.1 are listed below:

- Lifetime greenhouse construction is 15 years
- Plants are stored 1 day after the cultivation stage
- Plants are stored 1 day at the distribution centre
- Plants are kept 7 days at the retailer
- The use of a ceramic pot is not included as this is regarded as product-independent
- Fraction of potted plants wasted during distribution is 2.5% and during retail (not sold) is 5% (the upstream and downstream impact of this is included in the retail life cycle stage)
- Carbon dioxide emissions from peat oxidation is assumed to take place directly after filling the pots at a rate of 5% per year during the cultivation stage, where the remaining emissions take place during the end-of-life stage (GME, 2021), which means that it is largely emitted during the end of life stage in the lavender case. This is in line with the FloriPEFCR.
- The starting material process of Dracaena and lavender is assumed the same as the starting material process of Phalaenopsis as proxy, because of data gaps.
- Several parameters of the young plant process for Phalaenopsis are assumed the same for Dracaena and Lavender, because of data gaps (see detailed data inventory in Annex I)
- The contribution of the seed or cuttings to produce the starting material is assumed to negligible and therefore not included.

Limitations:

- Nitrogen emissions were calculated using the general PEF Guide rules (EC, 2021).
- Only three species in 2 different size pots cultivated in the Netherlands are considered for representing all types of potted plants sold in the EU; for this reason, the TS selected different plants and/or cultivation countries in the supporting studies.
- Equal share of indoor flowering, indoor non-flowering, and outdoor potted plants per pot were used for calculating the representative product rather than market shares of the three types of potted plants, because no comprehensive market data are available.
- 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
  - More granularity in the regionalisation of water flows for a proper assessment of water scarcity (it shouldn’t affect much the outcomes of this PEF-RP study though since all plants are cultivated in the Netherlands and this country has low water scarcity variability)
  - Modelling of Nitrogen emissions due to the application of fertilisers
  - Country-specific characterisation factors for N & P emissions in eutrophication are only available for EU countries however cultivation can happen worldwide
  - Modelling of pesticides (covering all types of biocides), both in open field as well as in greenhouses
  - How to consider green manure
  - How to model peat emissions
  - How to model heavy metal emissions
  - Quantify biodiversity impacts that go beyond impacts covered by the current list of impact categories

4 Life cycle inventory analysis

This section describes the compilation of the Life Cycle Inventory (LCI) and includes:
- List and description of life cycle stages,
- Description of modelling choices,
- Description of allocation approaches applied,
- Description and documentation of data used and sources,
- Data quality requirements and rating.

4.1 Life cycle stages

The following life cycle stages were modelled (inputs and outputs summarised):

1. Raw materials
The raw materials stage includes the production and transport of all external material inputs for cultivation, except for materials (such as capital goods and fuels) and for energy production as described in section 3.3. For the three products that are combined in the virtual RP, three sub-stages of cultivation were defined (see also section 3.3). As these substages are modelled as separate unit processes, the raw material stage was also modelled for the substages separately.

For the substage 'young plant', the following flows were included:
- greenhouse structure material production and waste treatment
- starting material production
- plugs in trays and trays production
- growing media production
- other less impactful inputs production
- transport and packaging of the pots, growing media, and other input

For the substage 'large plant', the following flows were included:
- greenhouse structure material production and waste treatment
- fertilisers production
- large pots production
- growing media production
- irrigation water from natural resources
- other less impactful inputs

For the substage 'acclimatisation' (only lavender), the following flows were included:
- Floor made from lava-stone material production
- Irrigation water from natural resources
- Carbon dioxide emissions from peat (only fraction)

2. Cultivation
The cultivation stage includes the production of fuels and other materials and capital goods for energy production, emissions from fuel combustion, electricity production, land use (occupation and transformation), and all kinds of emissions to air, water and soil (carbon dioxide to air from peat and lime, nitrous oxide and ammonia to air and nitrate to water from fertilisers and peat, phosphate emissions to water from fertilisers, and emissions from pesticides including all types of biocides). The flows are specified per substage of the cultivation stage.

For the substage 'young plant', the following flows are included:
- natural gas production for generating heat or combined heat and electricity
- electricity production from the grid
- emissions to air from combustion of natural gas (including carbon dioxide emissions)
- emissions from fertilisers and pesticides
- land use

For the substage 'large plant', the following flows are included:
- natural gas production for generating heat or combined heat and electricity
- electricity production from the grid
- emissions to air from combustion of natural gas (including carbon dioxide emissions)
- carbon dioxide emissions from peat
- emissions from fertilisers, such as carbon dioxide, nitrous oxide, ammonia to air and nitrate to water
- land use
- waste treatment of plants that cannot be sold due to damage

For the substage 'acclimatisation' (only lavender), the following flows were included:
- irrigation water
- carbon dioxide emissions from peat
- land use

3. Distribution
The distribution stage includes all transport of the potted plants as they leave the cultivation stage till it reaches the consumer. Cooling and heating during transport is not considered in this RP study, because there was not enough representative information available to specify this and it is expected to have a small contribution to the total environmental impact. For the three products of the RP, the plants are transported:
- from the grower to the auction,
- from auction to the distribution centre,
- from distribution centre to retail and
- from retail to the consumer.

