Product Environmental Footprint Category Rules - Decorative Paints

Product category: Decorative paints
Version number: version 1.0
Date of publication/revision: April 2018
Date of expiration: December 31st 2021

Developed by:
Technical Secretariat Decorative Paints

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Developed as a part of the European Commission initiative: Single market for green products

Product Environmental Footprint Category Rules Decorative paints

Version tracker

Date	**Version**	**Name**	**Comments**
03-2014	α1	Max Sonnen	First version based on PEF literature review (including comments from PEF Guide/ EN15804/ int EPD + IBU PCR, to enable a more detailed discussion per point
12-2014	α2	Emilie Carasso	Second version with following changes: - New template from EU Commission - Comments on version α1 taken into account - Addition of potential source of information + information itself
01-2015	β	Emilie Carasso	First real draft PEFCR - Sections written with proposed text - Reviewed by Max Sonnen/Matthew Percy Only rough idea of the content of each section, not a wording proposal.
05-2015	γ	Emilie Carasso	Addition of screening results, alterations taking into account published PEFCRs
08-2015	δ	Emilie Carasso	Inclusion of public consultation comments
10-2015	ε		Inclusion of feedback from steering committee (approval of PEFCR delta) Inclusion of primary data quality tables Version to be used for the supporting studies
08-2016	6.0	Olympia Dolla	Update of Review Panel Update of functional unit (opacity test & spreading rate options) Inclusion of Communication vehicles Supporting studies results Supporting studies feedback
11-2016	6.1	Olympia Dolla	Integration of feedback received from the public consultation
12-2016	6.2	Olympia Dolla	Integration of the feedback received from the Review panel
12-2017	7.0	Olympia Dolla	Conversion to new template Compliance with latest PEF guidance document
12-2017	7.1	Max Sonnen	Refinements of final PEFCR
02-2018	7.2	Max Sonnen	Restructuring and final drafting of PEFCR Update with remodelling results and aligned with v6.3 of the guide
03-2018	7.3	Max Sonnen	Amended after feedback from the review panel
03-2018	7.4	Max Sonnen	Amended after feedback from EC
04-2018	7.5	Max Sonnen	Amended after feedback from EU SC
04-2018	1.0	Olympia Dolla	Amended after additional adaptations from EC

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List of acronyms

AF	Allocation Factor
AP	Acidification Potential
AR	Allocation Ratio
B2B	Business to Business
B2C	Business to Consumer
BoC	Bill of Components
BOM	Bill of Materials
CAS	Chemical Abstracts Service
CEPE	The European Council for Paints, Printing Inks and Artists' colors
CF	Characterization Factor
CFF	Circular Footprint Formula
CFF-M	Circular Footprint Formula – Modular form
CMWG	Cattle Model Working Group
CPA	Classification of Products by Activity
CPC	Central Product Classification
DC	Distribution Centre
DeCo	Decorative Coatings
DMI	Dry Matter Intake
DNM	Data Needs Matrix
DQR	Data Quality Rating
EA	Economic Allocation
EC	European Commission
EF	Environmental Footprint
EFTA	European Free Trade Association
EI	Environmental Impact
ELCD	European Life Cycle Database
EOL	End-Of-Life
EP	Eutrophication Potential
EPD	Environmental Product Declaration
EU	European Union
FU	Functional Unit
GE	Gross Energy intake
GHG	Greenhouse Gas
GR	Geographical Representativeness
GWP	Global Warming Potential
HD	Helpdesk
ILCD	International Reference Life Cycle Data System
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCDN	Life Cycle Data Network

LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LT	Lifetime
NMVOC	Non-methane volatile compounds
ODP	Ozone Depletion Potential
P	Precision
PCR	Product Category Rules
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
POCP	Photochemical Oxidant Creation Potential
PoS	Point of Sale
RDC	Regional Distribution Centre
RF	Reference Flow
RM	Raw Material
RP	Representative Product
SB	System Boundary
SC	Steering Committee
SME	Small and Medium Enterprise
SMRS	Sustainability Measurement & Reporting System
SS	Supporting study
SVOC	Semi Volatile Organic Compounds
TAB	Technical Advisory Board
TeR	Technological Representativeness
TiR	Time Representativeness
TS	Technical Secretariat
UNEP	United Nations Environment Programme
UUID	Universally Unique Identifier
VOC	Volatile Organic Compounds

Definitions

For all terms used in this Guidance and not defined below, please refer to the most updated version of the Product Environmental Footprint (PEF) Guide, ISO 14025:2006, ISO 14040-44:2006, and the ENVIFOOD Protocol.

PEFCR Specific Definitions:

Biocide - Or "active substance", defined by the EU BPR (Regulation 528/2012) as "A substance or micro-organism that has an action on or against harmful organisms"

Biocidal content - Quantity and type of biocidal substance present in the paint (e.g. BIT, MIT, Terbutryn, Carbamic acid, Morpholine). Unit: gram/kg

Coverage - The surface area one can paint with one liter of product with an appropriate coverage level. Based on product specific test data. Determined according the guidance in Annex 5. Unit: m^2/L.

Dry mass - Weight of the paint product after the full evaporation of water and solvents present in the paint. Unit: gram/kg.

Maintenance multiplier - The number of maintenance cycles over the lifetime of the building. The maintenance multiplier is calculated according to the Guidance in Annex 4 – Durability. Depending on the type of paint, the specific tests shall be performed in order to measure the quality of paint and therefore the paint frequency. Unit: none.

Paint density - The volumetric mass density of a paint is its mass per unit volume. Unit: kg/L

Solid content - The solid content is the volume of the paint after it has dried (without solvents, VOCs etc.). It is defined as the percentage of non-volatile materials by weight. Solid content (%) = 100 – VOC content (%) – Water content (%)

VOC - Volatile organic compounds. (VOC) - means any organic compounds having an initial boiling point less than or equal to 250 °C measured at a standard pressure of 101,3 kPa as defined in Directive 2004/42/EC and which, in a non-polar capillary column, are eluting with a retention range up to and including Tetradecane ($C_{14}H_{30}$)

VOC content - The VOC content expressed as grams of VOCs per liter of paint shall be determined based on the CEPE VOC Guidance in Annex 3. Unit: gram/L.

EF Generic Definitions:

Activity data - This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). In the PEF Guide it is also called "non-elementary flows". The aggregated LCI results of the process chains that represent the activities of a process are each multiplied by the corresponding activity data[1] and then combined to derive the environmental footprint associated with that process (See Figure 1). Examples of activity data include quantity of kilowatt-hours of electricity used, quantity of fuel used, output of a process (e.g. waste), number of hours equipment is operated, distance travelled, floor area of a building, etc. In the context of PEF the amounts of ingredients from the bill of material (BOM) shall always be considered as activity data.

Aggregated dataset - This term is defined as a life cycle inventory of multiple unit processes (e.g. material or energy production) or life cycle stages (cradle-to-gate), but for which the inputs and outputs are provided only at the aggregated level. Aggregated datasets are also called "LCI results", "cumulative inventory" or "system processes" datasets. The aggregated dataset can

[1] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 2011).

have been aggregated horizontally and/or vertically. Depending on the specific situation and modelling choices a "unit process" dataset can also be aggregated. See Figure 1[2].

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

Benchmark – A standard or point of reference against which any comparison can be made. In the context of PEF, the term 'benchmark' refers to the *average* environmental performance of the representative product sold in the EU market. A benchmark may eventually be used, if appropriate, in the context of communicating environmental performance of a product belonging to the same category.

Bill of materials – A bill of materials or product structure (sometimes bill of material, BOM or associated list) is a list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture an end product.

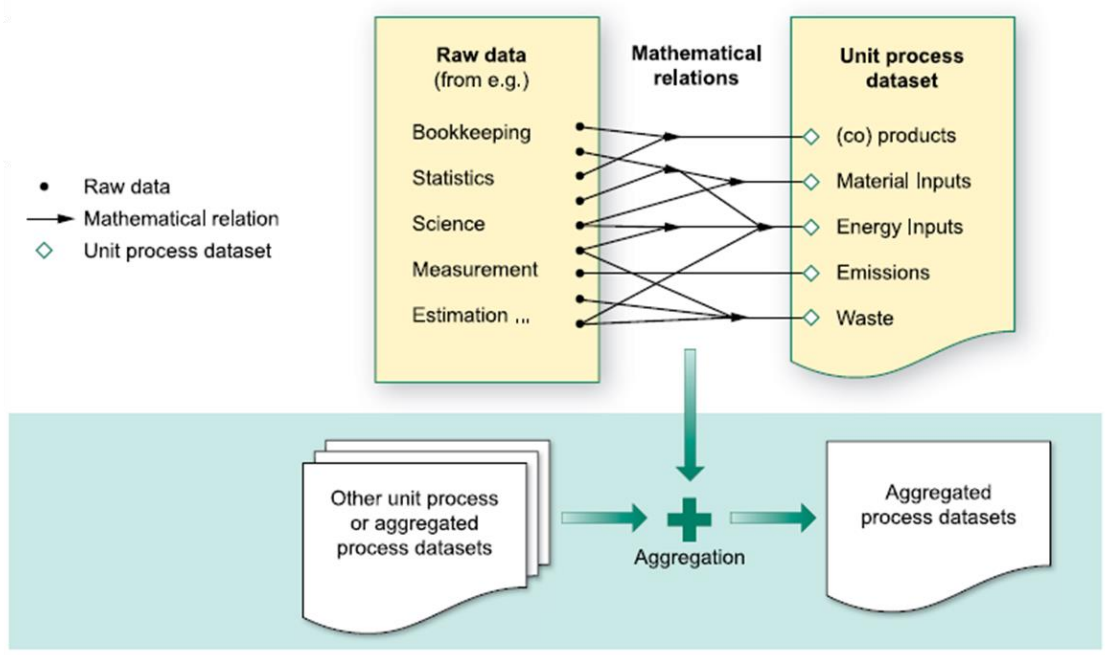

Figure D1 - Definition of a unit process dataset and an aggregated process dataset

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

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

Commissioner of the EF study - Organisation (or group of organisations) that finances the EF study in accordance with the PEF Guide, PEFCR Guidance and the relevant PEFCR, if available (definition adapted from ISO 14071/2014, point 3.4).

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

[2] Source: UNEP/SETAC "Global Guidance Principles for LCA Databases"

Comparative assertion – An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function (adapted from ISO 14025:2006).

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.

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

Direct elementary flows (also named elementary flows) – All output emissions and input resource use that arise directly in the context of a process. Examples are emissions from a chemical process, or fugitive emissions from a boiler directly onsite. See Figure 2.

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

EF communication vehicles – It includes all the possible ways that can be used to communicate the results of the EF study to the stakeholders. The list of EF communication vehicles includes, but it is not limited to, labels, environmental product declarations, green claims, websites, infographics, etc.

EF report – Document that summarises the results of the EF study. For the EF report the template provided as annex to the PECFR Guidance shall be used. In case the commissioner of the EF study decides to communicate the results of the EF study (independently from the communication vehicle used), the EF report shall be made available for free through the commissioner's website. The EF report shall not contain any information that is considered as confidential by the commissioner, however the confidential information shall be provided to the verifier(s).

EF study – Term used to identify the totality of actions needed to calculate the EF results. It includes the modelisation, the data collection, and the analysis of the results.

Electricity tracking[3] – Electricity tracking is the process of assigning electricity generation attributes to electricity consumption.

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.

Environmental aspect – Element of an organization's activities or products or services that interacts or can interact with the environment (ISO 14001:2015)

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

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

[3] https://ec.europa.eu/energy/intelligent/projects/en/projects/e-track-ii

Independent external expert – Competent person, not employed in a full-time or part-time role by the commissioner of the EF study or the practitioner of the EF study, and not involved in defining the scope or conducting the EF study (adapted from ISO 14071/2014, point 3.2).

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 - An intermediate product is a product that requires further processing before it is saleable to the final consumer.

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

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

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

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

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).

Partially disaggregated dataset - A dataset with a LCI that contains elementary flows and activity data, and that only in combination with its complementing underlying datasets yield a complete aggregated LCI data set. We refer to a partially disaggregated dataset at level 1 in case the LCI contains elementary flows and activity data, while all complementing underlaying dataset are in their aggregated form (see an example in Figure D2).

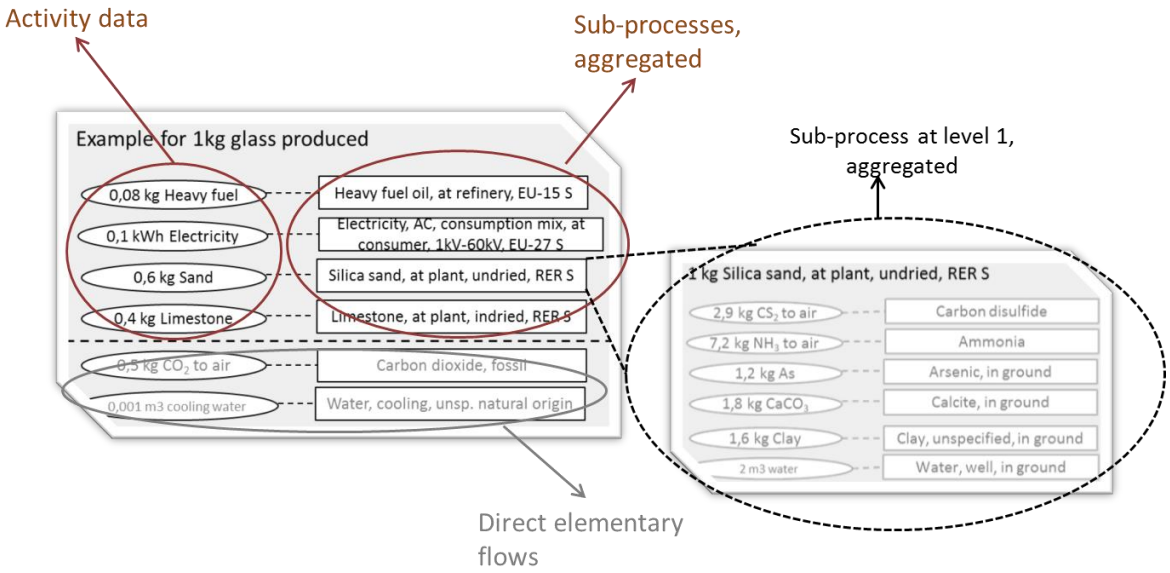

Figure D2 - An example of a partially aggregated dataset, at level 1.
The activity data and direct elementary flows are to the left, and the complementing sub-processes in their aggregated form are to the right. The grey text indicates elementary flows.

PEFCR Supporting study – The PEF study done on the basis of a draft PEFCR. It is used to confirm the decisions taken in the draft PEFCR before the final PEFCR is released.

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

PEF screening – 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 PEFCR.

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

Practitioner of the EF study – Individual, organisation or group of organisations that performs the EF study in accordance with the PEF Guide, PEFCR Guidance and the relevant PEFCR if available. The practitioner of the EF study can belong to the same organisation as the commissioner of the EF study (adapted from ISO 14071/2014, point 3.6).

Primary data[4] **-** This term refers to data from specific processes within the supply-chain of the company applying the PEFCR. Such data may take the form of activity data, or foreground elementary flows (life cycle inventory). Primary data are site-specific, company-specific (if multiple sites for the same product) or supply-chain-specific. Primary data may be obtained through meter readings, purchase records, utility bills, engineering models, direct monitoring, material/product balances, stoichiometry, or other methods for obtaining data from specific processes in the value chain of the company applying the PEFCR. 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 (PCR) – 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 guide.

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

Representative product (model) - The “representative product” may or may not be a real product that one can buy on the EU market. Especially when the market is made up of different technologies, the “representative product” can be a virtual (non-existing) product built, for

[4] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 2011).

example, from the average EU sales-weighted characteristics of all technologies around. A PEFCR may include more than one representative product if appropriate.

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

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

Secondary data[5] **-** It refers to data not from specific process within the supply-chain of the company applying the PEFCR. 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.

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

Sub-population – In this document this term indicates any finite or infinite aggregation of individuals, not necessarily animate, subject to a statistical study that constitutes a homogenous sub-set of the whole population. Sometimes the word "stratum" can be used as well.

Sub-processes - Those processes used to represent the activities of the level 1 processes (=building blocks). Sub-processes can be presented in their (partially) aggregated form (see Figure 2).

Sub-sample - In this document this term indicates a sample of a sub-population.

Supply-chain – It 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.

Type III environmental declaration – An environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information (ISO 14025:2006). The predetermined parameters are based on the ISO 14040 series of standards, which is made up of ISO 14040 and ISO 14044.

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).

Validation statement – Conclusive document aggregating the conclusions from the *verifiers* or the verification team regarding the EF study. This document is mandatory and shall be electronically or physically signed by the *verifier or in case of a* verification panel, by the lead verifier. The minimum content of the validation statement is provided in this document.

[5] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute, 2011)

Verification report – Documentation of the verification process and findings, including detailed comments from the *Verifier(s)*, as well as the corresponding responses. This document is mandatory, but it can be confidential. However, it shall be signed, electronically or physically, by the *verifier or in case of a* verification panel, by the lead verifier.

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

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

1 Introduction

The Product Environmental Footprint (PEF) Guide provides detailed and comprehensive technical guidance on how to conduct a PEF study. PEF studies may be used for a variety of purposes, including in-house management and participation in voluntary or mandatory programmes.

