Product Environmental Footprint Category Rules

for

Synthetic Turf Sports & Landscape Surfaces

Version 01 – May 2024

www.estc.info

Foreword

Synthetic turf surfaces used for sports or landscaping applications provide an attractive, hard-wearing, low maintenance surfacing solution for many situations where natural turf alternatives are not cost-effective, feasible or sustainable.

But, as with any man-made product, a synthetic turf surface needs to be installed, maintained and finally disposed of in a way that minimises its impact on the environment. The synthetic turf industry is committing significant resources to developing sustainable surfaces that will enable a cradle-to-cradle approach to the manufacturing and recycling of the surfaces.

There is a wide range of synthetic turf surfaces, some have an infill within the pile of the surface, others do not. The infill may comprise natural materials such as sand or cork or be a made from rubber or other forms of polymer. ESTC and its members recognise that they have a responsibility to ensure the products they supply are used and maintained responsibly so their impact on the environment are negligible.

The development of these Product Environmental Footprint Category Rules is seen as a key component in ensuring synthetic turf surfaces are manufactured, used and finally disposed of at end-of-life in as environmentally friendly way as possible. Manufacturers of synthetic turf surfaces and the components that form the sports and landscaping surfaces continue to innovate, using new materials and manufacturing technologies to aid the development that meet the needs of society and the planet on which we all live.

About ESTC

ESTC is the trade association for the synthetic turf industry in the EMEA region. Its objective and purpose is to serve, promote, develop, grow and advocate for the synthetic turf industry. We work in both the sports and landscaping sectors.

ESTC fulfils its role by means of close collaboration with all parties involved; members, end-users, sport's governing bodies and legislators.

ESTC is focused on the regions of Europe, Middle East and Africa. Via our partnership with the Synthetic Turf Council (STC) in North America, ESTC also helps its members achieve a global reach. On a local level, ESTC works closely with national industry associations to accomplish our goals and objectives.

Our members are at the core of everything we do and are the driving force of the organization. The strategy of ESTC can best be visualised in a 4-pillar model, consisting of Advocacy, Knowledge, Marketing and Networking. Our vision is to build a circular model considering sourcing of raw materials, regeneration, and responsible end-of-life processing to close the loop in our supply chains. ESTC is focused on working with members according to a circular economy model.

Further details about ESTC can be on our website at www.estc.info

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Any questions about this document should be addressed to info@estc.info

[1] Katarzyna Cenian was involved in the development of the 1st draft PEFCR.

Contents

Acronyms

3G	third generation
AD	activity data
AF	allocation factor
AR	allocation ratio
B2B	business to business
B2C	business to consumer
BoC	bill of components
BoM	bill of materials
BSI	British Standards Institution
$CaCO_3$	calcium carbonate
CF	characterisation factor
CFF	Circular Footprint Formula
CPA	Classification of Products by Activity
DC	distribution centre
DNM	Data Needs Matrix
DQR	Data Quality Rating
EC	European Commission
ef	elementary flow
EF	Environmental Footprint
EFTA	European Free Trade Association
ELT	end-of-life tires
EPDM	ethylene propylene diene monomer rubber
EoL	End of life
ESTC	EMEA Synthetic Turf Council
FU	functional unit
GHG	greenhouse gas
GR	geographical representativeness
GWP	global warming potential
HDPE	high density polyethylene
ILCD	International Reference Life Cycle Data System
ILCD-EL	International Reference Life Cycle Data System – Entry Level
IPCC	Intergovernmental Panel on Climate Change

ISO	International Organisation for Standardisation
JRC	Joint Research Centre
LCA	Life Cycle Assessment
LCDN	Life Cycle Data Network
LCI	life cycle inventory
LCIA	life cycle impact assessment
LDPE	low density polyethylene
LLDPE	linear low-density polyethylene
m^2a	square metre x year
NDA	non-disclosure agreement
NGO	non-governmental organisation
NH_3	ammonia
NMVOC	non-methane volatile compounds
NO_x	nitrogen oxides
P	precision
PA	polyamide
PAS	Publicly Available Specification
PE	polyethylene
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PEF-RP	PEF study of the representative product
PP	polypropylene
PU	polyurethane
PVC	polyvinylchloride
RF	reference flow
RP	representative product
SB	system boundary
SBR	styrene butadiene rubber
SD	secondary dataset
SEBS	styrene ethylene butylene styrene
SO_x	sulphur oxides
SS	supporting study
STS	synthetic turf system
TeR	technological representativeness
TPE	thermoplastic elastomers

TPV	thermoplastic vulcanizates
TiR	time representativeness
TS	Technical Secretariat
UK	United Kingdom
UNEP	United Nations Environment Programme
UUID	Universally Unique Identifier

Definitions

3G – 3rd generation synthetic turf system which is long-pile synthetic grass with a pile height of 40mm to 65mm. Typically filled with a combination of sand and performance infill (SIS Pitches 2019).

Activity data - This term refers to information which is associated with processes while modelling Life Cycle Inventories (LCI). The aggregated LCI results of the process chains that represent the activities of a process are each multiplied by the corresponding activity data[2] and then combined to derive the environmental footprint associated with that process. Examples of activity data include quantity of kilowatt-hours of electricity used, quantity of fuel used, output of a process (e.g. waste), number of hours equipment is operated, distance travelled, floor area of a building, etc. Synonym of non-elementary flow.