Besides transport, the distribution stage also includes:
- Electricity production from the grid for storage at the distribution centre,
- Heat production from natural gas for storage at the distribution centre (including production of natural gas and combustion emissions)
- Leakage of refrigerants at DC cooling system
- Production of any packaging that is required for transport (trays, which are secondary packaging and trolleys, which are tertiary packaging), and
- Production and waste treatment of product losses during distribution (including all flows that would otherwise be part of the raw material and cultivation stages). (default losses is 2.5%)

4. Storage
Storage is a stage that includes any kind of storage between cultivation and the distribution centre. In the case of the three potted plants in the RP, the plants are moved from the greenhouse to a storage space, usually in the same greenhouse or a separate building, where the products can be packed on trays and trolleys so they can be loaded in the trucks for transport. Usually, the products are picked up the same day. The flows included in this stage are:
- Electricity production from the grid for storage (lighting and cooling),
- Heat production from natural gas for storage (including production of natural gas and combustion emissions).

5. Auction
Auction of the three potted plants of the RP takes place at several locations in the west of the Netherlands. The auction facilities include large halls, which need to be cooled or heated, depending on the season and outside weather conditions. The plants are unloaded from the trucks and moved around the facilities, which

is done with small electric cars to tow the trolleys, but there is also some use of diesel powered vehicles. The following flows are included:

- Electricity production from the natural gas
- Electricity production from solar panels
- Heat production from natural gas (including production of natural gas and combustion emissions)
- Water use
- Diesel production and combustion

6. Retail

The retail stage includes the following flows:

- Electricity production for storage/display at retail
- Heat production from natural gas (including production of natural gas and combustion emissions)
- Raw materials, cultivation, distribution, storage, and auction of wasted potted plants during retail (default losses is 5%)
- Waste treatment of wasted potted plants during retail

7. Use stage

The use stage includes the production of all product dependent products. As it was decided that an additional outer pot (usually a ceramic or clay pot) is product independent, this is not included. Because no duration of the use stage could be determined, watering and carbon dioxide emissions from peat oxidation are excluded from the use stage.

8. End-of-life

The end-of-life stage includes all treatment of the wasted product, including the pot and consumer packaging, following the circular footprint equation. Besides this, the remaining carbon dioxide emissions from peat are included in this stage.

Details on which parts of the model were modelled specifically for the three products are listed in Table 7 with references to the respective tables in Annex I LCI data tables (file 'Life cycle inventory RP potted plants').

Table 7 *References for generically and product specifically modelled parts of the life cycle*

Table description	Phalaenopsis	Dracaena	Lavender
Total Life Cycle	**Table 1.1**		
Raw materials (1)	**Table 1.2**		
starting material	Table 2.1	Table 3.1	Table 4.1
1a young plants raw materials	Table 2.2	Table 3.2	Table 4.2
1b large plant raw materials	Table 2.3	Table 3.3	Table 4.3
1c acclimatisation			Table 4.4
stage 1 raw material acquisition & starter material	Table 2.4	Table 3.4	Table 4.5
Greenhouse construction	Table 6.1	Table 6.1	Table 6.3
Greenhouse installation	Table 6.2	Table 6.2	Table 6.4
Purified carbon dioxide from CHP	Table 5.2	Table 5.2	
Purified carbon dioxide from OCAP	Table 5.3	Table 5.3	
Cultivation (2)	**Table 1.3**		
2a young plants	Table 2.5	Table 3.5	Table 4.6
2b large plant	Table 2.6	Table 3.6	Table 4.7
2c acclimatisation			Table 4.8
stage 2 cultivation	Table 2.7		Table 4.9
Combined heat and power production	Table 5.1	Table 5.1	
Distribution (3)	**Table 1.4**		
stage 3a packaging	Table 2.8	Table 3.8	Table 4.10
stage 3b distribution	Table 2.9	Table 3.9	Table 4.11
stage 3 distribution	Table 2.10	Table 3.10	Table 4.12
Storage (4)	**Table 1.5**		
stage 4 storage	Table 2.11	Table 3.11	Table 4.13
Auction/Trade (5)	**Table 1.6**		
stage 5 auction	Table 2.12	Table 3.12	Table 4.14
Retail (6)	Table 1.7		
stage 6 retail	Table 2.13	Table 3.13	Table 4.15
Use stage (7)	**Table 1.8**		
stage 7 use	Table 2.14	Table 3.14	Table 4.16
End-of-life (8)	**Table 1.9**		
stage 8 end-of-life	Table 2.15	Table 3.15	Table 4.17
Default transport processes	Tables 7.1 and 7.2		
Waste treatment processes	Tables 8.1 to 8.9		

4.2 Modelling choices

The model is described in the data tables of this report. Each data table represents one unit process and can include the following subheadings:

- **Products or Waste treatment**: the rows below this heading include the product or co-products of the process or the waste treatment description in case of a waste treatment process
- **Resources**: below this heading all resource flows, such as water extraction from nature and land occupation and land transformation, are found that take place for the process
- **Non-energy inputs**: the rows below this heading include all material inputs and transport that correspond to the process
- **Energy inputs**: the rows below this heading include all electricity and heat inputs
- Emissions to air or water or soil: below this row all emissions that take place from this process are reported
- **Waste to treatment**: below this heading, the rows include the links to waste treatment processes from waste that is produced by the process