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

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

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

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

2 General information about the PEFCR

2.1 Technical Secretariat

The Technical Secretariat is composed of:

Name of the organization	**Type of organization**	**Name of the members**
CEPE (Leader)	Industry association	Emilie Carasso, Olympia Dolla and Jan van der Meulen
AkzoNobel	Paint producer	Carmen Alvarado, David Brunt, Rob Klaasen, Max Sonnen and Jean Jacques Trescol
Crown Paints (Hempel)	Paint producer	Rachel Demaine
DAW	Paint producer	Björn Schön
Jotun	Paint producer	Anne Lill Gade
ONIP	Paint producer	Patrick Verlhac
PPG	Paint producer	Bas Overzier and Matthew Percy
IMA (Industrial Mineral Association)	Industry association	Aurela Schtiza
PlasticsEurope	Industry association	Guy Castelan
VdL	Industry association	Peter Grochal

About 400 paint producers are active on the decorative market in the EU 28. The industry association CEPE (European council of paint, printing ink and artist colour producers) represents approximately 80 % of the EU 28 market. As such, the Technical Secretariat involved in the development of this PEFCR is representative of the EU market.

2.2 Consultations and stakeholders

All of the information related to the PEFCR development is available on the wiki page of the pilot
https://webgate.ec.europa.eu/fpfis/wikis/display/EUENVFP/Stakeholder+workspace%3A+PEFCR+pilot+Paints

1st stakeholder consultation (virtual and physical consultation)
The aim of the consultation was to discuss the goal and scope of the project and agree on the representative product(s) and the definition of the product category.
Opening date: 20th of February 2014
Closing date: 27th of March 2014
Number of comments received: 54

Comments received from: ACA, international EPD system, Sherwin Williams, Technical helpdesk and TMA consulting.

2nd stakeholder consultation (virtual consultation)
The aim of the consultation was to discuss the 1st draft of the PEFCR and the screening report.
Opening date: 2nd of July 2015
Closing date: 30th of July 2015
Number of comments received: 85 on the PEFCR and 61 on the Screening study
Comments received from: ACA, Belgium SPF, Eastman, EPDLA, international EPD system, the retail pilot, Sherwin Williams, TDMA, Thinkstep, and TMA consulting.

3rd stakeholder consultation (named "2nd consultation", virtual and physical consultation)
The aim of the consultation was to discuss the 2nd draft of the PEFCR, including data availability and quality, durability schemes and more clarifications in terms of modelling.
Opening date: 13th of September 2016
Closing date: 12th of October 2016
Number of comments received: 83
Comments received from: DG Environment, EMPAC, APEAL, TDMA, ACA, Sherwin Williams, Eastman, Belgian Federal Ministry and Tikkurila

2.3 Review panel and review requirements

Name of the reviewer	**Affiliation**	**Role**
Harry van Ewijk	IVAM/SGS	Chairman
Owen Abbe	BRE	Member
Thomas Peverelli	EVEA	Member

The reviewers have verified that the following requirements have been fulfilled:

- The PEFCR has been developed in accordance with the requirement provided in the PEFCR Guidance 6.3, and where appropriate in accordance with the requirements provided in the most recent approved version of the PEF Guide, and supports creation of credible and consistent PEF profiles,
- The functional unit, allocation and calculation rules are adequate for the product category under consideration,
- Company-specific and secondary datasets used to develop this PEFCR are relevant, representative, and reliable,
- The selected LCIA indicators and additional environmental information are appropriate for the product category under consideration and the selection is done in accordance with the guidelines stated in the PEFCR Guidance version 6.3 and the most recent approved version of the PEF Guide,
- The benchmarks are correctly defined, and
- Both LCA-based data and the additional environmental information prescribed by the PEFCR give a description of the significant environmental aspects associated with the product.

The detailed review report is provided in Annex 2 of this PEFCR.

2.4 Review statement

This PEFCR has been developed in compliance with Version 6.3 of the PEFCR Guidance, and with the PEF Guide adopted by the Commission on 9 April 2013.

The representative products correctly describe the average products sold in Europe for the product group in scope of this PEFCR.

PEF studies carried out in compliance with this PEFCR would reasonably lead to reproducible results and the information included therein may be used to make comparisons and comparative assertions under the prescribed conditions (see chapter 3.6 on limitations).

2.5 Geographic validity

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

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

2.6 Language(s) of PEFCR

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

2.7 Conformance to other documents

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

- PEFCR Guidance Version 6.3 – December 2017
- Product Environmental Footprint (PEF) Guide; Annex II to the Recommendation 2013/179/EU, 9 April 2013. Published in the official journal of the European Union Volume 56, 4 May 2013

3. PEFCR scope

This PEFCR covers paints that are included in product categories (a) through (d) of the Paints Directive (*2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in decorative paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC*).

Table 3.1 summarizes the selected paint categories. These selected categories represent about 84% of the decorative paints markets based on 2012 CEPE statistics.

Table 3.1 - Paint categories in scope

Name Paint Directive 2004/ 42/ EC	**Volume EU market**
a) 'matt coatings for interior walls and ceilings' b) 'glossy coatings for interior walls and ceilings'	58%
c) 'coatings for exterior walls of mineral substrate'	19%
d) 'interior/exterior trim and cladding paints for wood, metal or plastic'	7%

3.1 Product classification

The CPA (Classification Product by Activity) codes for the products included in this PEFCR are:

C – Manufactured products:

C20.3 - Paints, varnishes and similar coatings, printing ink and mastics
C20.3.0 - Paints, varnishes and similar coatings, printing ink and mastics

F – Constructions and construction works:

F43.3.4 - Painting and glazing works

3.2 Representative products

Different products representing different paint categories were selected according to the Paints Directive. The functionality of the products is different; therefore, four representative products were defined to cover these differences. The chosen representative products are based on the averages of real company formulations covering many relevant variations in paint: white or coloured paint; matt or glossy paint; solventborne or waterborne paint. Table 3.2 summarizes the different representative products.

Table 3.2 - Representative products

Representative products (sub categories)	**Substrate**	**Category of the Paints directive**
Indoor wall paint	Mineral	a & b
Indoor wood paint	Wood	d
Outdoor wall paint (Outdoor mineral wall paint)	Mineral	c
Outdoor wood paint (Exterior trim and cladding paints for wood)	Wood	d

The screening study is available upon request from the TS coordinator that has the responsibility of distributing it with an adequate disclaimer about its limitations.

Representative products formulations

The formulations were prepared by a multi-country group and cover a broad range of quality levels. For this reason, they should serve as a representative average of the products found throughout the European Decorative coatings industry, from large enterprises to SMEs.
These formulations shall not be used for the purpose of a PEF study but act as the averaged formulations that define the benchmark. The EF compliant datasets of the formulations are given in chapter 6. Table 3.3 to Table 3.6 present the formulations for all representative products.

Table 3.3 - Indoor wall averaged paint formulation

Indoor wall averaged paint	
Raw Material	*%*
Chemical Substances	
Tap water for paint, at user	31.25
Styrene Acrylate dispersion (SA), 50% in water	21.00
Titanium Dioxide	10.90
GCC dry	27.15
China clay, calcinated	4.25
Propylene glycol	0.40
Additive, unspecified	5.05
Other characteristics needed for the PEF calculation	
VOCs (g/L)	5.184
Dry mass (g/kg)	578.5
Biocides (%w/w)	0.05
Type of biocide	BIT
Quality level based on durability scheme ⇨ Maintenance multiplier	Indoor Wall Q2 8.33
Coverage test data (m2/L) CR 98%	9.50
Production losses (in %)	3%
Paint density (kg/L)	1.43

Table 3.4 - Indoor wood averaged paint formulation

Indoor wood averaged paint	
Raw Material	*%*
Chemical Substances	
Tap water for paint, at user	41.40
Titanium dioxide	21.70
Styrene Acrylate dispersion (SA), 50% in water	21.20
Propylene glycol	5.80
Silicate waterborne (37% in water)	6.40
Additive, unspecified	3.00
Other characteristics needed for the PEF calculation	
VOCs (g/L)	70.21
Dry mass (g/kg)	376.7
Biocides (% w/w)	0.04
Type of biocide	BIT

Indoor wood averaged paint	
Raw Material	*%*
Chemical Substances	
Quality level based on durability scheme ⇨ Maintenance multiplier	Indoor Wood Q2 5.81
Coverage test data (m2/L) CR 98%	9.80
Production losses (in %)	3%
Paint density (kg/L)	1.21

Table 3.5 - Outdoor wall averaged paint formulation

Outdoor wall averaged paint	
Raw Material	*%*
Chemical Substances	
Tap water for paint, at user	20.30
GCC dry	17.00
Titanium dioxide	12.80
Styrene Acrylate dispersion (SA), 50% in water	43.00
Ester alcohol	2.00
Monoethylene glycol (MEG)	0.50
Additive, unspecified	4.40
Other paint characteristics needed for the PEF calculation	
VOCs (g/L)	6.5
Dry mass (g/kg)	557.0
Biocides (% w/w)	0.05
Type of biocide	BIT
Quality level based on durability scheme ⇨ Maintenance multiplier	Outdoor Wall Q2 5.00
Coverage test data (m2/L) CR 98%	7.00
Production losses (in %)	3%
Paint density (kg/L)	1.30

Table 3.6 - Outdoor wood averaged paint formulation

Outdoor wood averaged paint	
Raw Material	*%*
Chemical Substances	
Alkyd resin (sunflower oil), 77% in low aromatic white spirit	41.00
Solvent naphtha 90/170	17.00
Titanium Dioxide	19.50
GCC dry	16.50
Diatomaceous earth (dried diatomite), calcinated	3.00
Additive, unspecified	3.00
Other paint characteristics needed for the PEF calculation	
VOCs (g/L)	349.5
Dry mass (g/kg)	743.0
Biocides (% w/w)	0.05
Type of biocide	50% BIT/ 50% Carbamic acid
Quality level based on durability scheme	Outdoor Wood Q2

Outdoor wood averaged paint	
Raw Material	*%*
Chemical Substances	
⇨ Maintenance multiplier	7.46
Coverage test data (m2/L) CR 98%	9.50
Production losses (in %)	3%
Paint density (kg/L)	1.36

3.3 Functional unit and reference flow

The functional unit (FU) is to protect and decorate 1 m^2 of substrate for 50 years at a specified quality level (minimum 98% opacity). The key aspects used to define the functional unit are shown in Table 3.7.

Table 3.7 - Key aspects of the FU

Question	**Description**
What?	Provide decoration and protection of a substrate
How much?	Coverage of 1 m² of substrate
How well?	With a minimum 98% opacity
How long?	For 50 years (life time of the building)

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in kg of paint. All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.

The reference flow shall be calculated with this formula:
kg of paint = 1 (m^2) / Coverage (m^2/L) / applied paint (-) * Paint density (kg/L) * Maintenance multiplier

Calculation example (applied to the representative product for indoor wall)

Parameter	**Value**	**Type of parameter**
Coverage (m^2/L)	9.50	**Company specific:** The amount of m^2 one can paint with 1 liter of product with and appropriate contrast ratio. Based on product specific test data. Determined according the guidance in Annex 5.
Applied paint (Fraction)	0.89	**Fixed parameter:** Fraction of paint that on average is applied from the can on the wall.
Paint density (kg/L)	1.43	**Company specific:** The mass (kg) per unit volume (liter). Based on product specific test data. Determined according the guidance in Chapter 5.1
Maintenance multiplier (unitless)	8.33 indoor wall Q2	**Company specific:** Number of expected maintenance cycles over the reference lifetime of the building (50 years). Based on product specific test data. Determined according the guidance in Annex 4.

Final example reference flow calculation is therefore:

1.409 kg = 1 m^2 / 9.5 m^2/L / 0.89 *1.43 kg/L * 8.33

Or expressed in a number of interim steps:

Step	**Description**	**Calculation example**

1	Calculate volume of applied paint	1 m^2 / 9.5 m^2/L = 0.105 L
2	Calculate volume of used paint	0.105 L / 0.89 = 0.118 L
3	Conversion to mass of paint	0.118 L * 1.43 kg/L = 0.169 kg
4	Multiply by number of maintenance cycles in the lifetime of the building	0.169 kg * 8.33 = **1.409 kg**

3.4 System boundaries – life-cycle stages and processes

This PEFCR includes the cradle to grave environmental impacts of the life cycle of decorative paints. It encompasses the raw material acquisition and pre-processing, production, distribution and storage, use and end-of-life of decorative paints, including all the processes that differentiate paint value chains.

Figure 3.1 shows the life cycle stages and processes that shall be included in the system boundary. '2a Paint production' represents the life cycle stage with operational control[6] (processes expected to be run by the company, which would fall into Situation 1 as defined in the Data requirements and quality requirements in PEFCR Guidance document). In the process of implementing the PEFCR, the specific level of operational control of each process in the supply chain shall be assessed again by the company doing a PEF study.

The raw material acquisition, production, construction and end-of-life of the substrate, the commuting of employees (both of the paint factory and the professional painters), administrative services (research and development, commercial activities etc.), and capital goods such as machinery used in the paint production process, buildings (factories, offices, warehouses, and shops), or office equipment, are excluded from the system boundaries. A full overview and justifications for these exclusions can be found in Annex 6.
According to this PEFCR, no cut-off is applicable.

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the organizational boundary, to highlight those activities under the control of the organization and those falling into Situation 1, 2 or 3 of the data need matrix.

[6] Operational control is defined as being within the scope of the paint manufacturers. The processes that are related to paint production shall be covered by primary data as well as data related to the product itself. This includes data relevant to the logistics, use and end of life stages that differentiate between paint product types.

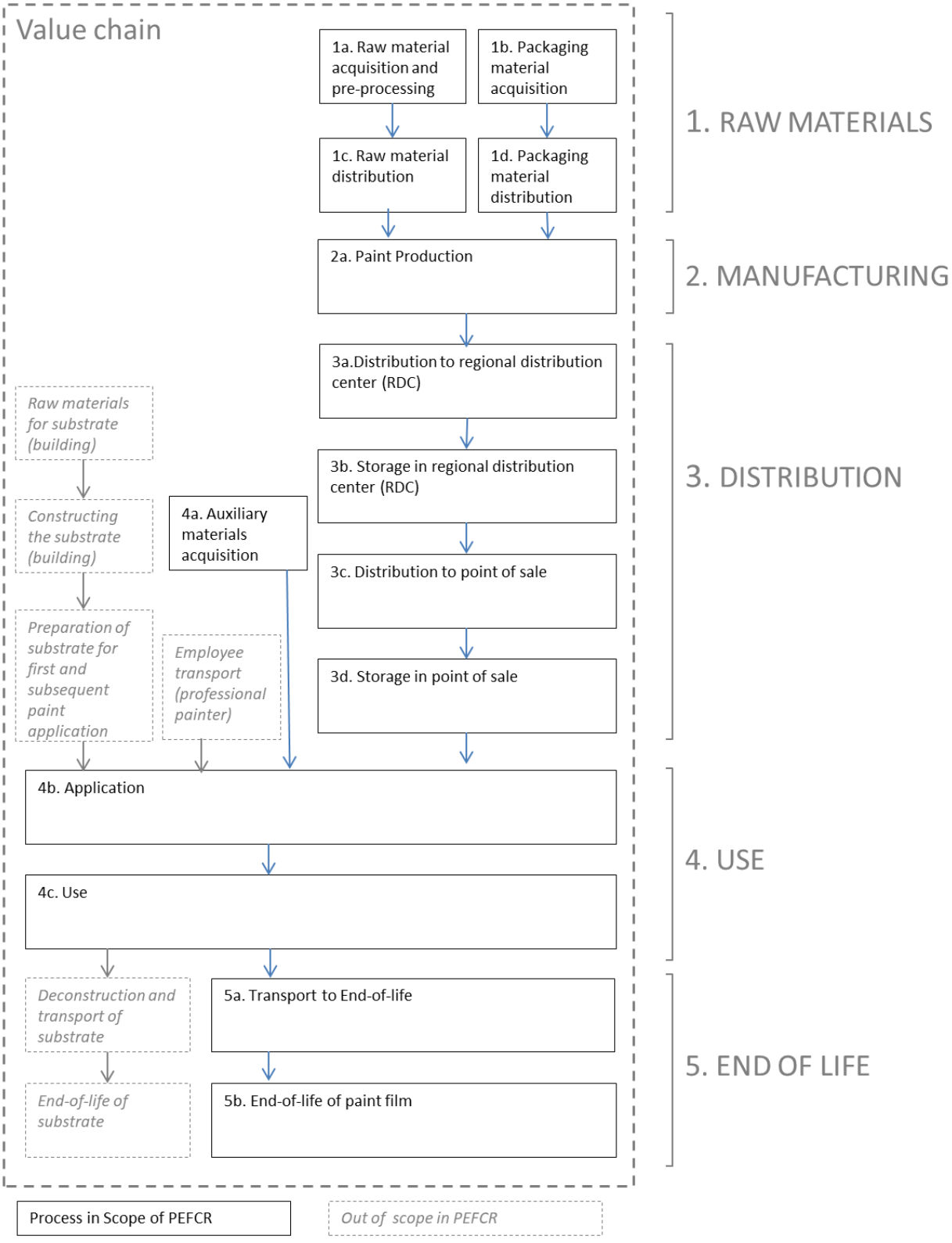

Figure 3.1 - System diagram

The following life cycle stages and processes shall be included in the system boundary (Table 3.8):