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

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

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

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

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

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.

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

[2] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute 2015).

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

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

Base - All elements of construction beneath the synthetic turf sports surfacing system (CEN/TR 17519:2020).

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

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

Biodegradable material – A material can be considered to be (bio)degradable if it achieves the pass criteria specified in any of the permitted test methods included in groups 1-4 of Table 22 of https://echa.europa.eu/documents/10162/2ddaab18-76d6-49a2-ec46-8350dabf5dc6. In short, these are: Group 1. Ready biodegradation; Group 2. Enhanced/modified ready biodegradation; Group 3. Inherent biodegradation; and Group 4. (Biodegradation relative to a reference material. If a material does not meet any of the pass criteria for the test methods in these groups, further assessment information (test methods in group 5) can be used to demonstrated (bio)degradability. Group 5 methods test half-time in the environment (under relevant conditions).

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

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

Characterisation – Calculation of the magnitude of the contribution of each classified input/output to their respective EF impact categories, and aggregation of contributions within each category. This requires a linear multiplication of the inventory data with characterisation factors for each substance and EF impact category of concern. For example, with respect to the EF impact category "climate change", CO_2 is chosen as the reference substance and kg CO_2-equivalents as the reference unit.

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

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

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

Commissioner of the EF study - Organisation (or group of organisations) that finances the EF study in accordance with the PEF method and the relevant PEFCR, if available (definition adapted from ISO 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 may be applied.

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

Comparative Assertion – An environmental claim regarding the superiority or equivalence of one product versus a competing product that performs the same function (including the benchmark of the product category) (adapted from ISO 14044:2006).

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.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Elementary flows – In the life cycle inventory, elementary flows include "material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation" (ISO 14040:2006, 3.12). Elementary flows include, for example, resources taken from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories.

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

Environmental Footprint (EF) Impact Assessment – Phase of the PEF analysis aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product (based on ISO 14044:2006). The impact assessment methods provide impact characterisation factors for elementary flows in order to aggregate the impact to obtain a limited number of midpoint indicators.

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

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

Environmental Footprint (EF) impact category indicator – Quantifiable representation of an EF impact category (based on ISO 14040:2006).

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

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

Environmental mechanism – System of physical, chemical and biological processes for a given EF impact category linking the life cycle inventory results to EF category indicators (based on ISO 14040:2006).

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

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

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

Field – Field of play including the playing area and the perimeter margins or run offs. Field is also known as the pitch (CEN/TR 17519:2020).

Filled synthetic turf – Synthetic turf surface whose pile is either totally filled or partly filled with an unbound particulate material, typically sand, rubber or sand and rubber mixes (EN 15330-1:2013).

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

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

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

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

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

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

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

Horizontal averaging – It is the action of aggregating multiple unit process datasets or aggregated process datasets in which each provides the same reference flow in order to create a new process dataset (UN Environment 2011).

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

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

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

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

Infill – Particulate materials used to infill the synthetic turf pile to provide support and aid the provision of the required performance characteristics (EN 15330-1:2013).

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).

In-situ shockpad or elastic layer – Shockpad formed as a wet pour mix and normally incorporating a binder (e.g. polyurethane) and elastomeric granulate (e.g. rubber granulate) that is mixed and machine-laid on site on the base or floor of the sports area.

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

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

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

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

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

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

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

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

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

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

Long pile surfaces – Synthetic turf surface whose pile length is equal to or greater than 30mm when tested in accordance with ISO 2549 (EN 15330-1:2013).

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

Mineral infill – An infill produced entirely from naturally occurring inorganic materials, e.g. sand.

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

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

Non-filled synthetic turf – Synthetic turf surface that does not contain any form of unbound particulate fill within the pile of the carpet (EN 15330-1:2013).