The table headings are explained as follows:

- **Input/output**: here you will find either the subheading as described above or a short description of the flow
- **Unit**: the unit of the flow is reported here. The unit is consistent to the unit convention of SimaPro and is always per amount of the reference flow of the process
- **Amount**: this is the amount of the flow
- **Source**: here a description is given of the source of the data and if data manipulations were done (such as unit conversions) these are described
- **LCI product/process name**: this field shows the exact name of the flow to link to the background data and processes modelled specifically for the study
- **TeR**: score of the technical representativeness for the flow
- **GR**: score of the geographic representativeness for the flow
- **TiR:** score of the time representativeness for the flow
- **P**: score of the precision for the flow
- **DQR**: average of the data quality scores

The following processes can be found in the tables:

- **RP life cycle process:** The life cycle process links to all the included stages of the virtual RP.
- **RP life cycle stage processes:** Each life cycle stage is modelled as a process linking to the three processes that include the flows of the life cycle stage for each individual product and weighting them by a factor of one third (equal weighting).
- **Product-specific life cycle stage '1. Raw materials':** This life cycle stage is modelled by different processes:
  - Starting material is a separate process as one of the raw material inputs
  - The purified carbon dioxide production from OCAP and from the CHP processes are also modelled separately
  - The greenhouse structure materials inputs and waste treatment processes is also separately modelled
  - Young plant, which includes the input of starting material
  - Large plant, which includes the input of young plants
  - Acclimatisation (only lavender), which includes the input of large plants
  - A process combining the different substages
- **Product-specific life cycle stage '2. Cultivation':** This life cycle stage is modelled by different processes:
  - The electricity and heat production from the CHP process is also modelled separately
  - Young plant, which includes the input of starting material
  - Large plant, which includes the input of young plants
  - Acclimatisation (only lavender), which includes the input of large plants
  - A process combining the different substages
- **Product-specific life cycle stage '3. Distribution':** this life cycle stage consists of two processes
  - Secondary and tertiary packaging production inputs and links to waste treatment
  - Transport and storage at the distribution centre
  - A process combining the different substages
- **Product-specific life cycle stage '4. Storage':** this life cycle stage is modelled by one process including the flows as described in the previous section.
- **Product-specific life cycle stage '5. Auction':** this life cycle stage is modelled by one process including the flows as described in the previous section
- **Product-specific life cycle stage '6. Retail':** this life cycle stage is modelled by one process including the flows as described in the previous section
- **Product-specific life cycle stage '7. Use stage':** this life cycle stage is modelled by one process including the flows as described in the previous section
- **Product-specific life cycle stage '8. End of life':** this life cycle stage is modelled by one process including the flows as described in the previous section
- **Default transport processes**: there are two processes to model the default distances and transport modes of input transport:
  - Transport of packaging materials
  - Transport of other materials

- **Circular footprint waste treatment processes**: several processes are included for modelling the various materials end-of-life with the circular footprint equation:
  - Plastic
  - Cardboard/paper
  - Steel
  - Aluminium
  - Glass
  - Concrete
  - Electronics
  - Biowaste
  - Wood

Important choices for the modelling are the following:
- Agricultural emissions are calculated with the basic equations of the PEF Guide (EC, 2021):
  - Nitrous oxide: Amount of nitrogen in fertilisers x 0.022 g N_2O per g N (EC, 2021).
  - Ammonia: Amount of nitrogen in fertilisers x (0.1 g NH_3-N per g N x17/14) (EC, 2021).
  - Peat carbon dioxide emissions: amount of peat dry matter x 0.425 g C per g dry matter x 44/12 (Blonk et al., 2009).
  - Peat carbon nitrogen emissions: amount of peat dry matter x 0.022 g N per g dry matter x 44/12 (Blonk et al., 2009) x 0.022 g N_2O per g N (EC, 2021).
  - Nitrate leaching: Amount of nitrogen in fertilisers x 0.3 g NO_3-N per g N x 62/14 (EC, 2021).
- Transport and logistics are modelled as follows:
  - For packaging and other material inputs, the default distances and transport modes are used, following (EC, 2021)
  - For transport from auction to the retail, the default distances and transport modes for intracontinental transport of product are used, following (EC, 2021) of inputs are divided by the total weight of the products auctioned during the period for which the inputs are reported, so the inputs are allocated based on mass.
- Storage and retail are included, based on the area the pot is occupying, following (EC, 2021).
- End-of-life modelling follows the Circular Footprint Formula and default parameter values (see Annex I for the parameter values).
- Electricity from the grid, from natural gas and from solar panels in the Netherlands and European average is modelled by the background EF3.1 datasets.
- Electricity from the CHP is modelled separately specifically for the study.

4.3 Handling multi-functional processes

If a process or facility provides more than one function, i.e. it delivers several goods and/or services (‘co-products’), it is ‘multifunctional’. In these situations, all inputs and emissions linked to the process were partitioned between the product of interest and the other co-products according to fixed rules. Systems involving multi-functionality of processes were modelled in accordance with a decision hierarchy resulting in specific allocation rules. Allocation 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. The relevant allocation rules following the PEFCR potted plants & cut-flowers are summarised in Table 8.