Table 3.8 - Detailed life cycle stages

Life cycle Stage	Substage	Short description of processes included
1. Raw materials	1a. Raw material acquisition and pre-processing	· Extraction of the natural resources (energy and materials used) · Transport of the materials from the point of extraction to the site of processing, and any on-site or intermediate transport · Processing of natural resources into paint raw materials including the impact of the energy requirements and waste processing. · Packaging of raw materials
	1b. Paint packaging material acquisition and pre-processing	· Extraction of the natural resources (energy and materials used) · Transport of the materials from the point of extraction to the site of processing, and any on site or intermediate transport · Processing of the natural resources into the paint packaging materials including the impact of the energy requirements and waste processing
	1c. Raw material distribution	· Fuel consumption for the operation of the vehicle during all transport activities · Fuel combustion (emissions) · Roads & Vehicles (construction and maintenance)
	1d. Paint packaging material distribution	· Fuel consumption for the operation of the vehicle during all transport activities · Fuel combustion (emissions) · Roads & Vehicles (construction and maintenance)
2. Manufacturing	2a. Paint production	· Utility use (e.g. energy and water) for processing at the production site · Disposal of waste generated in the production process: transport and end of life treatment · Emissions, both direct and indirect, during the production process
3. Distribution	3a. Distribution to Regional Distribution Centre (RDC)	· Fuel consumption for the operation of the vehicle during all transport activities · Fuel combustion (emissions) · Roads & Vehicles (construction and maintenance)
	3b. Storage in RDC	· Utility use (e.g. energy and water) & emissions · Disposal of waste generated: transport and end of life treatment (unsold paint and packaging materials) · Utility and paint losses are included
	3c. Distribution to Point of Sale (PoS)	· Fuel consumption for the operation of the vehicle during all transport activities · Fuel combustion (emissions) · Roads & Vehicles (construction and maintenance)

	3d. Storage in PoS	· Utility use (e.g. energy and water) & emissions · Disposal of waste generated: transport and end of life treatment (unsold paint and packaging materials) · Utility and paint losses are considered
4. Use	4a. Auxiliary materials	· Extraction of the natural resources (energy and materials used) · Transport of the materials and paint from the point of extraction to the site of processing, and any on site or intermediate transport (including fuel consumption for the operation of the vehicle during all transport activities, fuel combustion (emissions) and roads & vehicles (construction and maintenance))[7] · Processing of the natural resources into auxiliary materials including the impact of the energy requirements and waste processing – no losses · Distribution and storage for auxiliary materials (distribution to RDC, storage in RDC, distribution to PoS, storage in PoS, and distribution to paint location), including disposal of unsold materials.
	4b. Application	· Application of final product, including emissions to air and losses of paint · Disposal of waste generated: transport and end of life treatment (left-over paint, auxiliary materials and packaging) · Fuel consumption for the operation of the vehicle during all transport activities (from PoS to application site) · Fuel combustion (emissions) · Roads & Vehicles (construction and maintenance) [8]
	4c. Use	· Direct emissions over the lifetime of the coating (leaching of biocides for exterior coatings)
5. End of Life	5a. Transport to End-of-life	· Fuel consumption for the operation of the vehicle during all transport activities · Fuel combustion (emissions) · Roads & vehicles (construction and maintenance)
	5b. End-of-life of paint film	· Disposal of dried coating · Waste treatment · Energy recovery (avoided heat and electricity production) · Emission of biocides for interior coatings sent to landfill

[7] The transport process included in 4. Use is a deviation from the PEF Guidance it should be in 3. Distribution. This will be updated in a next version of this PEFCR.

[8] The transport process included in 4. Use is a deviation from the PEF Guidance it should be in 3. Distribution. This will be updated in a next version of this PEFCR.

3.5 EF impact assessment

Each PEF study carried out in compliance with this PEFCR shall calculate the PEF-profile including all PEF impact categories listed in Table 3.9 below.

Table 3.9 - List of the impact categories to be used to calculate the PEF profile.

Impact category	Indicator	Unit	Recommended default LCIA method
Climate change[9]	Radiative forcing as Global Warming Potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)
- Climate change-biogenic			
- Climate change – land use and land transformation			
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs 1999 as in WMO assessment
Human toxicity, cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)
Human toxicity, non-cancer*	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model (Rosenbaum et al, 2008)
Particulate matter	Impact on human health	disease incidence	UNEP recommended model (Fantke et al 2016)
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq U^{235} $_{eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC $_{eq}$	LOTOS-EUROS model (Van Zelm et al, 2008) as implemented in ReCiPe
Acidification	Accumulated Exceedance (AE)	mol H^+ $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N $_{eq}$	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N $_{eq}$	EUTREND model (Struijs et al, 2009b) as implemented in ReCiPe
Ecotoxicity, freshwater*	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model, (Rosenbaum et al, 2008)
Land use	• Soil quality index[10] • Biotic production • Erosion resistance	• Dimensionless (pt) • kg biotic production[11]	• Soil quality index based on LANCA (EC-JRC)[12] • LANCA (Beck et al. 2010)

[9] The sub-indicators 'Climate change - biogenic' and 'Climate change - land use and land transformation' shall be reported separately because their contribution to the total climate change impact, based on the benchmark results, is more than 5% each

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

[11] This refers to occupation. In case of transformation the LANCA indicators are without the year (a)

[12] Forthcoming document on the update of the recommended Impact Assessment methods and factors for the EF

Impact category	**Indicator**	**Unit**	**Recommended default LCIA method**
	• Mechanical filtration • Groundwater replenishment	• kg soil • m^3 water • m3 groundwater	• LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010) • LANCA (Beck et al. 2010)
Water use*[1]	User deprivation potential (deprivation-weighted water consumption)	m^3 world $_{eq}$	Available WAter REmaining (AWARE) Boulay et al., 2016
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb $_{eq}$	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002.
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002

*Long-term emissions (occurring beyond 100 years) shall be excluded from the toxic impact categories. Toxicity emissions to this sub-compartment have a characterisation factor set to 0 in the EF LCIA (to ensure consistency). If included by the applicant in the LCI modelling, the sub-compartment 'unspecified (long-term)' shall be used.

*[1]The results for water use might be overestimated and shall therefore be interpreted with caution. Some of the EF datasets tendered during the pilot phase and used in this PEFCR/OEFSR include inconsistencies in the regionalization and elementary flow implementations. This problem has nothing to do with the impact assessment method or the implementability of EF methods, but occurred during the technical development of some of the datasets. The PEFCR/OEFSR remains valid and usable. The affected EF datasets will be corrected by mid-2019. At that time it will be possible to review this PEFCR/OEFSR accordingly, if seen necessary.

The full list of normalization factors and weighting factors are available in Annex 7 - List of EF normalisation factors and weighting factors.

The full list of characterization factors (EC-JRC, 2017a) is available at this link http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml

3.6 Limitations

A PEF study will have the following limitations even if carried out in accordance with this PEFCR:

- The PEF distribution and use stage impact results reflect the average European situation, not necessarily the specific region or country specific values. The downstream scenario for decorative paints can vary significantly: distribution distances, application tool and surfaces, etc. For consistency across all European countries, all PEF studies shall use the generic European downstream scenario as defined in this PEFCR.
- It is allowed to make a comparison or comparative assertion. All information use in the comparison shall be based on verified EF studies (see chapter 8 verification).

4. Most relevant impact categories, life cycle stages and processes

4.1 Sub-category Indoor wall paint

The most relevant impact categories for this sub-category in scope of this PEFCR are:

- Climate change
- Particulate matter
- Acidification
- Resource use, fossils

The most relevant life cycle stages for the sub-category in scope of this PEFCR are:

Table 4.1 - Most relevant life cycle stages for indoor wall paints

Impact categories	**Life cycle stage**
Climate change	1. Raw materials
	4. Use
	5. End of Life
Particulate matter	1. Raw materials
	4. Use
Acidification	1. Raw materials
	4. Use
Resource use, fossils	1. Raw materials
	4. Use

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

Table 4.2 - Most relevant processes for indoor wall paints

Impact category	**Processes and datasets**
Climate change	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	GLO: Paints additive (LC stage 1)
	EU-28+3: Electricity grid mix 1kV-60kV (LC stage 2)
	EU-28+3: Thermal energy from natural gas (LC stage 3)
	GLO: Passenger car. average (LC stage 4)
	EU-28+EFTA: Landfill of municipal solid waste (LC stage 5)
Particulate matter	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	GLO: Paints additive (LC stage 1)
	EU-28+EFTA: Pallet. wood (80x120) (LC stage 1)
	GLO: Passenger car. average (LC stage 4)
Acidification	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	GLO: Passenger car. average (LC stage 4)
Resource use, fossils	GLO: Styrene acrylate dispersion (LC stage 1)
	RER: titanium dioxide production (LC stage 1)
	GLO: Paints additive (LC stage 1)
	EU-28+EFTA: PP granulates (LC stage 1)
	EU-28+3: Electricity grid mix 1kV-60kV (LC stage 2)
	GLO: Passenger car. average (LC stage 4)

4.2 Sub-category Indoor wood paint

The most relevant impact categories for this sub-category in scope of this PEFCR are:

- Climate change
- Particulate matter
- Photochemical ozone formation
- Acidification
- Resource use, fossils

The most relevant life cycle stages for the sub-category in scope of this PEFCR are:

Table 4.3 - Most relevant life cycle stages for indoor wood paints

Impact categories	**Life cycle stage**
Climate change	1. Raw materials
	4. Use
Particulate matter	1. Raw materials
	4. Use
Photochemical ozone formation	1. Raw materials
	4. Use
Acidification	1. Raw materials
Resource use, fossils	1. Raw materials
	4. Use

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

Table 4.4 - Most relevant processes for indoor wood paints

Impact category	**Processes and datasets**
Climate change	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	RER: Propylene glycol production (LC stage 1)
	GLO: Paints additive (LC stage 1)
	RER: Sodium silicate powder production (LC stage 1)
	EU-28+3: Electricity grid mix 1kV-60kV (LC stage 2)
	GLO: Passenger car. average (LC stage 4)
	Application Scenario <u-so> (LC stage 4)
	EU-28+EFTA: Waste incineration of paint (LC stage 5)
Particulate matter	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	RER: Propylene glycol production (LC stage 1)
	EU-28+EFTA: Pallet. wood (80x120) (LC stage 1)
	GLO: Passenger car. average (LC stage 4)
Photochemical ozone formation	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	Application Scenario (direct VOC emissions) (LC stage 4)
	GLO: Passenger car. average (LC stage 4)
Acidification	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	GLO: Passenger car. average (LC stage 4)
Resource use, fossils	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	RER: Propylene glycol production (LC stage 1)

	GLO: Paints additive (LC stage 1)
	EU-28+EFTA: PP granulates (LC stage 1)
	EU-28+3: Electricity grid mix 1kV-60kV (LC stage 2)
	GLO: Passenger car. average (LC stage 4)

4.3 Sub-category Outdoor wall paint

The most relevant impact categories for this sub-category in scope of this PEFCR are:

- Climate change
- Particulate matter
- Acidification
- Resource use, fossils

The most relevant life cycle stages for the sub-category in scope of this PEFCR are:

Table 4.5 - Most relevant life cycle stages for outdoor wall paints

Impact categories	**Life cycle stage**
Climate change	1. Raw materials
	4. Use
	5. End of Life
Particulate matter	1. Raw materials
Acidification	1. Raw materials
Resource use, fossils	1. Raw materials
	4. Use

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

Table 4.6 - Most relevant processes for outdoor wall paints

Impact category	**Processes and datasets**
Climate change	GLO: Styrene acrylate dispersion (LC stage 1)
	RER: titanium dioxide production (LC stage 1)
	GLO: Paints additive (LC stage 1)
	EU-28+3: Electricity grid mix 1kV-60kV (LC stage 2)
	GLO: Passenger car. average (LC stage 4)
	EU-28+EFTA: Landfill of municipal solid waste (LC stage 5)
Particulate matter	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	EU-28+EFTA: Pallet. wood (80x120) (LC stage 1)
	GLO: Passenger car. average (LC stage 4)
Acidification	RER: titanium dioxide production (LC stage 1)
	GLO: Styrene acrylate dispersion (LC stage 1)
	GLO: Passenger car. average (LC stage 4)
Resource use, fossils	GLO: Styrene acrylate dispersion (LC stage 1)
	RER: titanium dioxide production (LC stage 1)
	GLO: Paints additive (LC stage 1)
	EU-28+EFTA: PP granulates (LC stage 1)
	EU-28+3: Electricity grid mix 1kV-60kV (LC stage 2)
	GLO: Passenger car. average (LC stage 4)

4.4 Sub-category Outdoor wood paint

The most relevant impact categories for this sub-category in scope of this PEFCR are:

- Climate change
- Particulate matter
- Acidification
- Photochemical ozone formation
- Resource use, fossils

The most relevant life cycle stages for the sub-category in scope of this PEFCR are:

Table 4.7 - Most relevant life cycle stages for outdoor wood paints

Impact categories	**Life cycle stage**
Climate change	1. Raw materials
	4. Use
Particulate matter	1. Raw materials
	4. Use
Acidification	1. Raw materials
Photochemical ozone formation	4. Use
Resource use, energy carriers	1. Raw materials
	4. Use

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

Table 4.8 - Most relevant processes for outdoor wood paints

Impact category	**Processes and datasets**
Climate change	RER: titanium dioxide production (LC stage 1)
	EU-27: Alkyd resin (sunflower oil) (LC stage 1)
	Application Scenario <u-so> (LC stage 4)
	GLO: Passenger car. average (LC stage 4)
	EU-28+EFTA: Waste incineration of paint (LC stage 5)
Particulate matter	RER: titanium dioxide production (LC stage 1)
	EU-27: Alkyd resin (sunflower oil) (LC stage 1)
	EU-28+EFTA: Pallet. wood (80x120) (LC stage 1)
	GLO: Passenger car. average (LC stage 4)
Acidification	RER: titanium dioxide production (LC stage 1)
	EU-27: Alkyd resin (sunflower oil) (LC stage 1)
Photochemical ozone formation	EU-27: Alkyd resin (sunflower oil) (LC stage 1)
	Application Scenario (direct VOC emissions) (LC stage 4)
Resource use, energy carriers	EU-27: Alkyd resin (sunflower oil) (LC stage 1)
	RER: titanium dioxide production (LC stage 1)
	EU-28+3: Naphtha at refinery (LC stage 1)
	EU-28+EFTA: PP granulates (LC stage 1)
	GLO: Passenger car. average (LC stage 4)

5 Life cycle inventory

All newly created processes shall be EF-compliant.

5.1 List of mandatory company-specific data

The process paint production (in LC stage 2a) shall always use company-specific data.

The processes that require have mandatory company-specific input data are found in the following lifecycle stages:

- 1a. Raw material acquisition and pre-processing
- 2a. Paint production
- 4b. Application
- 4c. Use
- 5b. End-of-life treatment

All specific data required for these processes are based on the product properties measured or determined at production. These are:

1. **Paint density:** The volumetric mass density of a paint is its mass per unit volume. Unit: kg/L
2. **Biocidal content:** Quantity and type of biocidal substance present in the paint (e.g. BIT, MIT, Terbutryn, Carbamic acid, Morpholine). Unit: gram/kg
3. **VOC content**: The VOC content expressed as grams of VOCs per liter of paint shall be determined based on the CEPE VOC Guidance in Annex 3. Unit: gram/L.
4. **Dry mass:** Weight of the paint product after the full evaporation of water and solvents present in the paint. Unit: gram/kg.
5. **Coverage:** The surface area one can paint with one liter of product with an appropriate coverage level. Based on product specific test data. Determined according the guidance in Annex 5. Unit: m^2/L.
6. **Maintenance multiplier:** The number of maintenance cycles over the lifetime of the building. The maintenance multiplier is calculated according to the Guidance in Annex 4 – Durability. Depending on the type of paint, the specific tests shall be performed in order to measure the quality of paint and therefore the paint frequency. Unit: none.

Production process Inputs

7. **Bill of Materials**: For each raw material in the paint formulations; the name and quantity in %weight/weight shall be collected.
8. **Production losses:** The production loss is the fraction of Raw materials that is lost when producing 1 kg of paint. If for example, on a yearly basis, 103 tonnes of paint ingredients are used to produce 100 tonnes of packed paint. The production losses are 3 tonnes, or: 3 (losses) / 100 (paint in pack) = 0.03. Unit: none.
9. **Diesel:** Unit: kg/kg produced.
10. **Electricity:** specific electricity mix shall be used following the procedure from chapter 5.9 Unit: kWh/kg produced.
11. **Light Fuel Oil:** Fuel oil for heating. Unit: kg/kg produced.
12. **Liquefied Petroleum Gas (LPG):** Liquefied Petroleum Gas. Unit: kg/kg produced
13. **Natural gas (NG):** Natural gas for heating. Unit: MJ/kg produced.

14. **Process water:** Operating materials should be used when possible. The water consumption for other purposes shall be included. Unit: kg/kg produced.

Production process Outputs

15. **Hazardous waste (unspecified):** Hazardous waste according to the European waste directive 2008/98/EC Unit: kg/kg produced.
16. **Non-hazardous waste (unspecified):** Non-hazardous waste according to the European waste directive 2008/98/EC Unit: kg/kg produced.
17. **Water emitted:** Total water emitted to waste water treatment systems Unit: kg/kg produced.