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

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

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

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

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

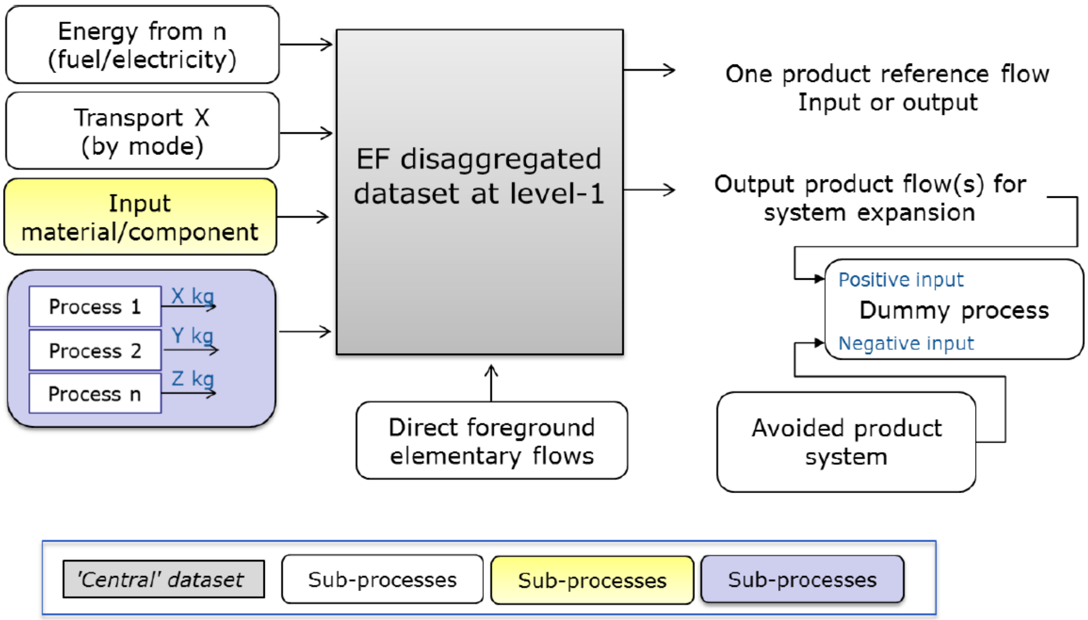


Figure 1: Example of a dataset partially disaggregated at level 1

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

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

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

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

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

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

Performance infill – Granulated materials used to form the upper layer of infill that help provide the required sports performance and player welfare characteristics of the surface (CEN/TR 17519:2020).

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

Polymeric infill – Material 5.0 mm or less in size made from a non-biodegradable polymer, or any infill material having a solid polymer surface coating, as a substance on their own or in a mixture in a concentration equal to or greater than 0.01% by weight or any particles containing or coated with at least 1% of polymer by weight (CEN/TR 17519:2020).

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

Pre-fabricated shockpad – Shockpad manufactured in a factory and normally comprising rolls or tiles that are transported to site laid on the base or floor of the sports area.

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

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

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

Product Environmental Footprint Category Rules (PEFCRs) – Product category specific, life cycle-based rules that complement general methodological guidance for PEF studies by providing further specification at the level of a specific product category. PEFCRs help to shift the focus of the PEF study towards those aspects and parameters that matter the most, and hence contribute to increased relevance, reproducibility and consistency of the results by reducing costs versus a study based on the comprehensive requirements of the PEF method. Only the PEFCRs listed on the European Commission website (http://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm) are recognised as in line with this method.

Product flow – Products entering from or leaving to another product system (ISO 14040:2006).

Product system – Collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product (ISO 14040:2006).

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

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

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

[4] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute 2015).

resurfacing, repainting, etc. Refurbished products may have been tested and verified to function properly.

Releases – Emissions to air and discharges to water and soil (ISO 14040:2006).

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

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

Repurpose – A discarded material or product is used in its original form, but for a different function than when it was new. The discarded material or product may be processed, typically by cleaning, repairing or otherwise refurbishing; inspection and/or testing to confirm that it is suitable for continued use. Example: A portion of the discarded turf is recovered from a synthetic turf field during the deconstruction phase. It is cleaned, repaired and used in a commercial or residential landscape application, batting cage, or soil amendment (Synthetic Turf Council 2017).

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

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

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

Secondary data[5] - It refers to data not from a specific process within the supply-chain of the company performing a PEF study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third party LCI database or other sources. Secondary data includes industry average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies and patents, and may also be based on financial data, and contain proxy data, and other generic data. Primary data that go through a horizontal aggregation step are considered as secondary data.

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

Shockpad – Elastic material placed beneath a synthetic turf sports surface that is designed to aid the provision of the performance properties of the sports surfacing system. Shockpads are also known as elastic layers (CEN/TR 17519:2020).

Short pile synthetic turf – Synthetic turf surface whose pile length is less than 30mm when tested in accordance with ISO 2549 (EN 15330-1:2013).

[5] Based on GHG protocol scope 3 definition from the Corporate Accounting and Reporting Standard (World resources institute 2015)

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

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

Stabilising infill – Particulate materials used to infill the lower portion of the synthetic turf surface to provide support to the carpet pile and ballast to hold the carpet in place and help prevent dimensional movement” (CEN/TR 17519:2020).

Stitch rate – Number of stitches per linear length (CEN/TR 17519:2020).

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

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

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

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

Synthetic turf carpet – surface comprised of a carpet of tufted, knitted or woven construction whose pile is designed to replicate the appearance of natural grass (adapted from (EN 15330-1:2013)).

Synthetic turf surfacing system (here also called Synthetic turf system) – All components of the surface that influence its sports performance or bio-mechanical characteristics including the synthetic turf carpet, infill, and shockpad, together with any supporting layers designed to contribute to the performance of the surface (EN 15330-1:2013).

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

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

Tufts per square meter – Number of tufts per square meter, which is a function of the number of stitches per linear length multiplied by the spacing (gauge) of the tufting needles (CEN/TR 17519:2020).

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

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

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

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

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

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

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

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

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

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

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

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

Vegetal infill – (also known as organic infill) an infill produced entirely from naturally occurring vegetal materials, e.g. cork. coconut fibre, nut husks, etc.

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

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

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

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

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

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

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

1 Introduction

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

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

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

Terminology: shall, should and may

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

- The term “shall” is used to indicate what is required in order for a PEF study to be in conformance with this PEFCR.
- The term “should” is used to indicate a recommendation rather than a requirement. Any deviation from a “should” 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

This PEFCR was developed by a Technical Secretariat led by the branch association representing the synthetic turf industry in the EMEA region, five industry organisations, one recycling organisation (SME), one non-governmental organisation, and one consultancy company.