Table 8 *Allocation rules for activity data and elementary flows*

Process	Allocation Rule	Modelling Instructions
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 in 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: $LO = Sum\ over\ phases\ (p)\ (GT_p * 1 / PD_p)$ With LO = Land occupation (yr*m^2) GT_p = Growing time of phase p (yr) PD_p = 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	The horticultural system should be subdivided into the heat and electricity production subsystem, the carbon dioxide capture and purification subsystem and the cultivation system. If the subdivision is feasible, the CO_2 output from the capture and purification system shall not receive the environmental impacts of the energy production, among which the CO_2 emission itself, and it shall receive the environmental impacts of the purification process. If only the subdivision between CHP and cultivation is feasible, the CO_2 output shall not receive the environmental impact of energy production nor purification. This impact goes to the energy production. If the 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 (see Section 6.2.2). Allocation between electricity and heat shall be carried out on energy content basis (see supplementary document on handling multi-functionality, Goglio et al., (2020)).
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%. Further information on this allocation can be found in Section 4.4.3 (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).

4.4 Data collection

Description and documentation of all company-specific data collected are shown in Annex I LCI Data Tables. Table 7 in Section 4.1 explains how all data tables in the Annex relate to all components of the model. The Annex includes all company-specific resource use, emissions and activity data with the appropriate source references, all linked secondary datasets with their appropriate metadata, and all derived calculations. The data collection was approached as described below.

- Industry representative data from research literature and environmental reporting systems was used for the potted plants in order to draw up a framework of all resource usages for the raw material acquisition and cultivation.
- Subsequently, the distribution stage, the starting material substage and the raw material acquisition and cultivation were populated with primary and public data sourced from the network of the authors. These data originated from prior LCA studies from companies, from environmental reporting systems and from individual industry experts who were approached for the specific purpose of this RP study.
- The distribution was based on public data and general estimates from the same industry experts and extensive consistency checks were made. The distribution information was used to model the space occupation of products in storage and retail.
- The data for the use stage and the end of life stage was based on assumptions and the guidance from (EC, 2021).
- The data for supporting models for resources like crop protection, growing media and capital goods, as well as for on-site energy production was collected from research literature and from experts from the network of the authors.

Validation of data, including documentation will be addressed after the public and expert review rounds.
Per life cycle stage, details on the data collection are listed below:

- '1. Raw materials':
  - Starting material production is based on company-specific data for Phalaenopsis (for Dracaena and Lavender the same data is used), this includes;
    - Pots
    - Paper
    - Ethanol
    - Tap water
    - Natural gas (boiler)
    - Electricity (grid)
    - Waste water
  - The purified carbon dioxide production from OCAP and from the CHP processes are based on literature, information from OCAP, and assumptions
  - Young plant is based on company specific data for Phalaenopsis; for Dracaena and Lavender partly the same data is used and partly based on assumptions and company-specific information (growers and a pot producer); this includes
    - Starting material
    - Growing media
    - Greenhouse construction
    - Purified CO_2 (from OCAP, CHP, and factory)
    - Dolomite
    - Trays
  - Large plant is based on KWIN data, company specific information (growers and s pot producer) and estimates
  - Acclimatisation (only lavender) is based on assumptions
- '2. Cultivation': This life cycle stage is modelled by different processes:
  - The electricity and heat production from the CHP process is also modelled separately, based on specific literature.
  - The resources and emissions are calculated based on the equations described in the previous paragraph with the input data for the raw materials.

- '5. Auction': this life cycle stage is modelled with company-specific data and includes:
  - Water
  - Electricity from Natural Gas
  - Electricity from Solar Panels
  - Diesel consumed
  - Natural gas consumed
- The life cycle stages '3. Distribution', '4. Storage', '6. Retail', '7. Use stage', and '8. End-of-life' are modelled with default data.

4.5 Data quality requirements and rating

A table listing all processes and their situation according to the Data Needs Matrix (DNM) is shown in the LCI data tables.

The DQR of the PEF study is 1.55. The data for these processes are specific and of high quality.

5 Impact assessment results

5.1 PEF results

Characterised results of all EF impact categories are reported as absolute values in Table 9.

Normalised results as absolute values are reported in Table 10 and normalised and weighted results as absolute values are reported in Table 11, where the total of all impact categories is the weighted results as single score.

Results of the use stage as well as the other stages are reported separately in the results tables.

5.2 Additional information

The specifications of the three products that are included in the virtual RP are as follows:

- the Phalaenopsis plant
  - has a pot size of 12 cm,
  - is 55 cm in height (including pot),
  - is an indoor flowering plant, and
  - its lifetime is expected at least 13 weeks.
- the Dracaena
  - has a pot size of 17 cm,
  - is 75 cm in height (including pot),
  - is an indoor leaf plant, and
  - its lifetime is expected at least 52 weeks.
- the Lavender
  - has a pot size of 12 cm,
  - is 25 cm in height (including pot),
  - is an outdoor plant, and
  - its lifetime is expected at least 52 weeks.