Table 5.1 - Data collection requirements for Paint production

#	**Primary data requirements for Paint production**			**Input to LC Stage**	**Requirements for modelling purposes**
	Activity data to be collected	*Specific requirement*	*Unit of measure*		
Product properties / parameters for modelling:					
1	Paint density	From the formulation of the paint product	kg/L of paint	4b	Not applicable
2	Biocidal content	From the formulation of the paint product	gram/kg of paint	4c, 5b	Not applicable
3	VOC content	According the CEPE VOC guidance in Annex 3 as part of the formulation.	gr/L of paint	4b, 5b	Not applicable
4	Dry mass	Paint weight after full evaporation of water and VOCs	kg/kg of paint	4b	Not applicable
5	Coverage	See Annex 5	m2/L of paint	4b	Not applicable
6	Maintenance multiplier	See Annex 4	unitless	4b	Not applicable
Production process Inputs:					
7	Bill of Materials	Based on the actual formulation of the paint product.	% w/w for 1 kg of paint	1a	Not applicable
8	Production losses	Fraction of paint lost when producing 1 kg of paint	unitless	2a	Not applicable
9	Diesel	Use per kg of produced paint product	kg/kg produced paint	2a	Not applicable
10	Electricity	Use per kg of produced paint product	kWh/kg produced paint	2a	Not applicable
11	Light Fuel Oil	Use per kg of produced paint product	kg/kg produced paint	2a	Not applicable
12	Liquefied Petroleum Gas (LPG)	Use per kg of produced paint product	kg/kg produced paint	2a	Not applicable

13	Natural Gas (NG)	Use per kg of produced paint product	MJ/kg produced paint	2a	Not applicable
14	ProcessWater	Use per kg of produced paint product	kg/kg produced paint	2a	Not applicable
Production process Outputs:					
15	Hazardous waste	Production residues in life cycle	kg/kg produced paint	2a	Not applicable
16	Non-hazardous waste	Production residues in life cycle	kg/kg produced paint	2a	Not applicable
17	Waste water	Water emitted to municipal waste water treatment	kg/kg produced paint	2a	Not applicable

There is no primary data needed on elementary flows.

For production of the same product in multiple sites, with differences in formulation and use of utilities and waste generation, a weighted average of the different sites shall be used. In case waste is treated on-site, impacts related to this treatment shall be included.

Utilities, consumables and other materials consumed in the operation of the manufacturing process shall be gathered as a whole. All data shall be collected and averaged with the total production of one calendar year to average seasonal variations. In the case of multiple paint products being produced on the same site, the data shall first be collected specifically for the paint product under study. If this is not possible, an allocation based on production volume shall be made.

Utility use and waste shall include that from offices, support and administrative functions related to the manufacturing process.

Where the site is shared with another function (such as R&D, HR, sales, etc) and there is no separate metering of the utility use or waste generation no allocation to these other functions shall be applied. Utility use and waste generation shall be measured for the smallest division which includes still the entire manufacturing operation (e.g. if the water use for the manufacturing operations and the sales functions are metered together, but metered separately from the R&D operations, then the value for the manufacturing and sales operations shall be used). Each type of utility, consumable and waste types, can be considered separately (e.g. water use may be based on the manufacturing operations use, and electricity on total site use).

5.2 List of processes expected to be run by the company

No processes are expected to be run by the company applying the PEFCR that are not covered in chapter 5.1.

The stages related to transport could be run by the company:

- 1c. Raw material distribution
- 1d. Paint packaging material distribution
- 3a. Distribution to Regional Distribution Centre (RDC)
- 3c. Distribution to Point of Sale (PoS)

In case a company wants to deviate from the default values from chapter 6 for transport and use company specific transport data a European average company specific transport scenario shall be developed. This shall be a weighted average of the actual transport distances and modes for the full European operations of the products the company is analysing. This analysis shall be added to the PEF Study background report.

5.3 Data gaps

Due to the large number of raw materials used in the decorative coatings industry, not all raw materials might be represented in the EF compliant datasets available in the different nodes available. For substances which do not have an EF-compliant dataset available in any node the following alternative sources of data sets shall be used:

CEPE approved data gap selection guide
If the data is listed in the CEPE approved data gap selection guidance, the data set can be used along with the approved data quality analysis values. This is relevant for the raw material list for a paint formulation for which selections are made. See the list in the excel Annex Tab 1. If the raw material is not in the CEPE data gap selection guidance, the user shall use the procedure as described in chapter 5.6. This could also lead to using supplier specific data, as long as it is in line with the requirements of chapter 5.6.

5.4 Data quality requirements

The data quality of each dataset and the total EF study shall be calculated and reported. The calculation of the DQR shall be based on the following formula with 4 criteria:

$$DQR = \frac{\overline{Te_R}+\overline{G_R}+\overline{Ti_R}+\bar{P}}{4} \qquad \textit{[Equation 1]}$$

where TeR is the Technological-Representativeness, GR is the Geographical-Representativeness, TiR is the Time-Representativeness, and P is the Precision/uncertainty. The representativeness (technological, geographical and time-related) characterises to what degree the processes and products selected are depicting the system analysed, while the precision indicates the way the data is derived and related level of uncertainty.
The next chapters provide tables with the criteria to be used for the semi-quantitative assessment of each criterion. If a dataset is constructed with company-specific activity data, company - specific emission data and secondary sub-processes, the DQR of each shall be assessed separately.

5.4.1 Company-specific datasets

The score of criterion P cannot be higher than 3 while the score for TiR, TeR, and GR cannot be higher than 2 (the DQR score shall be ≤1.6). The DQR shall be calculated at the level-1 disaggregation, before any aggregation of sub-processes or elementary flows is performed. The DQR of company-specific datasets shall be calculated as following:

1) Select the most relevant sub-processes and direct elementary flows that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one.

2) Calculate the DQR criteria TeR, TiR, GR and P for each most relevant process and each most relevant direct elementary flow. The values of each criterion shall be assigned based on Table 5.2

2.a) Each most relevant elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, evaluate the 4 DQR criteria named $Te_{R\text{-}EF}$, $Ti_{R\text{-}EF}$, $G_{R\text{-}EF}$, P_{EF} in Table 5.2. It shall be evaluated for example, the timing of the flow measured, for which technology the flow was measured and in which geographical area.

2.b) Each most relevant process is a combination of activity data and the secondary dataset used. For each most relevant process, the DQR is calculated by the applicant of the PEFCR as a combination of the 4 DQR criteria for activity data and the secondary dataset: (i) Ti_R and P shall be evaluated at the level of the activity data (named $Ti_{R\text{-}AD}$, P_{AD}) and (ii) Te_R, Ti_R and G_R shall be evaluated at the level of the secondary dataset used (named $Te_{R\text{-}SD}$, $Ti_{R\text{-}SD}$ and $G_{R\text{-}SD}$). As Ti_R is evaluated twice, the mathematical average of $Ti_{R\text{-}AD}$ and $Ti_{R\text{-}SD}$ represents the Ti_R of the most relevant process.

3) Calculate the environmental contribution of each most-relevant process and elementary flow to the total environmental impact of all most-relevant processes and elementary flows, in % (weighted using 13 EF impact categories, with the exclusion of the 3 toxicity-related ones). For example, the newly developed dataset has only two most relevant processes, contributing in total to 80% of the total environmental impact of the dataset:

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

4) Calculate the Te_R, Ti_R, G_R and P criteria of the newly developed dataset as the weighted average of each criterion of the most relevant processes and direct elementary flows. The weight is the relative contribution (in %) of each most relevant process and direct elementary flow calculated in step 3.

5) The applicant of the PEFCR shall derive the total DQR of the newly developed dataset using the equation B.2, where $\overline{Te_R}$, $\overline{G_R}$, $\overline{Ti_R}$, $\overline{P}$ are the weighted average calculated as specified in point 4).

$$DQR = \frac{\overline{Te_R}+\overline{G_R}+\overline{Ti_R}+\overline{P}}{4} \qquad \text{[Equation B.2]}$$

NOTE: in case the newly developed dataset has most relevant processes filled in by non-EF compliant datasets (and thus without DQR), then these datasets cannot be included in step 4 and 5 of the DQR calculation. (1) The weight of step 3 shall be recalculated for the EF-compliant datasets only. Calculate the environmental contribution of each most-relevant EF compliant process and elementary flow to the total environmental impact of all most-relevant EF compliant processes and elementary flows, in %. Continue with step 4 and 5. (2) The weight of the non-EF compliant dataset (calculated in step 3) shall be used to increase the DQR criteria and total DQR accordingly. For example:

- Process 1 carries 30% of the total dataset environmental impact and is ILCD entry level compliant. The contribution of this process to the total of 80% is 37.5% (the latter is the weight to be used).

- Process 1 carries 50% of the total dataset environmental impact and is EF compliant. The contribution of this process to all most-relevant EF compliant processes is 100%. The latter is the weight to be used in step 4.
- After step 5, the parameters $\overline{Te_R}, \overline{G_R}, \overline{Ti_R}, \overline{P}$ and the total DQR shall be multiplied with 1.375.

Table 5.2 - How to assess the value of the DQR criteria for datasets with company-specific information

\	P_{EF} and P_{AD}	$Ti_{R\text{-}EF}$ and $Ti_{R\text{-}AD}$	$Ti_{R\text{-}SD}$	$Te_{R\text{-}EF}$ and $Te_{R\text{-}SD}$	$G_{R\text{-}EF}$ and $G_{R\text{-}SD}$
1	Measured/calculated and externally verified	The data refers to the most recent annual administration period with respect to the EF report publication date	The EF report publication date happens within the time validity of the dataset	The elementary flows and the secondary dataset reflect exactly the technology of the newly developed dataset	The data(set) reflects the exact geography where the process modelled in the newly created dataset takes place
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the EF report publication date	The EF report publication date happens not later than 2 years beyond the time validity of the dataset	The elementary flows and the secondary dataset is a proxy of the technology of the newly developed dataset	The data(set) partly reflects the geography where the process modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the EF report publication date	Not applicable	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

5.5 Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific (listed in section 5.1) shall be evaluated using the Data Needs Matrix (see table 5.3). The DNM shall be used by the PEFCR applicant to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the applicant (company) has on the specific process. The following three cases are found in the DNM and are explained below:

1. **Situation 1**: the process is run by the company applying the PEFCR

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

Table 5.3 - Data Needs Matrix (DNM)[13] *Disaggregated datasets shall be used.

		Most relevant process	Other process
Situation 1: process run by the company applying the PEFCR	**Option 1**	Provide company-specific data (as requested in the PEFCR) and create a company specific dataset partially disaggregated at least at level 1 (DQR ≤1.6). Calculate the DQR values (for each criteria + total)	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR ≤3.0). Use the default DQR values
Situation 2: process not run by the company applying the PEFCR but with access to (company-)specific information	**Option 1**	Provide company-specific data (as requested in the PEFCR) and create a company specific dataset partially disaggregated at least at level 1 (DQR ≤1.6). Calculate the DQR values (for each criteria + total)	
	Option 2	Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets (DQR ≤3.0).* Re-evaluate the DQR criteria within the product specific context	
	Option 3		Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets (DQR ≤4.0). Use the default DQR values
Situation 3: process not run by the company applying the PEFCR and without access to (company)-specific information	**Option 1**	Use default secondary dataset, in aggregated form (DQR ≤3.0). Re-evaluate the DQR criteria within the product specific context	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR ≤4.0) Use the default DQR values

5.5.1 Processes in situation 1

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

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

[13] The options described in the DNM are not listed in order of preference

Situation 1/Option 1

For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section B.5.4.1.

Situation 1/Option 2

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

5.5.2 Processes in situation 2

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

- The company applying the PEFCR has access to extensive supplier-specific information and wants to create a new EF-compliant dataset[14] (Option 1);
- The company has some supplier-specific information and want to make some minimum changes (Option 2).
- The process is not in the list of most relevant processes and the company prefers to use a secondary dataset (option 3).

Situation 2/Option 1
For all processes run by the company and where the company applying the PEFCR uses company specific data. The DQR of the newly developed dataset shall be evaluated as described in section 5.4.1.

Situation 2/Option 2
Company-specific activity data for transport are used and the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets are substituted starting from the default secondary dataset provided in the PEFCR.
Please note that, the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.
The applicant of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating Te_R and Ti_R, using the table(s) provided 5.4. The criteria G_R shall be lowered by 30%[15] and the criteria P shall keep the original value.

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

[14] The review of the newly created dataset is optional

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

Table 5.4 How to assess the value of the DQR criteria when secondary datasets are used.

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

5.5.3 Processes in situation 3

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

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

Situation 3/Option 1

In this case, the applicant of the PEFCR shall make the DQR values of the dataset used context-specific by re-evaluating Te_R, Ti_R and G_r, using the table(s) provided. The criteria P shall keep the original value.

Situation 3/Option 2

For the non-most relevant processes, the applicant shall use the corresponding secondary dataset listed in the PEFCR together with its DQR values.

If the default dataset to be used for the process is not listed in the PEFCR, the applicant of the PEFCR shall take the DQR values from the original dataset.

5.6 Which datasets to use?

The secondary datasets to be used by the applicant are those listed in this PEFCR. Whenever a dataset needed to calculate the PEF-profile is not among those listed in this PEFCR, then the applicant shall choose between the following options (in hierarchical order):

- Use an EF-compliant dataset available on one of the following nodes:
  - http://eplca.jrc.ec.europa.eu/EF-node
  - http://lcdn.blonkconsultants.nl
  - http://ecoinvent.lca-data.com
  - http://lcdn-cepe.org
  - https://lcdn.quantis-software.com/PEF/
  - http://lcdn.thinkstep.com/Node
- Use an EF-compliant dataset available in a free or commercial source;
- Use another EF-compliant dataset considered to be a good proxy. In such case this information shall be included in the "limitation" section of the PEF report.
- Use an ILCD-entry level-compliant dataset that has been modelled according to the modelling requirements included in the Guidance version 6.3. In such case this information shall be included in the "limitations" section of the PEF report.
- Use an ILCD-entry level-compliant dataset. In such case this information shall be included in the "data gap" section of the PEF report.

5.7 How to calculate the average DQR of the study

In order to calculate the average DQR of the EF study, the applicant shall calculate separately the TeR, TiR, GR and P for the EF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single score (excluding the 3 toxicity-related ones). The calculation rules explained in chapter 5.4 shall be used.

5.8 Allocation rules

The allocation rules that apply to the PEFCR scope (paint manufacturing) are based on the physical relationship between the inputs and the outputs (paint ingredients). Paint manufacturing processes do not commonly involve multiple output processes. In case allocation is needed in a PEF study, mass allocation shall be used. If mass allocation is deemed not appropriate method follow the guidance in the PEF guide. The allocation that was applied shall be explained and justified in the PEF report. For allocation related to raw materials the relevant PEFCRs shall be followed in case they are not available the PEF guide shall be followed. The allocation applied shall be explained and justified in the PEF report.

5.9 Electricity modelling

The guidelines in this section shall only be used for the processes where company-specific information is collected (situation 1 / Option 1 & 2 / Option 1of the DNM).

The following electricity mix shall be used in hierarchical order:

(i) Supplier-specific electricity product shall be used if:
   (a) available, and
   (b) the set of minimum criteria to ensure the contractual instruments are reliable is met.

(ii) The supplier-specific total electricity mix shall be used if:
   (a) available, and
   (b) the set of minimum criteria that to ensure the contractual instruments are reliable is met.

(iii) As a last option the 'country-specific residual grid mix, consumption mix' shall be used (available at http://lcdn.thinkstep.com/Node/). Country-specific means the country in which the life cycle stage occurs. This may be an EU country or non-EU country. The residual grid mix characterizes the unclaimed, untracked or publicly shared electricity. This prevents double counting with the use of supplier-specific electricity mixes in (i) and (ii).

Note: if for a country, there is a 100% tracking system in place, case (i) shall be applied.

Note: for the use stage, the consumption grid mix shall be used.

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

Set of minimal criteria to ensure contractual instruments from suppliers:
A supplier-specific electricity product/mix may only be used when the applicant ensures that any contractual instrument meets the criteria specified below. If contractual instruments do not meet the criteria, then 'country-specific residual grid mix, consumption mix' shall be used in the modelling.

A contractual instrument used for electricity modelling shall:

1. Convey attributes:
   - Convey the energy type mix associated with the unit of electricity produced.
   - The energy type mix shall be calculated based on delivered electricity, incorporating certificates sourced and retired on behalf of its customers. Electricity from facilities for which the attributes have been sold off (via contracts or certificates) shall be characterized as having the environmental attributes of the country residual consumption mix where the facility is located.
2. Be a unique claim:
   - Be the only instruments that carry the environmental attribute claim associated with that quantity of electricity generated.
   - Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g. by an audit of contracts, third party certification, or may be handled automatically through other disclosure registries, systems, or mechanisms).
3. Be as close as possible to the period to which the contractual instrument is applied.

Modelling 'country-specific residual grid mix, consumption mix':

Datasets for residual grid mix, per energy type, per country and per voltage have been purchased by the European Commission and are available in the dedicated node (http://lcdn.thinkstep.com/Node/). In case the necessary dataset is not available, an alternative dataset shall be chosen according to the procedure described in section 5.8. If no dataset is available, the following approach may be used:

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

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

  These data may be found in the publications of the International Energy Agency (IEA).
- Available LCI datasets per fuel technologies in the node. The LCI datasets available are generally specific to a country or a region in terms of:
    - Fuel supply (share of resources used, by import and / or domestic supply),
    - Energy carrier properties (e.g. element and energy contents)
    - Technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.

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

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

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

On-site electricity generation:
If on-site electricity production is equal to the site own consumption, two situations apply:

- No contractual instruments have been sold to a third party: the own electricity mix (combined with LCI datasets) shall be modelled.
- Contractual instruments have been sold to a third party: the 'country-specific residual grid mix, consumption mix' (combined with LCI datasets) shall be used.