Table 1: Technical Secretariat

Name of the organisation	Type of organisation	Name of the members	Starting date of participation
EMEA Synthetic Turf Council (ESTC) *TS coordinator*	Branch (trade) association	Prof. Alastair Cox Stefan Diderich Natasja Faelens	Autumn 2019
FieldTurf Tarkett SAS	Manufacturing company of	Tina Kramer	Autumn 2019

Name of the organisation	Type of organisation	Name of the members	Starting date of participation
	synthetic turf products		
JUTA a.s.	Manufacturing company of synthetic turf products	Libor Laš	Summer 2021
Re-match A/S	Recycling company of synthetic turf products	Stefaan Florquin	Autumn 2019
Sport Group GmbH	Manufacturing company of synthetic turf products	Dr Thorsten van den Berg Dr Viktoria Grasmik Dr Marco Rehosek	Autumn 2019
Sports and Leisure Group NV	Manufacturing company of synthetic turf products	Jordi Vercauteren Sebastiaan De Groote	Autumn 2019
TenCate Grass BV	Manufacturing company of synthetic turf products	Dr Colin Young	Autumn 2019
Union of European Football Associations (UEFA)	Governing body for European football (NGO)	Lee Guerriero	Spring 2020

The Technical Secretariat had the support of PRé Sustainability for the development of the PEFCR.

2.2 Consultations and stakeholders

Two public consultations took place. The first stakeholder consultation was regarding the 1st draft PEFCR and 1st version of the PEF-RP studies. See further details of this consultation below:

- Opening and closing date of the public consultation: from 1 to 31 March 2022
- Number of comments received: 67
- Names of organisations that have provided comments: ALIAPUR; BeKoGr; maki Consulting GmbH, on behalf of the EF helpdesk; Polytan / Polytex / SG; Senbis Polymer Innovations B.V.; Signus Ecovalor S.L.; and Trocellen GmbH.
- Link to the online platform: Stakeholder Workspace - PEFCR Synthetic Turf - EU Environmental Footprint - EC Extranet Wiki (europa.eu)

The second stakeholder consultation was regarding the 2nd draft PEFCR and 2nd version of the PEF-RP studies. See further details of this consultation below:

- Opening and closing date of the public consultation: from 12 October to 9 November 2023
- Number of comments received: 50
- Names of organisations that have provided comments: Polytan GmbH; and Sphera (on behalf of the EF helpdesk).
- Link to the online platform: Stakeholder Workspace - PEFCR Synthetic Turf - EU Environmental Footprint - EC Extranet Wiki (europa.eu)

2.3 Review panel and review requirements of the PEFCR

The panel appointed to review this PEFCR development, and any related deliverable is displayed in Table 2. It covers both LCA/PEF expertise and knowledge of the synthetic turf industry.

Table 2: Review panel of the PEFCR

Name	Organisation	Role
Max Sonnen	Ecomatters BV	Chair and LCA/PEF expert
Céline Alexandre	RDC Environment NV	LCA/PEF expert
Dr Kathryn Severn (initial phase)	Football Foundation	Synthetic turf expert
Mickael Benetti (second phase)	Fédération Internationale de Football Association (FIFA)	Synthetic turf expert

The reviewers have verified that the following requirements are fulfilled:

a) The PEFCR has been developed in accordance with the requirements provided in the PEF method and Annex I and Annex II adopted by the Commission on 16 December 2021 (European Commission 2021);

b) The PEFCR supports the creation of credible, relevant and consistent PEF profiles;

c) The PEFCR scope and the representative products are adequately defined;

d) The functional unit, allocation and calculation rules are adequate for the product category under consideration;

e) Datasets used in the PEF-RPs and the supporting studies are relevant, representative, reliable, and in compliance with data quality requirements;

f) The selected additional environmental and technical information are appropriate for the product category under consideration and the selection is done in accordance with the requirements stated in Annex I (European Commission 2021),

g) The model of the RP and corresponding benchmark (if applicable) correctly represent the product category or sub-category;

h) The RP model, disaggregated in line with the PEFCR and aggregated in ILCD format, are EF compliant following the rules available at http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml;

i) The RP model in its corresponding excel version is compliant with the rules outlined in section A.2.3 of Annex II (European Commission 2021);

j) The Data Needs Matrix is correctly implemented;

k) The classes of performance, if identified, are appropriate for the product category.

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

2.4 Review statement

This PEFCR was developed in compliance with the PEF Method adopted by the Commission on 16 December 2021 (European Commission 2021).

The representative product(s) correctly describe the average product(s) sold in Europe for the product category/sub-category in scope of this PEFCR.

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

The final validation statement of the review panel is included in Annex 3.1 – Review statement of the PEFCR.

2.5 Geographic validity

The ESTC – TS coordinator of this PEFCR - represents the synthetic turf industry in the EMEA region. The ESTC wishes to see one set of product environmental footprint category rules adopted throughout this region (and ideally globally) to prevent companies having to undertake multiple studies to service regional markets. For this reason, this PEFCR is valid for products in scope sold or consumed in the European Union + EFTA + UK.

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 + UK shall be considered as the default market, with an equal market share for each country.