Table 9 *Characterised results of the virtual representative product for all EF impact categories as absolute values per pot*

Impact category	**Unit**	**Total**	**Stage 1. Raw materials**	**Stage 2. Cultivation**	**Stage 3. Distribution**	**Stage 4. Storage**	**Stage 5. Auction**	**Stage 6. Retail**	**Stage 7. Use stage**	**Stage 8. End-of-life**
Acidification	mol H+ eq	3,81E-03	1,16E-03	1,94E-03	3,79E-04	3,03E-06	9,93E-06	2,57E-04	0,00E+00	6,10E-05
Climate change	kg CO_2 eq	2,39E+00	3,14E-01	1,53E+00	1,90E-01	1,97E-03	1,46E-02	1,32E-01	0,00E+00	2,02E-01
Ecotoxicity, freshwater	CTUe	8,74E+00	5,68E+00	5,73E-01	1,91E+00	3,41E-03	3,46E-03	5,32E-01	0,00E+00	3,60E-02
Particulate matter	disease inc.	4,91E-08	3,26E-08	1,09E-08	3,55E-09	2,90E-11	8,03E-11	3,14E-09	0,00E+00	-1,31E-09
Eutrophication, marine	kg N eq	1,44E-03	3,27E-04	7,35E-04	1,18E-04	7,07E-07	3,68E-06	8,40E-05	0,00E+00	1,70E-04
Eutrophication, freshwater	kg P eq	1,68E-05	3,50E-06	8,36E-07	9,45E-07	1,45E-09	1,38E-09	8,70E-07	0,00E+00	1,07E-05
Eutrophication, terrestrial	mol N eq	1,16E-02	3,47E-03	4,93E-03	1,24E-03	7,64E-06	4,08E-05	7,08E-04	0,00E+00	1,20E-03
Human toxicity, cancer	CTUh	3,84E-10	1,80E-10	8,44E-11	8,99E-11	2,28E-13	2,33E-12	2,25E-11	0,00E+00	4,06E-12
Human toxicity, non-cancer	CTUh	6,22E-09	2,69E-09	7,77E-10	9,13E-10	2,75E-12	4,76E-12	3,79E-10	0,00E+00	1,45E-09
Ionising radiation	kBq U-235 eq	2,96E-02	1,91E-02	1,69E-02	8,03E-03	2,95E-04	8,33E-05	1,12E-02	0,00E+00	-2,59E-02
Land use	Pt	1,82E+01	1,37E+01	2,75E+00	8,13E-01	3,03E-03	1,73E-03	9,78E-01	0,00E+00	-1,14E-02
	kg CFC11 eq	2,76E-10	2,60E-10	2,70E-12	1,13E-11	2,46E-13	1,29E-14	2,16E-11	0,00E+00	-2,07E-11
Photochemical ozone formation	kg NMVOC eq	3,52E-03	8,82E-04	1,78E-03	3,44E-04	2,25E-06	1,22E-05	2,11E-04	0,00E+00	2,92E-04
Resource use, fossils	MJ	3,66E+01	6,44E+00	2,58E+01	3,93E+00	3,29E-02	2,44E-01	2,20E+00	0,00E+00	-2,08E+00
Resource use, minerals and metals	kg Sb eq	6,30E-07	1,48E-07	7,50E-08	3,49E-07	2,21E-10	4,54E-10	3,67E-08	0,00E+00	2,06E-08
Water use	m^3 depriv.	1,51E-01	6,91E-02	1,62E-02	2,10E-02	2,34E-04	2,71E-04	1,52E-02	0,00E+00	2,94E-02

Table 10 *Normalised results of the representative product as absolute values in person-year per pot*

Damage category	Unit	Total	Stage 1. Raw materials	Stage 2. Cultivation	Stage 3. Distribution	Stage 4. Storage	Stage 5. Auction	Stage 6. Retail	Stage 7. Use stage	Stage 8. End-of-life
Acidification	person-year	6,85E-05	2,1E-05	3,5E-05	6,8E-06	5,4E-08	1,8E-07	4,6E-06	x	1,1E-06
Climate change	person-year	3,16E-04	4,2E-05	2,0E-04	2,5E-05	2,6E-07	1,9E-06	1,8E-05	x	2,7E-05
Ecotoxicity, freshwater	person-year	1,54E-04	1,0E-04	1,0E-05	3,4E-05	6,0E-08	6,1E-08	9,4E-06	x	6,3E-07
Particulate Matter	person-year	8,24E-05	5,5E-05	1,8E-05	6,0E-06	4,9E-08	1,3E-07	5,3E-06	x	-2,2E-06
Eutrophication, marine	person-year	7,36E-05	1,7E-05	3,8E-05	6,0E-06	3,6E-08	1,9E-07	4,3E-06	x	8,7E-06
Eutrophication, freshwater	person-year	1,05E-05	2,2E-06	5,2E-07	5,9E-07	9,0E-10	8,6E-10	5,4E-07	x	6,6E-06
Eutrophication, terrestrial	person-year	6,56E-05	2,0E-05	2,8E-05	7,0E-06	4,3E-08	2,3E-07	4,0E-06	x	6,8E-06
Human toxicity, cancer	person-year	2,22E-05	1,0E-05	4,9E-06	5,2E-06	1,3E-08	1,4E-07	1,3E-06	x	2,4E-07
Human toxicity, non-cancer	person-year	4,83E-05	2,1E-05	6,0E-06	7,1E-06	2,1E-08	3,7E-08	2,9E-06	x	1,1E-05
Ionising radiation	person-year	7,01E-06	4,5E-06	4,0E-06	1,9E-06	7,0E-08	2,0E-08	2,6E-06	x	-6,1E-06
Land use	person-year	2,22E-05	1,7E-05	3,4E-06	9,9E-07	3,7E-09	2,1E-09	1,2E-06	x	-1,4E-08
Ozone depletion	person-year	5,27E-09	5,0E-09	5,2E-11	2,2E-10	4,7E-12	2,5E-13	4,1E-10	x	-4,0E-10
Photochemical ozone formation	person-year	8,62E-05	2,2E-05	4,4E-05	8,4E-06	5,5E-08	3,0E-07	5,2E-06	x	7,1E-06
Resource use, fossils	person-year	5,63E-04	9,9E-05	4,0E-04	6,1E-05	5,1E-07	3,7E-06	3,4E-05	x	-3,2E-05
Resource use, minerals and metals	person-year	9,90E-06	2,3E-06	1,2E-06	5,5E-06	3,5E-09	7,1E-09	5,8E-07	x	3,2E-07
Water use	person-year	1,32E-05	6,0E-06	1,4E-06	1,8E-06	2,0E-08	2,4E-08	1,3E-06	0	2,6E-06