If electricity is produced in excess of the amount consumed on-site within the defined system boundary and is sold to, for example, the electricity grid, this system can be seen as a multifunctional situation. The system will provide two functions (e.g. product + electricity) and the following rules shall be followed:

- If possible, apply subdivision.
- Subdivision applies both to separate electricity productions or to a common electricity production where you can allocate based on electricity amounts the upstream and direct emissions to your own consumption and to the share you sell out of your company (e.g. if a company has a wind mill on its production site and export 30% of the produced electricity, emissions related to 70% of produced electricity should be accounted in the PEF study.
- If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[16].
- Subdivision is considered as not possible when upstream impacts or direct emissions are closely related to the product itself.

5.10 Climate change modelling

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

1. Climate change – fossil: This sub-category includes emissions from peat and calcination/carbonation of limestone. The emission flows ending with '(fossil)' (e.g., 'carbon dioxide (fossil)" and 'methane (fossil)') shall be used if available.
2. Climate change – biogenic: This sub-category covers carbon emissions to air (CO_2, CO and CH_4) originating from the oxidation and/or reduction of biomass by means of its transformation or degradation (e.g. combustion, digestion, composting, landfilling) and CO_2 uptake from the atmosphere through photosynthesis during biomass growth – i.e. corresponding to the carbon content of products, biofuels or aboveground plant residues such as litter and dead wood. Carbon exchanges from native forests[17] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.

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

[16] For some countries, this option is a best case rather than a worst case.

[17] Native forests – represents native or long-term, non-degraded forests. Definition adapted from table 8 in Annex V C(2010)3751 to Directive 2009/28/EC.

The product life cycle or part of the life cycle does not have a carbon storage beyond 100 years and therefore no credits from biogenic carbon storage shall be modelled.

3. Climate change – land use and land transformation: This sub-category accounts for carbon uptakes and emissions (CO2, CO and CH4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (incl. soil carbon emissions). For native forests, all related CO2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest18 and residues), while their CO2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.
   For land use change, all carbon emissions and removals shall be modelled following the modelling guidelines of PAS 2050:2011 (BSI 2011) and the supplementary document PAS2050-1:2012 (BSI 2012) for horticultural products. PAS 2050:2011 (BSI 2011): Large emissions of GHGs can result as a consequence of land use change. Removals as a direct result of land use change (and not as a result of long-term management practices) do not usually occur, although it is recognized that this could happen in specific circumstances. Examples of direct land use change are the conversion of land used for growing crops to industrial use or conversion from forestland to cropland. All forms of land use change that result in emissions or removals are to be included. Indirect land use change refers to such conversions of land use as a consequence of changes in land use elsewhere. While GHG emissions also arise from indirect land use change, the methods and data requirements for calculating these emissions are not fully developed. Therefore, the assessment of emissions arising from indirect land use change is not included.
   The GHG emissions and removals arising from direct land use change shall be assessed for any input to the life cycle of a product originating from that land and shall be included in the assessment of GHG emissions. The emissions arising from the product shall be assessed on the basis of the default land use change values provided in PAS 2050:2011 Annex C, unless better data is available. For countries and land use changes not included in this annex, the emissions arising from the product shall be assessed using the included GHG emissions and removals occurring as a result of direct land use change in accordance with the relevant sections of the IPCC (2006). The assessment of the impact of land use change shall include all direct land use change occurring not more than 20 years, or a single harvest period, prior to undertaking the assessment (whichever is the longer). The total GHG emissions and removals arising from direct land use change over the period shall be included in the quantification of GHG emissions of products arising from this land on the basis of equal allocation to each year of the period[19].

1) Where it can be demonstrated that the land use change occurred more than 20 years prior to the assessment being carried out, no emissions from land use change should be included in the assessment.

[18] Following the instantaneous oxidation approach in IPCC 2013 (Chapter 2).
[19] In case of variability of production over the years , a mass allocation should be applied.

2) Where the timing of land use change cannot be demonstrated to be more than 20 years, or a single harvest period, prior to making the assessment (whichever is the longer), it shall be assumed that the land use change occurred on 1 January of either:
   - the earliest year in which it can be demonstrated that the land use change had occurred; or
   - on 1 January of the year in which the assessment of GHG emissions and removals is being carried out.

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

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

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

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

The sum of the three sub-categories shall be reported.
The sub-category 'Climate change-biogenic' shall be reported separately.
The sub-category 'Climate change-land use and land transformation' shall be reported separately.

5.11 Modelling of wastes and recycled content

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

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

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

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

With the following parameters:
A: allocation factor of burdens and credits between supplier and user of recycled materials.

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

Q_{Sin}: quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.

Q_{Sout}: quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.

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

R_1: it is the proportion of material in the input to the production that has been recycled from a previous system.

R_2: it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.

R_3: it is the proportion of the material in the product that is used for energy recovery at EoL.

$E_{recycled}$ (E_{rec}): specific emissions and resources consumed (per unit of analysis) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.

$E_{recyclingEoL}$ (E_{recEoL}): specific emissions and resources consumed (per unit of analysis) arising from the recycling process at EoL, including collection, sorting and transportation process.

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

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

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

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

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

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

LHV: Lower Heating Value of the material in the product

6. Life cycle stages

To appropriately model the life cycle stages based on the data collected in Chapter 5, the life cycle models shall be developed based on the guidance in this chapter. This chapter lists all technical requirements and assumptions to be used by the applicant and a reference to the associated process tables in the Excel annex Tab 2 (the file "PEFCR decorative paints life cycle stages" is available at http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR.html). For all processes the DQR values shall be reported (for each criterion + total) for all the datasets used. For consistency across all European countries, all PEF studies shall use the generic European downstream scenario as defined in this PEFCR. It is not allowed to deviate from these default parameters. See also the comment in chapter 3.6 and the clarification in Annex 4.5.4 under regional differences.

6.1 Raw material acquisition and pre-processing

LC Stage 1a. Raw material acquisition and pre-processing
See one example **Table 6.1.1** below. Other related tables with processes in Excel annex Tab 2: Table 6.1.1-6.1.4

Technical requirements and assumptions:

- The raw material production processes are never expected to be run by the company.
- The raw materials are based on the Bill of Materials.

LC Stage 1b. Paint packaging material acquisition and pre-processing
Related table with processes in Excel annex PEFCR: Table 6.1.5

Technical requirements and assumptions:

- As the packaging reuse is not under the influence of the paint manufacturer, no reuse is assumed as a worst-case scenario.

LC Stage 1c. Raw material distribution
Related table with processes in Excel annex PEFCR: Table 6.1.6

Technical requirements and assumptions:

- A total utilization rate of the truck is 64% (Utilization & empty return is applied in line with the PEF default data).
- The applicant of this PEFCR shall always check the utilisation ratio applied in the default dataset and adapt it accordingly.
- The raw materials are transported by truck over 460 km to the Paint production location. These distances are based on representative European industry averages.

LC Stage 1d. Paint packaging material distribution
Related table with processes in Excel annex PEFCR: Table 6.1.7

Technical requirements and assumptions:

- A total utilization rate of the truck is 64% (Utilization & empty return is applied in line with the PEF default data).
- The applicant of this PEFCR shall always check the utilisation ratio applied in the default dataset and adapt it accordingly.
- The packaging materials are transported by truck over 250 km to the Paint production location. These distances are based on representative European industry averages.

Example Table 6.1.1 Indoor wall 1a. Raw material acquisition and pre-processing

*Process name**	*Unit of measurement*	*Default*				*UUID*	*Default DQR*				*Most relevant process [Y/N]*	*Recycling (R1)*	*Utilisation ratio* (inc empty return)*
		Amount	*comment / mandatory company-specific data*	*Dataset*	*Dataset source*		*P*	*TiR*	*GR*	*TeR*			
INPUT													
Styrene Acrylate dispersion (SA), 50% in water	kg	2,10E+01	7. Bill of Materials	Styrene acrylate dispersion technology mix Production mix, at plant 50% in water	http://lcdn-cepe.org	52c3c043-c70d-4e20-a55e-aeac6e8fecb5	3	3	2	3	Y	0	
Titanium Dioxide	kg	1,09E+01	7. Bill of Materials	titanium dioxide production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	06fa4d7a-939c-4c42-b177-6b5bb45aaf94	2	1	1	2	Y	0	
GCC dry	kg	2,72E+01	7. Bill of Materials	Ground calcium carbonate production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	8a229880-bcf4-46ba-aa92-ad538a1ecd76	2	1	2	2	N	0	
China clay, calcinated	kg	4,25E+00	7. Bill of Materials	Kaolin production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	f57ebfdb-d033-4e45-aa13-25bbd71bb3e3	2	1	1	1	N	0	
Propylene glycol	kg	4,00E-01	7. Bill of Materials	Propylene glycol production technology mix production mix, at plant 100% active substance	http://ecoinvent.lca-data.com/	f08552b4-a251-42f5-921d-3b39b8f7ecd8	2	1	2	2	N	0	
Additive, unspecified	kg	5,05E+00	7. Bill of Materials	Paints additive technology mix Production mix, at plant	http://lcdn-cepe.org	017ae7f6-12aa-4701-aaa8-b4e4426409b7	3	3	3	3	Y	0	
OUTPUT													
Non-water raw materials	kg	6,88E+01											

6.2 Manufacturing

LC Stage 2a. Paint production
Related tables with processes in Excel annex PEFCR: Table 6.2.1 – 6.2.4

Technical requirements and assumptions:

- The processes are highly parametrised unit processes that include the raw material and packaging material inputs, the use of supplies and energy, the direct emissions and the production of waste.
- The waste of products used during the manufacturing shall be included in the modelling. A default loss rate of 3% is applied for all subcategories.

6.3 Distribution stage

LC Stage 3a. Distribution to Regional Distribution Centre (RDC)
Related table with processes in Excel annex PEFCR: Table 6.3.1

Technical requirements and assumptions:

- A total utilization rate of the truck is 64% (Utilization & empty return is applied in line with the PEF default data).
- The applicant of this PEFCR shall always check the utilisation ratio applied in the default dataset and adapt it accordingly.
- The packaged paint is transported by truck over 350 km to the RDC. These distances are based on representative European industry averages.

LC Stage 3b. Storage in RDC
Related table with processes in Excel annex PEFCR: Table 6.3.1

Technical requirements and assumptions:

- The packed paint is stored in the RDC. The impacts of heating and lighting in the RDC are included in the model.
- 1% of the paint will not be sold and will never be sent to the shop. Usually, this paint is returned to the paint factory and reworked, but as worst-case scenario, it is considered to be disposed as paint waste and non-hazardous waste (packaging materials).

LC Stage 3c. Distribution to Point of Sale (PoS)
Related table with processes in Excel annex PEFCR: Table 6.3.2

Technical requirements and assumptions:

- A total utilization rate of the truck is 64% (Utilization & empty return is applied in line with the PEF default data).
- The applicant of this PEFCR shall always check the utilisation ratio applied in the default dataset and adapt it accordingly.
- The packaged paint is transported by truck over 370 km to the PoS. These distances are based on representative European industry averages.

LC Stage 3d. Storage in PoS
Related table with processes in Excel annex PEFCR: Table 6.3.2

Technical requirements and assumptions:

- The packaged paint is stored at the PoS. The impacts of heating and lighting the PoS are included in the model.
- 1% of the paint will not be sold. Paint waste is generated due to unsold amounts of paints. Usually, this paint is returned to the paint factory and reworked, but as worst-case scenario, it is considered to be disposed as paint waste and non-hazardous waste (packaging materials).

6.4 Use stage

When using the paint, different types have different emissions during the use stage and at the end of life. The integrated overview of the assumptions is shown below in Figure 6.1 Fate of paint.

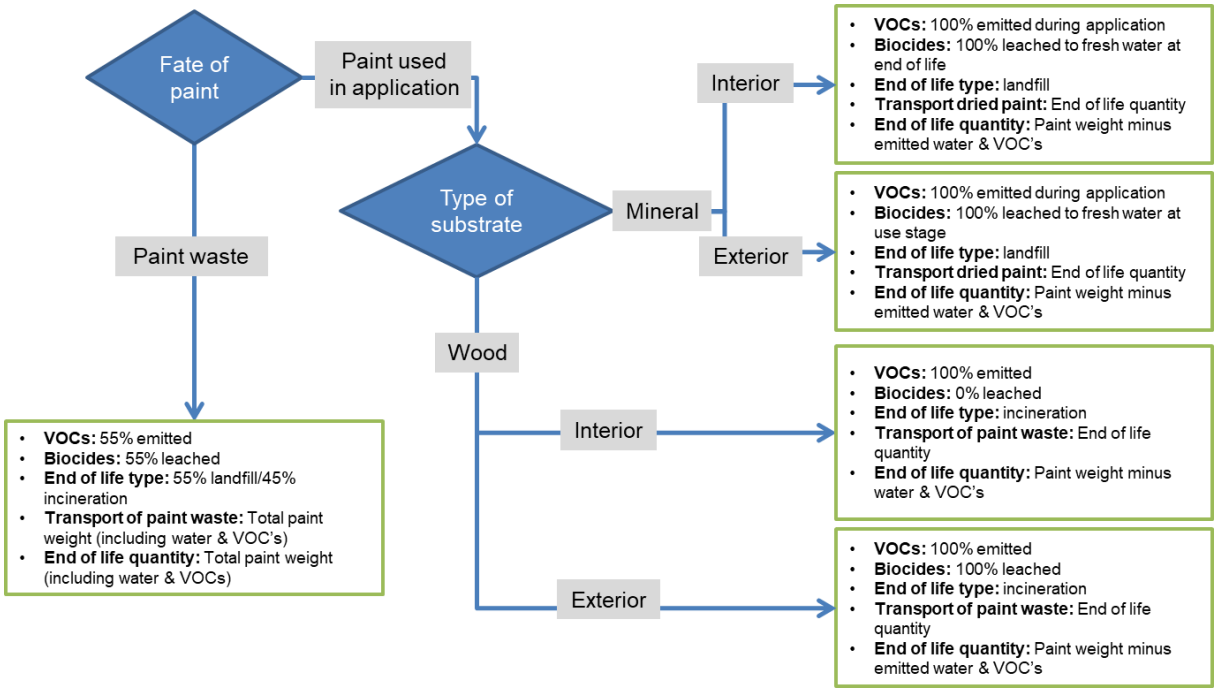

Figure 6.1 - Fate of paint

LC Stage 4a. Auxiliary materials

Related table with processes in Excel annex PEFCR: Table 6.4.1

Technical requirements and assumptions:

- The impact of auxiliary materials consists of the extraction of natural resources, transport of the materials, processing into auxiliary materials, distribution and disposal.
- The auxiliary materials scenario is based on the consumed auxiliary materials such as brushes, covering paper for floors etc.

LC Stage 4b. Application

Related tables with processes in Excel annex PEFCR: Table 6.4.2 – 6.4.5

Technical requirements and assumptions:

- The amount of paint used per paint job depends on the paint characteristics as described in chapter 3.3.
- The hot water is made at the application site.

- The transport is both professional and consumer transport and is an average of a number of activities specifically related to the application: e.g. Going to the shop, have meetings with a professional painter and finally selecting and getting the materials to do the work. The total average distance travelled for these activities is 60 km by car. The transport distance is averaged based on the market share of each product type and modelled with a car as a worst-case scenario. Since a typical paint application is defines as painting 85.7 m2. This means that per m2 painted 0.70 km is driven.
- The use of paint and auxiliary materials is defined by the average paint job, which is based on average market share and practice for the different types of products.
- 100% of the VOCs in the applied paint are emitted to air during the application stage. No other emissions during application are considered.
- The disposal of the waste includes the transport, treatment and disposal of paint remains (paint waste), packaging and solid auxiliary materials (hazardous waste).
- Re-application of paint is considered to have the same characteristics as the first application. No differences in coverage, use of auxiliary materials, emissions or any other aspect are assumed.
- The maintenance multiplier is based on the number of repaints needed over the 50 years lifetime of the building.
- 89% of the paint is applied (Applied paint factor) the rest (11%) is treated as non-hazardous waste.

LC Stage 4c. Use
Related tables with processes in Excel annex PEFCR: Table 6.4.6 – 6.4.9

Technical requirements and assumptions:
- During use, 100% of the contained biocides are leached as emissions into freshwater for the subcategory outdoor wood and outdoor wall. This is a worst-case assumption since more accurate data is not available.
- The quantity of biocides is not deducted from the total amount of paint film applied to the wall when considering it at the end of life as biocides are present in very small amounts.
- No other emissions will take place.

6.5 End of life

LC Stage 5a. Transport to End-of-life
Related table with processes in Excel annex PEFCR: Table 6.5.1

Technical requirements and assumptions:
- A total utilization rate of the truck is 64% (Utilization & empty return is applied in line with the PEF default data).
- The applicant of this PEFCR shall always check the utilisation ratio applied in the default dataset and adapt it accordingly.
- The waste is transported by truck over 80 km to the end of life treatment.

LC Stage 5b End-of-life
To treat all the types of waste from the different life cycle stages different treatment scenarios are created:

Life cycle stage	Type of waste	Treatment scenario

2a. Paint production	Non-hazardous waste	5b2 End-of-life of non-hazardous paint waste
	Hazardous waste	5b3. End-of-life of hazardous paint waste
3b. Storage in RDC	Paint and packaging waste	5b2 End-of-life of non-hazardous paint waste
3d. Storage in PoS	Paint and packaging waste	5b2 End-of-life of non-hazardous paint waste
4b. Application	Paint & Auxiliary waste	5b2 End-of-life of non-hazardous paint waste
4c. Use	Dried paint film	5b1 End-of-life of dried paint film

The three treatment scenarios are found below. All scenarios are based on European averages.