2.6 Language

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

2.7 Conformance to other documents

This PEFCR has been prepared in conformance with annexes I and II of the of the Commission recommendation on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisation (European Commission 2021).

3 PEFCR scope

This PEFCR is applicable for the assessment of the environmental footprint of synthetic turf systems throughout their entire life cycle. Natural grass can often be used for similar applications to synthetic turf. However, natural grass is not covered in the scope of this PEFCR.

Product environmental footprint results of individual components to be used in synthetic turf systems - synthetic turf carpet, performance infill and shockpad – shall follow the rules stipulated in the PEFCR (see Figure 2). To follow the PEF method of European Commission (2021) for these is not sufficient. There is also a preparatory layer needed to install the STS i.e. the groundworks (construction of the base). However, the scope of the PEFCR is on the synthetic turf system (the surface), not on the entire synthetic turf field. Hence, the groundworks is not in the scope of the PEFCR.

Two sub-categories of synthetic turf are covered by the PEFCR:

- Synthetic turf sports surfacing, and
- Synthetic turf landscaping applications.

There are five main sectors for sports applications: Municipalities, Educational (school / universities), Community clubs, Professional clubs, and Commercial. For landscaping applications, the main sectors are: Residential, Commercial, and Public.

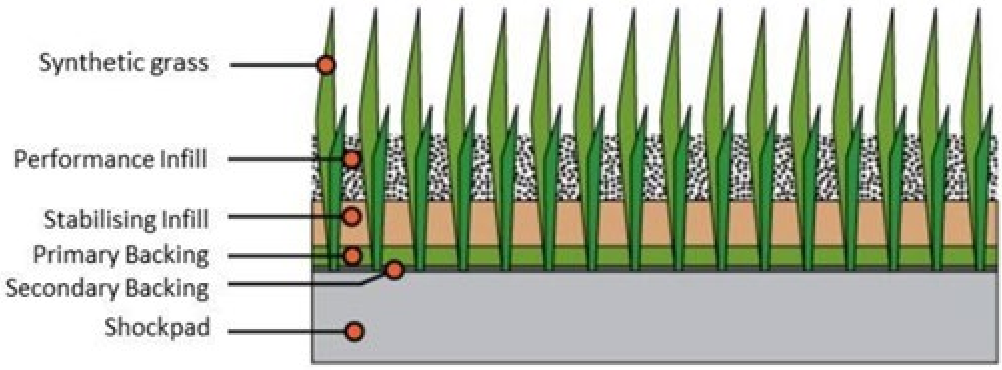


Figure 2: Principal components of a synthetic turf system (synthetic grass in the Figure is equivalent to synthetic turf)

The key performance criteria for a sports system will depend on the specific sports use, but includes:

- Ball rebound
- Ball roll distance
- Shock absorption
- Vertical deformation/surface stability
- Energy return
- Surface foot friction/rotational traction
- Durability, including resistance to wear, weathering and use

Typical sports uses of synthetic turf systems are football, hockey, tennis, rugby, Gaelic games, American football, cricket, bowls, and multi-sports use. Some surfaces are specific to a single sport, whereas others may be suitable for several sports (e.g. football and rugby).

The key performance criteria for a landscaping application are:

- Aesthetics – visual impression
- Durability, including resistance to wear, weathering and use
- User comfort

Typical landscaping uses of synthetic turf systems are residential, gardens, balconies, etc. Resorts and commercial environments, municipal and commercial hard landscaping

3.1 Product classification

The CPA codes[6] for the synthetic turf systems, which may be composed of various components, included in this PEFCR are:

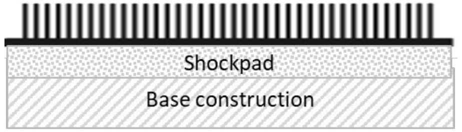
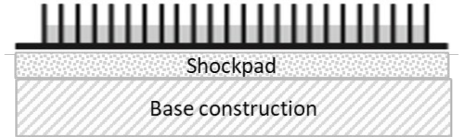
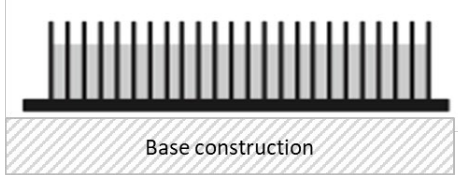
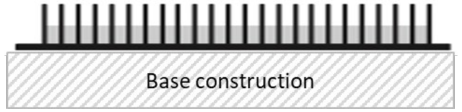
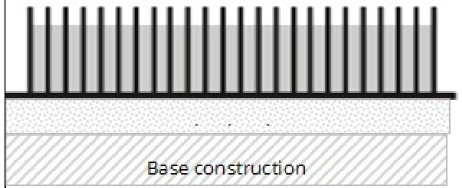
- 13.93.13 Carpets and other textile floor coverings, tufted