Table 11 *Normalised and weighted results as absolute values (μPt means 10^{-6} points, where one point is equivalent to the total impact per capita in one year)*

Damage category	**Unit**	**Stage 1. Raw materials**	**Stage 2. Cultivation**	**Stage 3. Distribution**	**Stage 4. Storage**	**Stage 5. Auction**	**Stage 6. Retail**	**Stage 7. Use stage**	**Stage 8. End-of-life**	**Total**
Acidification	μPt	1.3	2.2	0.4	0.0	0.0	0.3	0.0	0.1	4.2
Climate change	μPt	8.8	42.8	5.3	0.1	0.4	3.7	0.0	5.6	66.6
Ecotoxicity, freshwater	μPt	1.9	0.2	0.6	0.0	0.0	0.2	0.0	0.0	3.0
Particulate matter	μPt	4.9	1.6	0.5	0.0	0.0	0.5	0.0	-0.2	7.4
Eutrophication, marine	μPt	0.5	1.1	0.2	0.0	0.0	0.1	0.0	0.3	2.2
Eutrophication, freshwater	μPt	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
Eutrophication, terrestrial	μPt	0.7	1.0	0.3	0.0	0.0	0.1	0.0	0.3	2.4
Human toxicity, cancer	μPt	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.5
Human toxicity, non-cancer	μPt	0.4	0.1	0.1	0.0	0.0	0.1	0.0	0.2	0.9
Ionising radiation	μPt	0.2	0.2	0.1	0.0	0.0	0.1	0.0	-0.3	0.4
Land use	μPt	1.3	0.3	0.1	0.0	0.0	0.1	0.0	0.0	1.8
Ozone depletion	μPt	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Photochemical ozone formation	μPt	1.0	2.1	0.4	0.0	0.0	0.2	0.0	0.3	4.1
Resource use, fossils	μPt	8.2	33.0	5.0	0.0	0.3	2.8	0.0	-2.7	46.8
Resource use, minerals and metals	μPt	0.2	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.7
Water use	μPt	0.5	0.1	0.2	0.0	0.0	0.1	0.0	0.2	1.1
Total	μPt	30.3	84.9	13.8	0.1	0.8	8.4	0.0	4.0	142.4

Table 12 *List of most relevant impact categories with the percentage contributions to the normalised and weighted total, and the most relevant life cycle stages and processes with the percentage contributions to the total of the impact category*

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 strength: 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 strength: 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 | 1500 t 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	-
				Corner foam, PS {EU+EFTA+UK} | polymerisation of styrene, foam production | production mix, at plant | 28 kg/m^3, tensile strength: 3 kg/cm^2 | LCI result – Stage 3 Distribution RP potted plants	2.5	n.a. because it's aggregated	-

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
				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 strength: 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 strength: 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	-
				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	-

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
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/m³ | 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/m³ | 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/cm³, 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/m² | LCI result	3.5%	n.a. because it's aggregated	
				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	

Most relevant impact category	%	Most relevant Life cycle stages	%	Most relevant processes	%	Most relevant direct elementary flow	%
		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 strength: 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	

6 Interpreting PEF results

6.1 Assessment of the robustness of the PEF study

The overall data quality rating (DQR) of this RP study is 1.55. The DQR of the most relevant stages is as follows: Raw Materials 1.62, Cultivation 1.39, End-of-life 2.93. The data quality of the Cultivation is perceived as very complete and accurate and the data quality level is 'very good'. [2] The data quality of Raw Materials can be seen as sufficient for its smaller contribution to the most relevant processes and achieves the data quality level 'very good'. The distribution processes may not be as granular as desired, given the large role of a two EF 3.1 data process, reflecting road transport. The processes have the Very Good to Excellent data quality level, resulting in a corresponding data quality for Distribution.

This RP study relied on custom made processes contributing to Raw Materials and Cultivation, namely Combined heat and power, Capital goods, Crop protection and Starting material have a data quality level between 2.3 and 1.5.[3] The processes reflecting Raw Materials and Cultivation for all potted plants species have a DQR of 1.5, which is Excellent data quality level. The direct emissions in these custom made processes, which could be seen as the foreground processes, contribute to more than 80% of the single score.