LC Stage 5b1 End-of-life of dried paint film

Related tables with processes in Excel annex PEFCR: Table 6.5.2 – 6.5.5

Technical requirements and assumptions:

- Dried paint films are currently not recycled. Therefore, recycling is not considered.
- The dried paint film is treated together with the substrate according as construction materials.
- The subcategory indoor wood and outdoor wood have an energy content and are assumed to be incinerated with energy recovery.
- The subcategory indoor wall and outdoor wall have a mineral substrate and thus no energy content and are assumed to be landfilled.
- During use, 100% of the contained biocides are leached as emissions into freshwater for the subcategory outdoor wood and outdoor wall. This is a worst-case assumption since more accurate data is not available.
- As part of the landfill process, 100% of the contained biocides are leached as emissions into freshwater for the subcategory indoor wall. This is a worst-case assumption since more accurate data is not available.
- For the circular footprint formula, the following applies: A=0, B=0, R1= 0, R2 = 0, In case of incineration R3 value = 0,45 in all other cases the R3 value = 0.

LC Stage 5b2. End-of-life of non-hazardous paint waste

Related table with processes in Excel annex PEFCR: Table 6.5.6

Technical requirements and assumptions:

- Although some small-scale initiatives exist, it is not common practice to recycle waste paint and auxiliary materials. Therefore, recycling is not considered.
- Statistics show that 45% of the waste paint is incinerated and 55% is landfilled.
- When waste paint is landfilled, 100% of the VOCs are emitted to air and 100% of the biocides are leached to the groundwater (Emissions to water).
- When waste paint is incinerated, it is done with energy recovery. The incineration process avoids the production of 1.01MJ of electricity and 2.16 MJ of heat per kilogram of treated waste.
- If relevant, for the recycling and reuse of packaging materials (like pallets, paper boxes etc), the default described EF values have to be used.
- For the circular footprint formula, the following applies: A=0, B=0, R1= 0, R2 = 0, In case of incineration R3 value = 0,45 in all other cases the R3 value = 0

LC Stage 5b3. End-of-life of hazardous paint waste

Related table with processes in Excel annex PEFCR: Table 6.5.7

Technical requirements and assumptions:

- Hazardous paint waste is currently not recycled. Therefore, recycling is not considered.
- Statistics show that 45% of the hazardous paint waste is incinerated and 55% is landfilled.
- When waste paint is incinerated, it is done with energy recovery. The incineration process avoids the production of 17.1MJ of electricity and 1.27 MJ of heat per kilogram of treated waste.
- For the circular footprint formula, the following applies: A=0, B=0, R1= 0, R2 = 0, In case of incineration R3 value = 0,45 in all other cases the R3 value = 0.

7. PEF results

7.1 Benchmark values

The following tables present the benchmarks derived for each representative product. The results are provided characterised, normalised, and weighted, each in a different table.

Sub category Indoor Wall paint 1 m2, on substrate, for 50 years

Table 7.1 - Characterised benchmark values for indoor wall paints

Impact category	Unit	Life cycle excl. use stage	Use stage
Climate change	kg $CO_{2\ eq}$	3.54E+00	1.40E+00
Climate change - biogenic		*7.93E-01*	*1.23E-01*
Climate change – land use and land transformation		*2.22E-03*	*4.21E-03*
Ozone depletion	kg CFC-11 $_{eq}$	5.27E-08	4.66E-10
Particulate matter	disease incidence	1.69E-07	4.01E-08
Ionising radiation, human health	kBq U^{235} $_{eq}$	1.31E-01	6.35E-02
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	9.24E-03	4.30E-03
Acidification	mol H^+ $_{eq}$	2.23E-02	3.89E-03
Eutrophication, terrestrial	mol N $_{eq}$	2.62E-02	1.53E-02
Eutrophication, freshwater	kg P $_{eq}$	2.06E-04	1.86E-05
Eutrophication, marine	kg N $_{eq}$	2.77E-03	1.34E-03
Land use	Dimensionless (pt)	1.13E+01	8.21E+00
Water use	m^3 world $_{eq}$	7.41E-01	-8.10E-02
Resource use, minerals and metals	kg Sb $_{eq}$	1.31E-05	6.29E-07
Resource use, fossils	MJ	4.46E+01	1.65E+01

Table 7.2 - Normalised benchmark values for indoor wall paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	4.56E-04	1.81E-04
Ozone depletion	2.25E-06	1.99E-08
Particulate matter	2.66E-04	6.30E-05
Ionising radiation, human health	3.10E-05	1.50E-05
Photochemical ozone formation, human health	2.28E-04	1.06E-04
Acidification	4.02E-04	7.01E-05
Eutrophication, terrestrial	1.48E-04	8.65E-05
Eutrophication, freshwater	8.07E-05	7.31E-06
Eutrophication, marine	9.79E-05	4.73E-05
Land use	8.49E-06	6.17E-06
Water use	6.44E-05	-7.04E-06
Resource use, minerals and metals	2.26E-04	1.09E-05
Resource use, fossils	6.83E-04	2.52E-04

Table 7.3 - Weighted benchmark values for indoor wall paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	1.01E-04	4.01E-05
Ozone depletion	1.52E-07	1.34E-09
Particulate matter	2.54E-05	6.01E-06
Ionising radiation, human health	1.66E-06	8.08E-07
Photochemical ozone formation, human health	1.16E-05	5.40E-06
Acidification	2.67E-05	4.65E-06
Eutrophication, terrestrial	5.79E-06	3.38E-06
Eutrophication, freshwater	2.38E-06	2.16E-07
Eutrophication, marine	3.05E-06	1.47E-06
Land use	7.15E-07	5.20E-07
Water use	5.82E-06	-6.36E-07
Resource use, minerals and metals	1.82E-05	8.78E-07
Resource use, fossils	6.09E-05	2.25E-05
Total impact (single score)	**2.63E-04**	**8.53E-05**

Sub category Indoor wood paint 1 m2, on substrate, for 50 years

Table 7.4 - Characterised benchmark values for indoor wood paints

Impact category	Unit	Life cycle excl. use stage	Use stage
Climate change	kg $CO_{2\ eq}$	2.50E+00	1.12E+00
Climate change - biogenic		*6.34E-02*	*7.62E-02*
Climate change – land use and land transformation		*1.46E-03*	*2.93E-03*
Ozone depletion	kg CFC-11 $_{eq}$	1.23E-07	3.26E-10
Particulate matter	disease incidence	1.63E-07	2.80E-08
Ionising radiation, human health	kBq U^{235} $_{eq}$	1.26E-01	4.48E-02
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	7.56E-03	1.19E-02
Acidification	mol H^+ $_{eq}$	2.28E-02	2.71E-03
Eutrophication, terrestrial	mol N $_{eq}$	2.19E-02	1.07E-02
Eutrophication, freshwater	kg P $_{eq}$	1.87E-04	1.28E-05
Eutrophication, marine	kg N $_{eq}$	2.24E-03	9.30E-04
Land use	Dimensionless (pt)	9.25E+00	5.72E+00
Water use	m^3 world $_{eq}$	6.74E-01	-5.79E-02
Resource use, minerals and metals	kg Sb $_{eq}$	1.39E-05	4.39E-07
Resource use, fossils	MJ	3.58E+01	1.15E+01

Table 7.5 - Normalised benchmark values for indoor wood paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	3.23E-04	1.45E-04
Ozone depletion	5.27E-06	1.39E-08
Particulate matter	2.55E-04	4.39E-05
Ionising radiation, human health	2.98E-05	1.06E-05
Photochemical ozone formation, human health	1.86E-04	2.94E-04
Acidification	4.11E-04	4.89E-05
Eutrophication, terrestrial	1.24E-04	6.02E-05
Eutrophication, freshwater	7.32E-05	5.00E-06
Eutrophication, marine	7.90E-05	3.29E-05
Land use	6.96E-06	4.30E-06
Water use	5.86E-05	-5.03E-06
Resource use, minerals and metals	2.40E-04	7.59E-06
Resource use, fossils	5.49E-04	1.76E-04

Table 7.6 - Weighted benchmark values for indoor wood paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	7.16E-05	3.21E-05
Ozone depletion	3.55E-07	9.39E-10
Particulate matter	2.44E-05	4.19E-06
Ionising radiation, human health	1.60E-06	5.70E-07
Photochemical ozone formation, human health	9.50E-06	1.50E-05
Acidification	2.73E-05	3.25E-06
Eutrophication, terrestrial	4.84E-06	2.35E-06
Eutrophication, freshwater	2.16E-06	1.48E-07
Eutrophication, marine	2.47E-06	1.03E-06
Land use	5.86E-07	3.62E-07
Water use	5.30E-06	-4.55E-07
Resource use, minerals and metals	1.94E-05	6.13E-07
Resource use, fossils	4.90E-05	1.57E-05
Total impact (single score)	**2.18E-04**	**7.49E-05**

Sub category Outdoor Wall paint 1 m2, on substrate, for 50 years

Table 7.7 - Characterised benchmark values for outdoor wall paints

Impact category	Unit	Life cycle excl. use stage	Use stage
Climate change	kg $CO_{2\ eq}$	3.43E+00	8.66E-01
Climate change - biogenic		*5.87E-01*	*8.48E-02*
Climate change – land use and land transformation		*1.87E-03*	*2.53E-03*
Ozone depletion	kg CFC-11 $_{eq}$	4.08E-08	2.79E-10
Particulate matter	disease incidence	1.66E-07	2.41E-08
Ionising radiation, human health	kBq U^{235} $_{eq}$	1.18E-01	3.75E-02
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	8.91E-03	2.97E-03
Acidification	mol H^+ $_{eq}$	2.09E-02	2.33E-03
Eutrophication, terrestrial	mol N $_{eq}$	2.46E-02	9.20E-03
Eutrophication, freshwater	kg P $_{eq}$	2.13E-04	1.15E-05
Eutrophication, marine	kg N $_{eq}$	2.55E-03	8.06E-04
Land use	Dimensionless (pt)	9.93E+00	4.93E+00
Water use	m^3 world $_{eq}$	9.24E-01	-4.70E-02
Resource use, minerals and metals	kg Sb $_{eq}$	1.22E-05	3.78E-07
Resource use, fossils	MJ	4.78E+01	9.84E+00

Table 7.8 - Normalised benchmark values for outdoor wall paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	4.42E-04	1.12E-04
Ozone depletion	1.74E-06	1.19E-08
Particulate matter	2.61E-04	3.78E-05
Ionising radiation, human health	2.81E-05	8.90E-06
Photochemical ozone formation, human health	2.19E-04	7.31E-05
Acidification	3.77E-04	4.21E-05
Eutrophication, terrestrial	1.39E-04	5.20E-05
Eutrophication, freshwater	8.36E-05	4.49E-06
Eutrophication, marine	9.01E-05	2.85E-05
Land use	7.47E-06	3.71E-06
Water use	8.04E-05	-4.09E-06
Resource use, minerals and metals	2.11E-04	6.52E-06
Resource use, fossils	7.32E-04	1.51E-04

Table 7.9 - Weighted benchmark values for outdoor wall paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	9.81E-05	2.48E-05
Ozone depletion	1.18E-07	8.06E-10
Particulate matter	2.49E-05	3.61E-06
Ionising radiation, human health	1.51E-06	4.78E-07
Photochemical ozone formation, human health	1.12E-05	3.73E-06
Acidification	2.50E-05	2.79E-06
Eutrophication, terrestrial	5.42E-06	2.03E-06
Eutrophication, freshwater	2.47E-06	1.32E-07
Eutrophication, marine	2.81E-06	8.89E-07
Land use	6.29E-07	3.12E-07
Water use	7.26E-06	-3.69E-07
Resource use, minerals and metals	1.71E-05	5.27E-07
Resource use, fossils	6.53E-05	1.34E-05
Total impact (single score)	**2.62E-04**	**5.23E-05**

Sub category Outdoor wood paint 1 m2, on substrate, for 50 years

Table 7.10 - Characterised benchmark values for outdoor wood paints

Impact category	Unit	Life cycle excl. use stage	Use stage
Climate change	kg $CO_{2\ eq}$	4.02E+00	2.39E+00
Climate change - biogenic		*9.33E-02*	*1.07E-01*
Climate change – land use and land transformation		*2.09E-03*	*3.77E-03*
Ozone depletion	kg CFC-11 $_{eq}$	8.20E-08	4.18E-10
Particulate matter	disease incidence	2.27E-07	3.59E-08
Ionising radiation, human health	kBq U^{235} $_{eq}$	1.87E-01	5.71E-02
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	1.38E-02	6.73E-02
Acidification	mol H^+ $_{eq}$	3.39E-02	3.48E-03
Eutrophication, terrestrial	mol N $_{eq}$	4.43E-02	1.37E-02
Eutrophication, freshwater	kg P $_{eq}$	3.76E-04	1.66E-05
Eutrophication, marine	kg N $_{eq}$	1.41E-02	1.20E-03
Land use	Dimensionless (pt)	3.34E+02	7.35E+00
Water use	m^3 world $_{eq}$	6.33E-01	-7.30E-02
Resource use, minerals and metals	kg Sb $_{eq}$	2.10E-05	5.64E-07
Resource use, fossils	MJ	6.82E+01	1.48E+01

Table 7.11 - Normalised benchmark values for outdoor wood paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	5.18E-04	3.08E-04
Ozone depletion	3.50E-06	1.78E-08
Particulate matter	3.57E-04	5.64E-05
Ionising radiation, human health	4.44E-05	1.35E-05
Photochemical ozone formation, human health	3.40E-04	1.66E-03
Acidification	6.10E-04	6.28E-05
Eutrophication, terrestrial	2.50E-04	7.74E-05
Eutrophication, freshwater	1.47E-04	6.51E-06
Eutrophication, marine	4.98E-04	4.23E-05
Land use	2.51E-04	5.53E-06
Water use	5.50E-05	-6.35E-06
Resource use, minerals and metals	3.62E-04	9.74E-06
Resource use, fossils	1.04E-03	2.26E-04

Table 7.12 - Weighted benchmark values for outdoor wood paints

Impact category	Life cycle excl. use stage	Use stage
Climate change	1.15E-04	6.84E-05
Ozone depletion	2.36E-07	1.20E-09
Particulate matter	3.41E-05	5.38E-06
Ionising radiation, human health	2.38E-06	7.26E-07
Photochemical ozone formation, human health	1.73E-05	8.45E-05
Acidification	4.05E-05	4.17E-06
Eutrophication, terrestrial	9.78E-06	3.03E-06
Eutrophication, freshwater	4.35E-06	1.92E-07
Eutrophication, marine	1.55E-05	1.32E-06
Land use	2.12E-05	4.65E-07
Water use	4.97E-06	-5.73E-07
Resource use, minerals and metals	2.93E-05	7.87E-07
Resource use, fossils	9.31E-05	2.02E-05
Total impact (single score)	**3.88E-04**	**1.89E-04**

7.2 PEF profile

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

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

Together with the PEF report, the applicant shall develop an aggregated EF-compliant dataset of its product in scope. This dataset shall be made available on the EF node (http://eplca.jrc.ec.europa.eu/EF-node). The disaggregated version may stay confidential. The parts of the PEF report (requirements described in Annex 1) which contains business sensitive information such as a detailed Bill of material, consumption or test data may stay confidential.

7.3 Additional technical information

No additional technical information shall be given by the user

7.4 Additional environmental information

Biodiversity is not considered as relevant for this PEFCR

8. Verification

The verification of an EF study/report carried out in compliance with this PEFCR shall be done according to all the general requirements included in Section 8 of the PEFCR Guidance 6.3 and the requirements listed below.

The verifier(s) shall verify that the EF study is conducted in compliance with this PEFCR. These requirements will remain valid until an EF verification scheme is adopted at European level or alternative verification approaches applicable to EF studies/report are included in existing or new policies.

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

- the verifier shall check if the correct version of all impact assessment methods was used. For each of the most relevant impact categories, at least 50% of the characterisation factors (for each of the most relevant EF impact categories) shall be verified, while all normalisation and weighting factors of all ICs shall be verified. In particular, the verifier shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[20];
- all the newly created datasets shall be checked on their EF compliancy (for the meaning of EF compliant datasets refer to Annex H of the Guidance). All their underlying data (elementary flows, activity data and sub processes) shall be validated;
- the aggregated EF-compliant dataset of the product in scope (meaning, the EF study) is available on the EF node (http://eplca.jrc.ec.europa.eu/EF-node).
- for at least 70% of the most relevant processes in situation 2 option 2 of the DNM, 70% of the underlying data shall be validated. The 70% data shall include all energy and transport sub processes for those in situation 2 option 2;
- for at least 60% of the most relevant processes in situation 3 of the DNM, 60% of the underlying data shall be validated;
- for at least 50% of the other processes in situation 1, 2 and 3 of the DNM, 50% of the underlying data shall be validated.

In particular, it shall be verified for the selected processes if the DQR of the process satisfies the minimum DQR as specified in the DNM.

The selection of the processes to be verified for each situation shall be done ordering them from the most contributing to the less contributing one and selecting those contributing up to the identified percentage starting from the most contributing ones. In case of non-integer numbers, the rounding shall be made always considering the next upper integer.