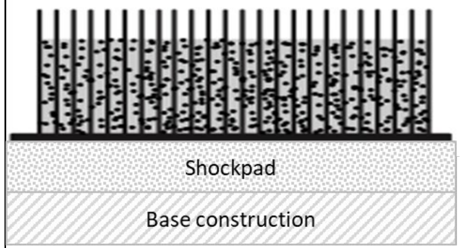
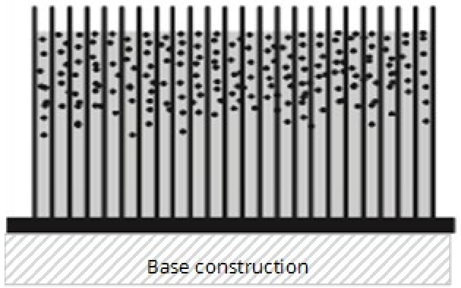
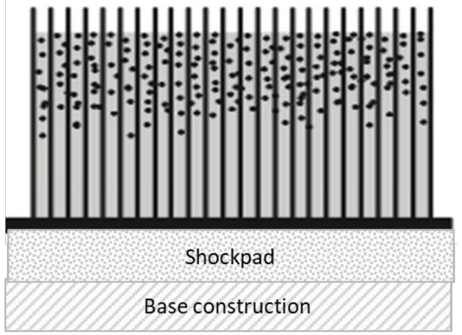
[6] https://ec.europa.eu/eurostat/web/cpa/cpa-2008

- 22.19.20 Unvulcanised rubber and articles thereof; vulcanised rubber, other than hard rubber, in thread, cord, plates, sheets, strip, rods and profile shapes
- 22.19.72 Floor coverings and mats of vulcanised rubber other than cellular

Based on the EN 15330-1 (EN 15330-1:2013) classifications, there are 10 synthetic turf systems' classifications for sports (see Table 3). For landscaping four types are considered (see Table 4).

Table 3: Classifications and characteristics of synthetic turf systems for sports surfacing. Source: Adapted by the TS on basis of EN 15330-1:2013

Classification	Primary uses	STS design	Typical pile height (mm)	Number of tufts/m²	Performance infill	Stabilising infill	Infill depth (% of pile height)	Shockpad
Sport 1 Non-filled	Hockey		10-20	> 60,000	No	No	n/a	Yes
Sport 2 Sand dressed	Hockey		10-20	37,500-55,000	No	Yes	< 75	Yes
Sport 3 Sand filled	Tennis		10-20	25,000-35,000	No	Yes	80-90	No
Sport 4 Sand dressed	Tennis		10-20	37,500-55,000	No	Yes	60-75	No
Sport 5 Sand filled	Multi-sports		15-35	25,000-35,000	No	Yes	80-90	Yes

Classification	Primary uses	STS design	Typical pile height (mm)	Number of tufts/m^2	Performance infill	Stabilising infill	Infill depth (% of pile height)	Shockpad
Sport 6 3G	Football & multi-sports		35-40	6,000-11,000	Yes	Yes	60-80	Yes
Sport 7 3G	Football		50-60	6,000-11,000	Yes	Yes	60-80	No
Sport 8	Rugby		60-65	6,000-11,000	Yes	Yes	60-80	Yes

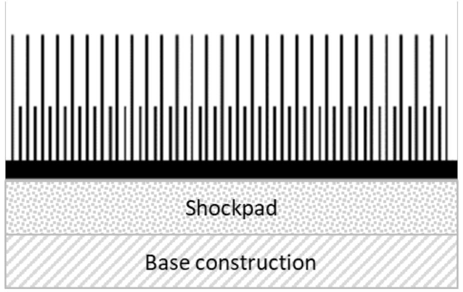
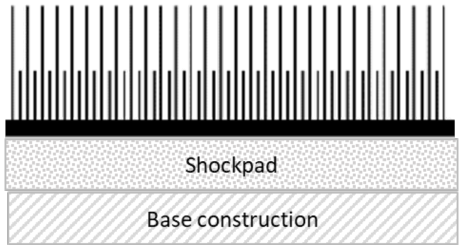
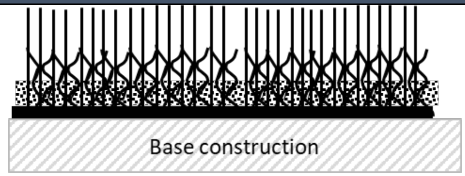
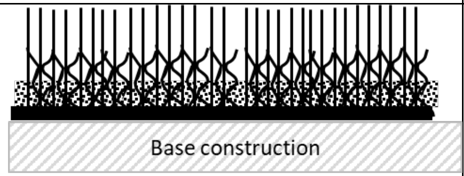
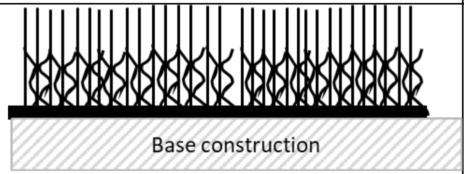
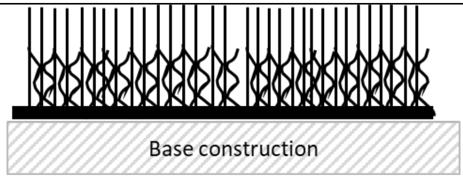
Classification	Primary uses	STS design	Typical pile height (mm)	Number of tufts/m²	Performance infill	Stabilising infill	Infill depth (% of pile height)	Shockpad
Sport 9 Long pile & no infill	Football & multi-sports		25-50	11,000-25,000	No	No	n/a	Yes
Sport 10 Long pile & sand dressed	Football & multi-sports		25-50	11,000-25,000	No	Yes	20-40	Yes