The current version of this PEF-RP study is using the secondary EF-compliant datasets version 3.1. These datasets have an averaged DQR of 1.55 and the direct emissions from these processes contribute to 81% of the single score. Overall, the DQRs of datasets from different sources show that the data quality level is sufficient and the study is expected to be fairly robust, but limitations are known and discussed in sections 3.6 and 6.3.

6.2 Hotspot analysis

The list of most relevant impact categories, life cycle stages, processes and elementary flows is found in Table 12.
The hotspot analysis resulted in the following:

- the most important impact categories are
  1. climate change
  2. resource use, fossil
  3. particulate matter

The TS have found freshwater ecotoxicity, water use and land use to also be relevant for this sector.

- The most relevant life cycle stages identified for the RP for potted plants are:
  - Stage 2. Cultivation (climate change, resource use, fossil)
  - Stage 1. Raw materials (climate change, resource use, fossil and particulate matter)
  - Stage 8. End-of-life (climate change)
- There were 11 most relevant processes identified for climate change, 7 for fossil resource use and 15 for particulate matter. Of these most relevant processes, the ones related to natural gas production and

[2] The DQRs of the life cycle stages are determined by the DQRs of the primary and secondary model processes in which the largest LCI flows occur. The DQR of these processes is not a reflection of the use level of these processes or the appropriateness of choosing this process, i.e. the DQR of the air transport process does not inform about the data quality of how much air transport is used or whether the right type of air transport is chosen. The data quality of the use levels and database choices has been assessed in Annex I but does not find its way into the presented DQRs, which is compliant to (EC, 2021).

[3] It is hard to estimate whether important crop protection products were missed for each modeled process. It does not translate into a worse DQR, since the DQR considers known uncertainties. The crop protection processes are not identified as a most relevant process.

combustion are highly contributing, as well as materials for the greenhouse, landfill of biodegradable waste and electricity use.
- There is 1 most relevant elementary flow identified: carbon dioxide, fossil (appearing in three most relevant processes).

6.3 Limitations and relationship of the EF results relative to the defined goal and scope of the PEF study

The limitations and relationship of the EF results relative to the defined goal and scope of the PEF RP study are the following:
- Nitrogen emissions were calculated using the general PEF Guide rules (EC, 2021), but the contribution of these emissions to the results are limited; so, the impact of this limitation to the results is limited.
- Only three species in 2 different size pots cultivated in the Netherlands are considered for representing all types of potted plants sold in the EU; for this reason, the TS intends to select different plants and/or cultivation countries in the supporting studies.
- Equal share of indoor flowering, indoor non-flowering, and outdoor potted plants per pot were used for calculating the representative product rather than market shares of the three types of potted plants, because no comprehensive market data are available.
- So, we cannot guarantee that the outcomes of the RP-study are truly representative for all potted plants being grown worldwide and transported to the EU market.
- The inventory data is largely based on secondary data; so, we cannot guarantee that the outcomes of the RP-study are truly representative for potted plants.
- 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. So, we cannot predict if the results will significantly change with newly developed rules.

6.4 Conclusions and recommendations

The following is concluded:
- The most relevant impact categories, life cycle stages and processes are identified as listed in 6.2. A summary is given in Table 12.
- Secondary data needs have been identified, as derived from the most relevant processes. These data needs are defined in the FloriPEFCR (Broekema et al., 2024). The data needs address the most relevant processes in Table 12.
- The benchmark results have been calculated as provided in section 5.1.
- The developed model can be used as a ‘skeleton’ for all product-specific models.

The following is recommended:
- Datasets with large contributions could be split up into specific technologies or regions for more granularity. Study practitioners could also develop custom made datasets.
- It could be considered to broaden the number of plant species studied in order to improve representativeness of the study results as a benchmark. Considerable outreach throughout networks of suppliers and experts is required and the supporting studies could play a role in data collection or in linking up the right stakeholders in the field.
- The N and P modelling approaches should be studied, both in terms of its benefit of increased accuracy and in terms of its cost in terms of additional data collection. The N and P modelling approach discussed in the FloriPEFCR (Broekema et al., 2024) could be a very good study case, especially if supported by the Agricultural Working Group. The burden of calculations can be limited because a supporting excel file is available. The supporting studies could play a role in this.
- It could be considered to develop a default dataset for crop protection use and emissions without knowing the application rates and active ingredients from primary sources, based on default spraying schemes and classification of crops and cultivation methods; on the other hand, a more detailed approach could be trialled in order to stress-test the assumptions in the RP study. The same holds for starting material.

7 Validation statement

Title of the PEF study: 2nd Draft of the Product Environmental Footprint of the Representative Product for 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 of the Representative Product for Potted Plants 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.
- 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 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

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Sources and literature

AIPH & Union Fleurs (2022). International Statistics Flowers and Plants Yearbook 2021. Volume 69.

Blonk. H., Kool, A., Luske, B., Ponsioen, T. and Scholten, J. (2010). Methodology for assessing carbon footprints of horticultural products. Blonk Milieu Advies. CA Gouda. NL.