These data checks shall include, but should not be limited to, the activity data used, the selection of secondary sub-processes, the selection of the direct elementary flows and the CFF parameters. For example, if there are 5 processes and each one of them includes 5 activity data, 5 secondary datasets and 10 CFF parameters, then the verifier(s) has to check at least 4 out of 5 processes (70%) and, for each process, (s)he shall check at least 4 activity data (70% of the

[20] Available at: http://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml

total amount of activity data), 4 secondary datasets (70% of the total amount of secondary datasets), and 7 CFF parameters (70% of the total amount of CFF parameters), i.e. the 70% of each of data that could be possible subject of check.

The EF report contains the full test reports used to determine the parameters 5 and 6: Coverage and the Maintenance multiplier. The verifier shall check the relevance, completeness and applicability of the tests and the calculation of the Coverage and the Maintenance multiplier, against the procedure as described in Annex 4 and 5.

9. References

- PEFCR Guidance Version 6.3 – December 2017
- Product Environmental Footprint (PEF) Guide; Annex II to the Recommendation 2013/179/EU, 9 April 2013. Published in the official journal of the European Union Volume 56, 4 May 2013
- Paints Directive (2004/42/EC of the European Parliament and of the Council of 21 April 2004 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in decorative paints and varnishes and vehicle refinishing products and amending Directive 1999/13/EC).

Annex 1 - Check-list for PEF study

Each PEF study shall include this annex, completed with all the requested information.

ITEM: This column lists all the items that shall be included in a PEF report or PEF Supporting study (SS) (The PEF report can stay confidential)	**Included in the study:** Indicate if the item is included or not in the study (Y/N)	**Section**: Indicate in which section # the item is included	**Page**: Indicate in which page the item is included
Summary			
General information about the product			
General information about the company			
Diagram with system boundary and indication of the situation according to DNM			
List and description of processes included in the system boundaries			
List of co-products, by-products and waste			
Identification of most relevant impact categories (only SS)			
Identification of most relevant life cycle stages (only SS)			
Identification of most relevant processes (only SS)			
Identification of most relevant direct elementary flows (only SS)			
Feedback to the draft PEFCR (only SS)			
List of activity data used			
List of secondary datasets used			
Data gaps			
Assumption			
Scope of the study			
(sub)category to which the product belongs			
DQR calculation of each dataset used for the most relevant processes, the new ones created, and other processes in situation 1.			
Average DQR of the study			
The full test report(s) used to determine the parameters 5: Coverage			
The full test report(s) used to determine the parameters 6: Maintenance multiplier.			

Annex 2 - Critical review report

#	Page, line number, figure number etc.	Topic of the comment	Comment	TS feedback	Final comment review panel
# P1	(whole document)	General	As reviewer of these PEFCR - Decorative Paints, but as LCA practitioner too, it is not always clear what is general PEF CR (based on the PEFCR Guidance Version 6.3) and what is specific for decorative Paints.	**No action:** no additional added value to the final user/ non LCA expert	*Accepted*
# P2	Line 15	Editorial	The guidance mentions that the PEFCR is valid until the 31th of December 2020 (p.160 of the guidance 6.3). Therefore I think that the expiration date of 4 years is a bit overrated.	**updated**	*Accepted*
# P3	Page 7 (List of acronyms)	Editorial	EF is missing.	**updated**	*Accepted*
# P4	Line 244, Chapter 2.3,	Editorial	This sentence should convey the intention, as written now it reads like a confirmation.	**Not updated:** PEFCR template, I think the EC requests that confirmation	*Accepted*
# P5	Line 263	Technical	Should we include or make reference to the earlier review process in 2016?	**No action:** Please feel free to make a reference in your review statement	*Accepted*
# P6	Line 269	Editorial	"PEF Guide adopted by the Commission on December 2017" is ambiguous.	**updated**	*Accepted*
# P7	Line 374	Technical	I wonder how the number of layers is managed. 9.5 m²/L is assumed, but if it is a double layer paint, is it the same?	**No action:** The 9.5 m2 is based on the amount of paint required to get to the right layer thinkness. This could be one or 2 layers in practice, so the is considered	*Accepted*
# P8	Line 404	Technical	Deconstruction process is not taken in account. Though, shouldn't it appear on the diagram and then explain if applicant can exlude the calculations related to this stage?	**Updated:** added the system diagram	*Accepted*
# P9	Line 404	Technical	I wonder the same way about the preparation of the wall at each refurbishment.	**Updated:** added the system diagram	*Accepted*
# P10	Line 435	Editorial	I think that there is an editorial mistake : "country" instead of "county".	**Updated**	*Accepted*
# P11	Line 520	Editorial	...'The processes that requires mandatory…'	**Updated**	*Accepted*
# P12	Line 542; Chapter 5.1	Editorial	"… based on the Guidance in Annex 4 ..." is ambiguous.	**Updated**	*Accepted*
# P13	Line 580	Editorial	…'that from to offices…'	**Updated**	*Accepted*
# P14	Line 607; Chapter 5.3	Technical	"Select a Proxy from the EF database An EF compliant data set can be chosen as a proxy for the substance in question."	**Updated**	*Accepted*
# P15	Line 616; Chapter 5.4	General	It is this DQR section where the general idea arouses to have insight in what is in PEF Guidance 6.3 and what is specific for Decorative Paints. Many original fragments are better readable due to layout and order. See examples below (not limited).	**No action:** no additional added value to the final user/ non LCA expert	*Accepted*
# P16	Line 642 & 646; Chapter 5.4.1	Editorial	Table 5.20 seems wrong reference.	**Updated**	*Accepted*
# P17	Line 665 & 688; Chapter 5.4.1	Editorial	(Like in source [PEF Guidance 6.3]) Shouldn't the second "Process 1" be "Process 2"?	**Updated**	*Accepted*

# P18	Line 672	Editorial	...'Shall the total DQR…'	**Updated**	*Accepted*
# P19	Line 698	Editorial	Wrong table reference: tThe DNM is Table 5.3, not 5.21.	**Updated**	*Accepted*
# P20	Line 760 & 762; table title & 5.5.3	Editorial	Titles differ (slightly) from original. Is there a reason?	**Updated**	*Accepted*
# P21	Line 763	Editorial	I think the correct number is "table 5.4".	**Updated**	*Accepted*
# P22	Line 810	Technical	Just mentioning mass allocation is a bit light as if any other case appears no recommendation will be made. I agree that cases are quite rare for paint production, and when it occurs mass allocation is to be preferred, but "what if...?".	**Clarified:** allocation relates to processes under control of Paint producer only. If physical or mass allocation is not the appropriate method, look at PEF guide. Allocation related to raw materials the relevant PEFCRs shall be followed and otherwise the PEF guidance	*Accepted*
# P23	Lines 939-940, 945-946	Editorial	Both seem to convey questions with answers.	**Updated**	*Accepted*
# P24	Line 945-946, and 1018-1024	Editorial	These are the only ones that are added compared to the original text.	**Updated**	*Accepted*
# P25	Line 1107, 1118, etc.	Technical	I would like to see (reference to) the calculation of 64%.	**Clarified:** utilization rate of the truck	*Accepted*
# P26	Line 1107, 1118, etc.	Editorial	"… in life ..."	**Updated**	*Accepted*
# P27	Line 1108	Editorial	I would add "until it can be proved/demonstrated that there is a recycling process effective".	**Not updated:** if someone can show they do recycle it they can model it according to the PEF rules. This comment is relevant for all assumptions in case of a future update of the PEFCR, therefore I do not see the need to add this.	*Accepted*
# P28	Line 1117; 1129	Technical	Transportation distances look very unconservative to me. I would have taken specific data and, if not available, much more conservative ones (1 000 and 500 for instance?).	**Clarified:** based on industry averages.	*Accepted*
# P29	Chapter 6.3	Technical	Is there a relation between the 1% not be sold (2x) and 64%?	**Clarified:** utilization rate of the truck	*Accepted*
# P30	Chapter 6.3	Editorial	Why are "DQR values" included/introduced here in LC Stage 3d, in Chapter 6?	**Updated:** removed	*Accepted*
# P31	Chapter 6.5	Editorial	"• As part of the landfill process, 100% of the contained biocides are leached as emissions into freshwater for the subcategory indoor wall. This is a worst-case assumption since more accurate data is not available."	**No action:** Also after use, since these are **indoor** wall paints it is assumed that the biocides have not leached during use	*Accepted*
# P32	Chapter 7.1	Editorial	Include FU in titles	**Updated**	*Accepted*
# P33	Chapter 7.1, page 49	Editorial	Introductory text on benchmark values, change from 'Here you can find' to 'The following tables present the benchmarks derived for each representative product…'	**Updated**	*Accepted*
# P34	Chapter 7.4, page 55	Editorial	text on biodiversity needs to be a statement. Change to 'Biodiversity is not considered relevant for the PEFCR'.	**Updated**	*Accepted*
# P35	Annex 1, Page 57	Editorial	The table appears to be addressed to participants in pilot study, though there is a footnote (13)	**Updated:** amended and Made the checklist in line with PEF study only	*Accepted*

			that states otherwise. Perhaps the way the texts are written?		
# P36	Annex 6	Editorial	"It was decided to avoid taking local differences into account." Include this very important remark prominent in the main text.	**Updated:** clarified in chapter 6	*Accepted*
# P37	Annex 6	Editorial	The text describing durability schemes is in the wrong annex (6). It probably should be in annex 4. Overall it appears the annexes could be reordered?	**Updated:** amended durability annex according to your comments	*Accepted*

Annex 3 - CEPE Specific Guidance to determining VOC emissions

Paints and coatings products often contain VOCs. These are either part of the paint formulation or the raw materials. These VOC's are released to the environment mainly during application of the paint or coating.

The emission of VOCs is most relevant to solvent based paints. However, for water-based paints, the addition of smaller amounts of coalescing solvents can also result in emissions of VOCs to the environment.

The denomination VOC includes a great variety of materials with specific environmental impacts; the most common ones are included in the current impact assessment methods. For paint producers it is extremely difficult to monitor the content of specific VOCs. This is due to the great variety of solvent mixes used during the formulation of both final product and raw materials. It is common practice in the paints and coatings industry to express the concentration of VOC in grams per litre of paint (g/L).

For the purpose of the study the equation below should be used to obtain the mass value of VOC in the quantity of paint under consideration*:*

$$VOC\ content\ (g/kg) = VOC\ content\left(\frac{g}{L}\right) \times Density\ of\ paint(\frac{kg}{L})$$

The considered VOC content shall be the regulatory reportable amount of VOC as defined in Directive (2004/42/EC). Emissions of these VOCs shall be modelled as Non-methane VOC emissions (NMVOC).

Annex 4 - Durability and maintenance multiplier

For each representative product a different test is needed to analyse the quality level and corresponding maintenance multiplier based on the life time, based on the durability class.
The formula for the maintenance multiplier is:

Maintenance multiplier (unitless) = Reference life time of the building (50 years) / Reference durability for class (years).
For Indoor wall Q2 this would be: 8.33 = 50 (years) / 6 (years)

The reference lifetime of the building (50 years) is in conformance with the agreed lifetime of a building with the other PEF construction pilots.

Below you can find the full testing identifying the correct durability class and the corresponding maintenance multiplier.

A4.1 Durability scheme for indoor wall paint

The user shall evaluate the durability of an indoor wall paint based on the wet scrub resistance property. The standards that shall be followed are shown in the table below.

The user of the PEFCR shall perform a wet scrub resistance test on the indoor wall paint by following the EN 13300:2001 and ISO 11998 classification.

Property	**Test**	
	Reference	**Name**
Wet Scrub resistance	EN 13300:2001 and ISO11998	EN13300 - Paints and varnishes. Water-borne coating materials and coating systems for interior walls and ceilings. Classification ISO 11998 - Paints and varnishes. Determination of wet-scrub resistance and cleanability of coatings.

Based on the loss of thickness, the paint will be assigned to a wet scrub resistance class which will indicate the quality of the paint based on the table below:

Quality Level	**WSR class**	**Loss of thickness**	**Durability (years)**	**Maintenance multiplier**
Q1	1	< 5 µm at 200 scrub cycles	15	3.33
Q2	2	≥ 5 to < 20 µm at 200 scrub cycles	6	8.33
Q3	3	≥ 20 to < 70 µm at 200 scrub cycles	3	16.67
Q4	4 & 5	Based on 40 scrub cycles	1	50

A4.2 Durability scheme for indoor wood paint

The indoor wood scheme uses both the initial hardness (König hardness) of the paint and the loss of hardness after application of hand cream (Atrix). The overall score is the equal weighting of the two properties. The higher the overall score, the higher the paint quality.

In order to calculate the initial hardness, the testing conditions should proceed as: that König hardness is measured 28 days after drying at room temperature based on ISO-1522. Higher

hardness generally correlates with higher resistance to scratches and dents which is also shown in the table below. The user shall follow this in order to assign the score for the initial hardness test.

Class	König seconds	König swings	Score
Q1	51 to 70	36 to 50	9
Q2	31 to 50	22 to 35	6
Q3	10 to 30	7 to 21	3

For the measurement of the hardness loss hand cream test, the following steps should be followed:

1. Apply a drawdown of the test paint on a glass panel equivalent to one normal wet paint layer.
2. Allow to dry at 23°C / 50% RH for 28 days.
3. Apply the test compound (Atrix) to the paint film for 1 hour. The exposed surface area should be large enough to rest both feet of the König pendulum on for taking a hardness measurement.
4. Clean the exposed surface of the paint film with a wet cloth and directly measure the König hardness of both the exposed and non-exposed part. Make sure the testing conditions are 50% relative humidity and 23°C temperature.
5. Report the hand cream resistance as a percentage of: (exposed film hardness / non-exposed film hardness *100)

Based on the percentage of the original hardness, there is a score which is given to the paint analysed based on the table below:

Class	% original hardness	Score
Q1	51-100%	9
Q2	21-50%	6
Q3	0-20%	3

In order to calculate the overall quality level, the sum of the scores of the two criteria need to be equally weighted:

$$\text{Overall Score: } \frac{(Initial\ hardness\ score + Loss\ of\ hardness\ score)}{2}$$

Based on the outcome of the overall score, the points are assigned to three different quality levels as in the table below:

Quality Level	Points	Durability (years)	Maintenance multiplier
Q1	≥7	12	**4.17**
Q2	5≤ x <7	8.6	**5.81**
Q3	<5	4.6	**10.87**

A4.3 Durability scheme for outdoor mineral wall paint

The assessment of the tested paints shall be done according to ISO 4628, following 1000hrs of QUV-A exposure following ISO 11507 (100 hrs UVE 4 hours/60 ºC and humidity 4 hrs/50 ºC.

Color change shall be measured using DE2000 following the ISO 11664-6.

Algae and fungal resistance would be assessed following a formula check of the active level content in the paint. In the table below the standards based on each type of property to be used are given.

Type of property	**Test**	**Standard**	**Reference**	
Protective properties	**Lab weathering QUV**	11507:2007	1000hours UVA 4hours/60C + humidity 4 hours/50C	
	Evaluation of degradation of coatings	EN ISO 4628-1	Evaluation of degradation of coatings (quantity, size and intensity of defects)	
	Blistering	EN ISO 4628-2	Assessment of degree of blistering	0-5
	Cracking	EN ISO 4628-4	Assessment of degree of cracking	0-5
	Flaking	EN ISO 4628-5	Assessment of degree of flaking	0-5
	Chalking	EN ISO 4628-6		
Aesthetic properties	**Lab weathering QUV**	11507:2007	1000hours UVA 4hours/60C + humidity 4 hours/50C	
	Colour change	ISO 11664-1 to 4	Colorimetry. Classes based on ISO 105-A02	CIELAB difference dE2000 (ISO 11664-4)
Formulation	Biocides content			

Regarding the testing conditions, more information is given for the substrate, the paint reference and the primer in the table below:

Testing conditions		
	Substrate	Fibre Cement Panel
	Paint tested	White paint tested to avoid different PEF scores per color.(see test in Annex 5)
	Primer	According to TDS

In the case of masonry products, it was decided to focus on laboratory testing to create a durability scheme. The scheme is based on the main properties evaluated by QUV and formulation assessment. Both protective properties and aesthetic properties are included: degradation of coatings (blistering, flaking, chalking etc.), colour change and algae and fungi resistance.

The scheme is built on a minimum threshold concept with the rationale being that complete failure on an aspect cannot be compensated by good scoring on other aspects. (e.g. excellent color retention is irrelevant if the coating completely flakes off). The coating then performs as good as its worst aspect.

The final quality score of an outdoor wall paint is determined by the highest level score on all tested properties. For example, a coating with a level 5 score on blistering and level 1 for all

other properties will have as final quality score of 5. According to the quality level table this will result in a quality level Q3.

Degradation / Defect score					
Blistering	Level	**Cracking**	Level	**Flaking**	Level
0	1	**0**	1	**0**	1
1	1	**1**	1	**1**	1
2	2	**2**	2	**2**	2
3	3	**3**	3	**3**	3
4	4	**4**	4	**4**	4
5	5	**5**	5	**5**	5

Fungi/Algae/Dirt Pick-up		**Aesthetics**			
Fungal /algal	Level	**Chalking**	Level	**Color dE_{ab}**	Level
Content active substance (ppm)					
≥ 1500	1	**1**	1	**<1**	1
500-1500	2	**2-3**	2	**1-3**	2
< 500	3	**4-5**	3	**3-5**	3
				5 and >5	4

Overall classes outdoor mineral wall paint:

Quality Level	**Final Quality Score**	**Durability (years)**	**Maintenance multiplier**
Q1	1 to 2	15	**3.33**
Q2	3	10	**5**
Q3	4 to 5	5.45	**9.17**

A4.4 Durability scheme for Exterior trim and cladding paints for wood

The durability scheme covers both solventborne and waterborne paints and is based on three criteria: the volume of the total solid, the pigment volume concentration and the biocides content, as seen in the table below.