Table 4: Classifications and characteristics of synthetic turf systems for landscaping applications, provided by the Technical Secretariat

Classification	STS design	Typical pile height (mm)	Number of tufts/m^2	Performance infill	Stabilising infill	Infill depth (% of pile height)	Shockpad
Landscaping 1 **Low/medium tuft density, sand dressed**		15-50	6,000-12,000	No	Yes	20-40	Optional
Landscaping 2 **High tuft density, sand dressed**		15-50	12,000-20,000	No	Yes	20-40	Optional
Landscaping 3 **Low/medium tuft density, non-filled**		15-50	6,000-12,000	No	No	n/a	Optional
Landscaping 4 **High tuft density, non-filled**		15-50	12,000-20,000	No	No	n/a	Optional

3.2 Representative products

The synthetic turf systems have two primary applications – sports and landscaping. Depending on the application, the system may contain certain components, require specialist maintenance or undergo different treatment at the end of life. Capturing those differences and identifying hotspots relevant for each application requires two distinct representative products.

Due to commercial reasons, the TS members did not wish to use real products as RPs and virtual products were explored instead. Average product based on European sales proved to be not feasible to calculate and not useful for the industry representatives, for a number of reasons:

- Huge number of permutations depending on sport and sports regulations,
- Extremely time-consuming collection of sales data,
- Reluctance to share commercially sensitive data,
- Limited value to companies undertaking studies (therefore reduced motivation).

Ultimately, virtual representative products were based on the most common synthetic turf configuration in given application.

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

3.2.1 RP for sports surfacing

Globally, contact sports are the largest end-use application of synthetic turf, accounting for 47% of demand. 80% of installations are designed for football or multi-sports use where football is a key consideration. Therefore, a common configuration of a football surface including all components was selected as representative product for sports surfacing (Figure 2). The RP (see Table 5) includes all components used in the synthetic turf system (STS): carpet, performance infill, stabilising infill and shockpad. The exact configuration was modelled by calculating the arithmetic average of the most common configuration manufactured by four TS members for a football pitch (see Annex 4.1 - Representative product for sports surfacing for further details).

Table 5: Representative product of synthetic turf systems for sports surfacing, defined based on a virtual product

Component	Virtual product
Pile yarn	Polyethylene monofilament
Pile height	48 mm
Pile weight	1338 g/m^2
Primary backing	Polypropylene 252.5 g/m^2
Secondary backing (dry)	SBS latex (70%) and $CaCO_3$ filler (30%) 1000 g/m^2
Performance infill	ELT, 0.8 – 3.0 mm, 8 kg/m^2
Stabilising infill	Sand, 0.2 – 0.8 mm, 19.25 kg/m^2
Shockpad	PE foam, 10 mm thick, 533 g/m^2

A synthetic turf field can be split into two main parts: 1) groundworks (i.e. construction of the base) and 2) synthetic turf surfacing system. Groundworks are always site-specific and will vary across regions. This is why the representative product and the data requirements for installation do not include the construction of the base. There is a preparatory layer needed to install the STS. However, the scope of the PEFCR is on the synthetic turf system (surface), not on the entire synthetic turf field. Hence, it is not in the scope of the PEFCR. Installation materials, such as adhesives or tape, have negligible contribution and thus have not been included in the scope of this PEFCR. The machinery for the installation of the carpet and shockpad is also considered product independent, and thus it has also been excluded from the system boundary.

The operation (use of the STS) includes routine mechanical maintenance (including watering when relevant) and specialist mechanical maintenance. Routine maintenance, which includes cleaning of the surfaces, levelling/redistribution of the infill and brushing of the fibres is product dependent and was included in the scope of the PEFCR. Specialist mechanical maintenance, which includes top dressing of performance infill to compensate for loss and compaction and chemical treatments, is also product dependent and thus it was included in the scope of this PEFCR. The type of specialist maintenance depends on the STS. Other operation relevant variables were determined based on expert judgement of the TS members and are summarised in Table 6.

Table 6: Operational usage (per week) of the representative product for sports surfacing

Players per hour	25
Surface area (m^2)	7000
Operational (hours per week)	40
Lifetime (years)	8

Currently, there are no official statistics describing treatment of synthetic turf systems at the end of life. Therefore, average European end of life was modelled on basis of experience from the Technical Secretariat. This is further detailed in section 6.5.

Understanding the limitations of this virtual representative product, the PEF RP-study includes scenario analyses of individual components, and the supporting studies will cover synthetic turf systems used in different sports applications (tennis, hockey, etc.) to ensure this PEFCR is representative for all applications.

Detailed information on the representative product for sports surfacing is included in Annex 4.1 - Representative product for sports surfacing.

3.2.2 RP for landscaping applications

For landscape applications, the arithmetic average of the four most common sold landscape synthetic turf systems of one TS member were put together to develop a representative product (Table 7). The RP for landscape applications only includes the carpet, which consists of yarn, primary and secondary backing. Additional components like stabilising infill and shockpad are not commonly used though they can be used in some landscape applications, such as recreational. This configuration with extra components will be assessed in a supporting study.