Bol.com (2021). https://www.bol.com/nl/p/phalaenopsis-3-tak-wit-in-keramiek-hoogte-45-cm-pot-o-12-cm/9200000102507519/ (accessed 6 January 2021)

Boon (2019). Personal communication. H. Boon (RHP)

Broekema, R., Helmes R., Vieira M., Hopman. M, Gual Rojas P., Ponsioen T., Weststrate J., Verweij-Novikova, 2024. *Product Environmental Footprint Category Rules for Cut flowers and Potted plants; Final version.* Wageningen, Wageningen Economic Research, Report 2024-023.

de Groot, G.M. (2010). Briefrapport 609021107/2010 BEMS: emissie-eisen voor middelgrote stookinstallaties Informatie voor de VROM-Inspectie. Contact: G.M. de Groot. Centrum Inspectie-. Milieu en Gezondheidsadvisering (IMG)

EC (2021). Commission Recommendation on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisations. Brussels. C92021) 9332 final.

EEA (2019). EMEP/EEA Air pollutant emission inventory guidebook 2019. EEA Technical report 13/2019. European Environment Agency (EEA). Copenhagen. Available: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

GME. (2021). Growing Media Environmental Footprint Guidenline V1.0.

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

Helmes, R., Ponsioen, T., Van der Linden, R., Verweij-Novikova, I. (2021). Environmental footprint of Phalaenopsis Representative product study. Wageningen. Wageningen Economic Research. Report 2021-059.

Helmes, R., Ponsioen, T., Blonk, H., Vieira, M., Goglio, P., van den Linden, R., Gual Rojas, P., Kan, D. and Verweij-Novikova, I. (2020). Hortifootprint Category Rules: Towards a PEFCR for horticultural products. Wageningen Economic Research. Report 2020-041.

Hortiinnovations.nl (2021) https://www.hortiinnovations.nl/deense-karren-containers-rolcontainers-transportkarren.html#modal-one

Infomil (2021) Kenniscentrum InfoMil. https://www.infomil.nl/ (accessed 6 January 2021)

IPCC. 2007. DEFAULT EMISSION FACTORS FOR STATIONARY COMBUSTION IN THE RESIDENTIAL AND AGRICULTURE/FORESTRY/FISHING/FISHING FARMS CATEGORIES

Modiform (2020). PRODUCT CATALOGUE 2020 – 2021.

OCAP (2019). Factsheet: Zuivere CO2voor de glastuinbouw. https://www.ocap.nl/nl/images/OCAP_Factsheet_Nederlands_tcm978-561157.pdf

Paradiso, R., Maggio, A. and De Pascale, S. (2012). Moderate variations of day/night temperatures affect flower induction and inflorescence development in Phalaenopsis. Scientia horticulturae. 139. 102-107.

Raaphorst, M. and Benninga, J. (2019). Kwantitatieve Informatie voor de Glastuinbouw (KWIN). Edition 26. Report GTB–5121. Bleiswijk.

van der Velden, N. and Smit, P. (2017). Energiemonitor van de Nederlandse glastuinbouw 2016. (Wageningen Economic Research rapport; No. 2017-094). Wageningen Economic Research. https://doi.org/10.18174/424123

Van Harmelen, T., Koornneef, J.M., van Horssen, A., Ramirez-Ramirez, C.A. and Van Gijlswijk, R. (2008). The impacts of CO2 capture technologies on transboundary air pollution in the Netherlands.

Vermeulen (2009). Data sheet Peter Vermeulen 'materiaalinzet kas en teeltsysteem versie 10-03-2009'

Vermeulen, P. (2016). Kwantitatieve informatie voor de glastuinbouw 2016-2017: kengetallen voor groenten. snijbloemen. pot en perkplanten teelten. (Rapport GTB 5121) - 330. Bleiswijk.

Vermeulen, P.C.M. and van der Lans, C.J.M. (2011). CO2 dosering in de biologische glastuinbouw: Onderzoek naar alternatieve bronnen-Toepassingen in gangbare tuinbouw (No. 1085). Wageningen UR Glastuinbouw.

Annexes

Annex I - LCI Tables RP potted plants

The following Excel file contains inventory data:

- Annex I LCI Tables RP potted plants PUBLIC.xlsm

The inventory file is composed of a number of worksheets:

0. Parameters (general. species specific and waste treatment)
1. Life cycle stages
2. Phalaenopsis
3. Dracaena
4. Lavender
5. CHP & CO_2
6. Capital Goods
7. Transport
8. Waste treatment

Each table in sheet 1 to 10 represents a separate process/dataset which together with the background data from EF 3.1 data compose the LCI model. Which individual tables address different parts of the supply chain is illustrated in Table 7 in paragraph 4.1.

Annex II - Confidential report

No confidential report.

Annex III - Ef compliant dataset

The aggregated EF-compliant dataset of the product in scope will be made available to the European Commission in Excel format and in ILCD format.

Wageningen Economic Research
P.O. Box 29703
2502 LS The Hague
The Netherlands
T +31 (0)70 335 83 30
E communications.ssg@wur.nl
wur.eu/economic-research

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To explore the potential of nature to improve the quality of life

Wageningen Economic Research
P.O. Box 29703
2502 LS Den Haag
The Netherlands
T +31 (0) 70 335 83 30
E communications.ssg@wur.nl
wur.eu/economic-research

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