For each of the criteria given, there is a range that defines a low, medium and high score. The lower the score the more points are awarded. In the end, the score is summed up and the final quality class is given by the sum of the three criteria.

Properties		**Quality Low-High**		
		L (10 points)	**M (5 points)**	**H (0 points)**
Volume % Total Solid	waterborne	<20	20-30	>30

	solventborne	<45	45-55	>55
Pigment Volume Concentration (PVC)		>40	< 15 or 31-40	15-30
Biocides content	waterborne	Y <500 ppm	Y < 1500 ppm	Y > 1500 ppm
	solventborne	Y <500 ppm	Y <1000 ppm	Y > 1000 ppm

The score is the sum of all properties with a maximum score of 30. The higher the score the lower the quality of the paint.

Overall classes exterior trim and cladding paints for wood

Quality level	Points	Durability (years)	Maintenance multiplier
Q1	0 to 10	10	**5**
Q2	11 to 20	6.7	**7.46**
Q3	21 to 30	3.5	**14.29**

A4.5 Background to the development of the durability schemes

To differentiate paints from a sustainability standpoint, the durability of the coating (its capacity to keep on protecting and decorating the substrate on which it is applied) is crucial. The reason for this is that the Product Environmental Footprint Category Rules (PEFCR) for decorative paints cover the lifetime of the building, estimated at 50 years. The quantity of paint needed during these 50 years will then greatly depend on the number of times repainting will be necessary.

The decorative paint sector discerns different quality levels. On the low quality end, formulations using raw materials of a lower quality and more water or solvent will have a limited durability, whereas on the high quality end, raw materials of a higher quality lead to a less frequent need for repainting.

There is no standard that assesses the lifetime of a coating, but there are many standards to assess various properties of the paint, depending on the type of paint (indoor wall, indoor wood, outdoor masonry or outdoor wood). 'PEF WG 7 on durability' was created to define four schemes that would classify the different paints into quality levels. The schemes were developed between July 2014 and March 2016.

The quality levels then need to be related to a lifetime in years. No data is available on the lifetime of paints of different quality levels. To have a robust estimation, 17 companies provided feedback on the lifetime of all the different paints considered, at all quality levels. The data was collected in February and March 2015.

A4.5.1 Development of durability schemes

The development of the durability schemes was done by WG7 as a whole, or by sub working groups for specific paint types. Technical experts from the following companies were involved: AkzoNobel, Crown Paints, Jotun, PPG, and the German association VdL.

The group followed a consistent process to create the scheme for each of the four paint types. The steps for this process were:

1. Compilation of paint properties: technical, aesthetical, and other relevant properties
2. Collection of data on the paint properties: existence of a standard test method and interpretation rules, frequency of use, cost, reliability etc.
3. Selection of the properties correlated to durability and preferentially associated to European standards to be included in the schemes
4. Definition of the different schemes
5. Verification of the validity of the scheme with a portfolio check

More information on each scheme is provided below.

A4.5.2 Indoor paints

Indoor wall

The "indoor wall" category is broad, it uses the same criteria to assess different types of paint (matt and glossy paints, paints with specific properties, etc.). WG7 has discussed the use of separate benchmarks to cover all the different types of indoor wall paints, but decided against it based on the consumer's ability to use the other information present on the can, and his decision to choose a specific product depending on his needs.

- A consumer looking for a specific property (resistance to high humidity for example) will compare paints with the same application.
- A consumer looking for a matt paint will compare matt paints (using the gloss level indicated on the can), not matt paints with glossy paints.

These are consumer choices that are not influenced by sustainability information.
The decision to use wet scrub resistance was straightforward as it is directly correlated to the durability of the paint. Other properties were discussed but were either considered as a basic requirement (e.g. adhesion), or as not being correlated to durability (e.g. hiding power).
The user of the PEFCR shall therefore perform a wet scrub resistance test on the indoor wall paint by following the EN 13300:2001 and ISO 11998 classification.

Indoor Wood

Many properties were discussed in the case of indoor wood, but many were not differentiating enough (e.g. wet scrub resistance) or not directly applicable to wood paints. In the end, it was agreed that scratch resistance is the best proxy to assess the need to repaint, as a scratched paint will be replaced, even though it doesn't evolve over time.

Scratch resistance is evaluated by using the paint hardness as a proxy: a softer paint is usually correlated to a lower scratch resistance. The indoor wood scheme uses both the initial hardness (König hardness) of the paint, and the loss of hardness after application of hand cream (Atrix). The overall score is the equal weighting of the two properties. The higher the overall score is the higher the quality level of paint.

A4.5.3 Outdoor paints

Outdoor paint durability can either be evaluated by natural weathering or by laboratory weathering. Although natural weathering is considered closer to reality, it has a lot of drawbacks that make it currently unsuitable for a durability scheme.

First, natural weathering requires long exposure times (usually around 3 years). Also, the weather conditions from one site to another, or even from one year to another at the same site, can be really different (number of rainy days, UV exposure, ranges of temperatures etc.), making it almost impossible to compare samples that were not tested at the same time at the same site. Laboratory weathering results are not always 100% aligned with reality, but have the benefit of being comparable to each other.

Outdoor weathering techniques are still being improved, which is one of the reasons the paint industry doesn't have any standards predicting the lifetime of coatings yet.

Outdoor wood

Outdoor wood products are even more difficult to evaluate than outdoor wall products. A three years research project called Servowood started in 2014 to try to improve service life prediction for wood coatings. The project confirms the validity of criteria taken as most relevant to the outdoor wood paints.

A4.5.4 Commonalities across all durability schemes

A few points were addressed for all four categories of paint.

System or topcoat

The scope of the PEF pilot is decorative paints. It was agreed to focus on the topcoat and to consider that the substrate was correctly prepared, with 'prepared' meaning in accordance with the manufacturer's recommendation. In the case of outdoor weathering, the substrate has to be correctly prepared by following the recommendation of the Technical Data Sheet (TDS) to prepare bare substrate. Where the manufacturer gives different options such as 'apply one or two coats of primer X before applying this topcoat', the most critical option has to be followed (which in this case is one coat of primer X).

Regional differences

The paint markets, like the European climate, is not uniform: the weather conditions in Norway or in southern Spain are quite different, and the exposure conditions may be harsher in one climate compared to another. The implications of a regional quality assessment would be that the same outdoor paint can have different PEF scores depending on where it is sold or tested. This would be a big burden when coming to communication on the footprint of the products, labelling etc., and it was decided to avoid taking local differences into account.

Colour differences

The different shades of the same paint could age differently for some properties like gloss or colour change, depending to the pigment used. However, WG7 has determined not to have different quality levels for the same paint in different shades for multiple reasons. First, having different PEF scores for the same paint is a huge burden as explained in the "regional differences" section. Then, a lot of decorative paints are tinted in the shop, meaning that the distributor would have to select the correct PEF score for the correct shade and would need to have access to all of the different labels. Finally, the number of shades is infinite, making this issue unmanageable.

Two options were then possible: either agree on a colour to test, or recommend using the worst-case colour as is done for the EU Ecolabel. WG7 determined that testing the durability on a white or the white base paint. Since all manufacturers have a white base paint it creates a level playing field.

Glossary for paint properties

Adhesion – ability of the paint to adhere properly to the substrates to which it is applied.
Algae or fungi resistance – ability of the paint to prevent algal or fungal growth, which is seen as black, grey, or brown areas on the surface of the paint.
Blistering – physical alteration of the paint with the appearance of bubbles or pimples (blisters).
Chalking - formation of a white, chalky powder on the surface of the paint film.
Cracking – physical alteration of the paint with the appearance of breaks in irregular lines wide enough to expose the underlying surface (cracks).
Flaking – physical alteration of the paint with detachment of small pieces of the film from the surface of previous coat of paint. Blistering and cracking usually precede it.
Hiding power - ability of a paint to hide the previous surface or colour.
Weathering - the effect of exposure to weather on paint films. It can be either natural (panels are exposed outdoor for a few months to years) or artificial with the help of machines like QUV.
QUV - A method of artificial weathering, using high-intensity ultraviolet light, moisture, and heat to simulate weathering.
Scratch resistance - ability of the paint to resist surface scratches and deformations, which will diffract light and cause it to lose its glossy appearance.
Stain resistance - ability of the paint to resist absorption of dirt and stains.
Wet scrub resistance - ability of a paint film to withstand scrubbing and cleaning with water, soap etc.

A4.6 Representative product formulations

The PEFCR covers four different types of representative products. The TS assigned WG7 to create European average formulations that would represent each of the four decorative paint products.

Each company involved in the group provided the formulations that were representative for their European market. Each formulation would be in the median quality of the product e.g. for Indoor Wall paints there are four quality levels so the median quality level shall be Q2,5. For the rest of the product categories, the median quality was Q2. For this reason, each company sent 5 formulations (1 Indoor Wall Q2, 1 Indoor Wall Q3, Indoor Wood Q2, Outdoor Wall Q2 and Outdoor Wood Q2).

For all the formulations, it was agreed that waterborne formulations would be considered, except the case of Outdoor Wood which was a solventborne product formulation. The group took this decision based on the sales volume of products across Europe.

For the data collection of formulations, a common template of raw materials was used in order to have as close as possible “common” basis formulations per each company. The next step was to average each raw material to one formulation that would represent the averaged product formulations.

By equally weighting each formulation input, the final results were the following four representative product formulations:

- Indoor Wall waterborne Q2,5
- Indoor Wood waterborne Q2
- Outdoor Wall waterborne Q2
- Outdoor Wood solventborne Q2

The group evaluated each raw material and characteristics to make it more realistic if needed. For the calculation of the benchmark, the EF compliant datasets that were used as inputs to the product formulation models are shown in chapter 6. These SHALL NOT be used for the purpose of a PEF analysis as the product formulation is part of the mandatory data required from the PEFCR.

Annex 5 - Coverage and spread rate

The parameter coverage is calculated based on the spreading rate and represents the amount of paint needed to secure a layer thickness that ensures adequate coverage.
The spreading rate for the contrast ratio is determined as at least 98% for the white reference colour RAL 9010. If the colour RAL 9010 is not available and can't be made via a mixing machine system, then the lightest available white colour must be in line with comparable colours in the product line. This is determined by a modification of ISO 6504-3:

ISO 6504-3 determines the contrast ratio when the wet film thickness is between 50 and 100 microns. However, at this range of thickness, most paints will not achieve a contrast ratio near 98%. Therefore, it should be ensured that higher wet film thickness are also used, potentially up to 300 microns. The chosen film thickness should allow for the determination of the spreading rate of 98% contrast ratio by interpolation, i.e. the highest film thickness should have a contrast ratio value >98%.

Interpolations should be done by plotting contrast ratio against the spreading rate calculated according to ISO 6504-3, and fitting a straight line through the data as shown in Figure 5.1. These tests can be done on Leneta foil or Byko opacity chart. A single application at each spreading rate is allowed.

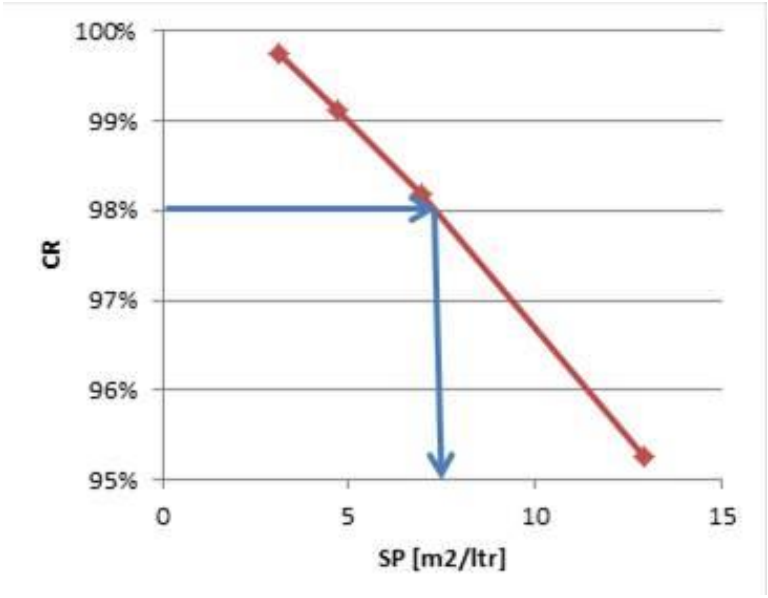

Figure A0.1 - Contrast ratio and spreading rate plot based on ISO 6504-3

The determined spreading rate (based on value for the 98% contrast ratio) results in a value expressed in the m^2/L. This value is used for parameter 5: "coverage" in the PEF calculation. However, a single measurement of at least 98% opacity is suitable for determining the spreading rate to the LCA calculation. The user shall report whether interpolation or single measurement of spreading rate was used.

Annex 6 - Background information on methodological choices taken during the development of the PEFCR

System boundaries

The TS has decided to exclude capital goods, administrative activities and commuting from all life cycle processes. This includes buildings, machinery, offices, employees and professional painters commuting, as well as administrative activities like R&D and commercial activities.

Table A5.1 Justification of system boundaries exclusions

Life cycle stage	Process	Justification
5 - Paint manufacturing	Administrative services	Small impact; Not a differentiator
	Capital good (factory, offices, etc.)	Not a differentiator
	Commuting of employees and business travels	Small impact; Not a differentiator; No control
6 and 7- Logistics	Storage capital good (warehouse and shop)	Not a differentiator
8 – product application	Commuting of professional painter	No control, not a differentiator

The detailed justifications are:

- Not a differentiator - these processes are not a differentiator between different products because they are included in the standard scenarios that shall be used in the PEFCR (upstream or downstream), and sometimes divert the focus from the actual hotspots.
- No control – these processes are outside of the control of the paint manufacturer. No improvement is possible.
- Small impact – these processes represent a negligible impact over the life cycle of the product according to the screening study.

Use of buildings (heating and electricity) is included.

The reason why the capital goods are not considered a differentiator, according to the industry, is because there are not important differences in the size and typology of the production and distribution facilities (factories, RDCs, shops and machinery). Differences in the production systems are driven by the use of supplies, which is included in the scope of the studies. By excluding the facilities from the scope, the footprint focuses on the real performance of the paints, allowing a well-established comparability between the products.

Annex 7 - List of EF normalisation and weighting factors

Global normalisation factors are applied within the EF. The normalisation factors (NF) as the global impact per person are used in the EF calculations.

Impact category	Unit	Normalisation factor	Normalisation factor per person	Impact assessment robustness	Inventory coverage completeness	Inventory robustness	Comment
Climate change	kg $CO_{2\ eq}$	5.35E+13	7.76E+03	I	II	I	
Ozone depletion	kg CFC-11 $_{eq}$	1.61E+08	2.34E-02	I	III	II	
Human toxicity, cancer	CTUh	2.66E+05	3.85E-05	II/III	III	III	
Human toxicity, non-cancer	CTUh	3.27E+06	4.75E-04	II/III	III	III	
Particulate matter	disease incidence	4.39E+06	6.37E-04	I	I/II	I /II	NF calculation takes into account the emission height both in the emission inventory and in the impact assessment.
Ionising radiation, human health	kBq $U^{235}{}_{eq}$	2.91E+13	4.22E+03	II	II	III	
Photochemical ozone formation, human health	kg NMVOC $_{eq}$	2.80E+11	4.06E+01	II	III	I/II	
Acidification	mol $H+_{eq}$	3.83E+11	5.55E+01	II	II	I/II	
Eutrophication, terrestrial	mol N $_{eq}$	1.22E+12	1.77E+02	II	II	I/II	
Eutrophication, freshwater	kg P $_{eq}$	1.76E+10	2.55E+00	II	II	III	
Eutrophication, marine	kg N $_{eq}$	1.95E+11	2.83E+01	II	II	II/III	
Land use	pt	9.20E+15	1.33E+06	III	II	I I	The NF is built by means of

							regionalised CFs.
Ecotoxicity, freshwater	CTUe	8.15E+13	1.18E+04	II/III	III	III	
Water use	m^3 world $_{eq}$	7.91E+13	1.15E+04	III	I	II	The NF is built by means of regionalised CFs.
Resource use, fossils	MJ	4.50E+14	6.53E+04	III	I	II	
Resource use, minerals and metals	kg Sb $_{eq}$	3.99E+08	5.79E-02	III			

Weighting factors for Environmental Footprint

	Aggregated weighting set	Robustness factors	Calculation	**Final weighting factors**
	(50:50)	(scale 1-0.1)		
WITHOUT TOX CATEGORIES	A	B	C=A*B	C scaled to 100
Climate change	15.75	0.87	13.65	**22.19**
Ozone depletion	6.92	0.6	4.15	**6.75**
Particulate matter	6.77	0.87	5.87	**9.54**
Ionizing radiation, human health	7.07	0.47	3.3	**5.37**
Photochemical ozone formation, human health	5.88	0.53	3.14	**5.1**
Acidification	6.13	0.67	4.08	**6.64**
Eutrophication, terrestrial	3.61	0.67	2.4	**3.91**
Eutrophication, freshwater	3.88	0.47	1.81	**2.95**
Eutrophication, marine	3.59	0.53	1.92	**3.12**
Land use	11.1	0.47	5.18	**8.42**
Water use	11.89	0.47	5.55	**9.03**
Resource use, minerals and metals	8.28	0.6	4.97	**8.08**
Resource use, fossils	9.14	0.6	5.48	**8.92**