Table 7: Representative product of synthetic turf systems for landscaping applications, defined based on a virtual product

Component	Virtual product	
Pile yarn	Polyethylene (67.5%) & Polypropylene (32.5%)	
Pile height	34 mm	
Pile weight	1278 g/m^2	
Primary backing	Polypropylene	177.5 g/m^2
Secondary backing (dry)	SBS latex (60%) and $CaCO_3$ filler (40%) 800 g/m^2	

Similarly to the RP for sports surfacing, also for this RP the base construction during installation is not included because that is site-specific and not product dependent. Installation materials, such as adhesives or tape, have negligible contribution and thus have not been included in the scope of this PEFCR. However, the cutting losses are much larger for landscaping, about 20% according to the TS. This is due to the random shapes of landscape areas, whereas sports fields and courts are rectangular. Turf carpet is produced in rolls, that need to be manufactured/cut to shape. The losses during installation are treated the same way to end of life of the system.

A lifetime of 8 years for the STS is assumed, following the length of warranty offered by the producers. No activities are foreseen in the use stage, so this life cycle stage does not include any processes for this RP model.

It is assumed that synthetic turf systems used in landscape applications are not recycled at the end of life. Main markets in landscaping are domestic use (homeowners) with small areas. Most of these will dispose the product in a similar way to household carpets, i.e. as kerbside collection of municipal solid waste. In consequence, the synthetic turf systems are either landfilled or incinerated. The waste treatment at the end of life of the representative product for landscape surfacing is based on municipal waste treatment incineration and landfill shares on EU, following the values of Annex C to the PEF method (European Commission 2020).

Detailed information on the representative product for landscaping applications is included in Annex 4.2 – Representative product for landscaping applications.

3.3 Functional unit and reference flow

The **functional unit** (FU) is 1 m^2 of synthetic turf system installed, used for 8 years assuming reasonable usage and adequate maintenance (i.e. 8 m^{2}a). Table 8 summarizes the key aspects in defining the FU.

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in m^2. All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.

Table 8: Key aspects of the functional unit

	Sports sub-category	Landscaping subcategory
What	Synthetic turf **sports** surface defining the specific sport application	Synthetic turf **landscaping** surface defining if for residential or recreational use
How much	1m x 1m (1m^2)	1m x 1m (1m^2)
How long	8 years subject to reasonable usage and adequate maintenance	8 years subject to appropriate usage and maintenance[7]
How well	In good condition with no significant wear[8]	In good condition with no significant wear, colour change, or pile flattening[8]

Synthetic turf surfaces are replaced for many differing reasons. Some are based on retaining acceptable performance in compliance with the EN 15330-1, others will wait until the surface is showing significant signs of wear and tear. Often budget availability will be the key factor. The synthetic turf industry generally advises consumers to budget on replacing surfaces after 8 years. Many suppliers will also offer warranties based on 8-year durations. Therefore, 8 years is a well-established and accepted life expectancy, and was adopted as the default lifetime. Reasonable usage entails the weekly operational usage as described in Table 6, i.e. 40 hours usage, 25 players per hour, for 7,000 m2 area over the 8 years lifetime. Adequate maintenance includes the routine maintenance and specialist mechanical maintenance as described in chapter 3.2.1. That is, routine maintenance includes cleaning of the surfaces, levelling/redistribution of the infill and brushing of the fibres. Specialist mechanical maintenance includes top dressing of performance infill to compensate for loss and compaction and chemical treatments.

Durability of the product affects its environmental footprint because it determines how much product is needed to fulfil the function over the product's lifetime. The durability attributes most relevant to the yarn are, resistance to wear (splitting and tearing), resistance to UV degradation (causing premature wear) and for some sports resiliency (the ability of the yarn to remain upright when subjected to loadings in use).

The carpet of a synthetic turf system for sports surfacing shall always be modelled for 8 years durability as defined in the functional unit. According to the EN 15330-4:2023, shockpads can last for two carpet lifetimes, i.e. for 16 years. Therefore, a carpet shall be modelled for a lifetime of 8 years and a shockpad shall be modelled for a lifetime of 16 years (i.e. 2 carpets). That means, the reference flow of a shockpad is 8/16 = 0.5 m^2.

The lifetime in landscaping is based on the length of the warranties offered by synthetic turf producers. Here, the lifetime is assumed to be the same as in sports surfacing, namely 8 years. So, all carpets for landscaping surfaces shall be modelled for 8 years.

[7] Appropriate maintenance of the synthetic turf depends on expectations of owner. In some cases it is purely decorative so no maintenance needed. In other cases loss of appearance is a consequence of use. Commercial use (resorts, etc.) may vacuum-clean to keep clean. Since this is a product-independent activity, vacuum cleaning shall be excluded in PEF calculation according to the PEFCR.

[8] There are no specific standards to measure good condition; this has to do with the expectations/perception of the owner.

Next to the functional unit, users of this PEFCR can also express PEF results of synthetic turf systems for sports surfacing in a **declared unit**[9], which represents the size of the entire pitch. Results per declared unit can be provided to improve the usability of the PEF study – the recipients of the results can learn about the impacts of a complete system that they will purchase and install. The declared unit depends on the final sports application (see Table 9).

Table 9: Declared unit of synthetic turf systems per sports application; all sports performance characteristics to comply with EN 15330-1

Sport	Declared unit
Football	7,000 m^2 x 8 years = 56,000 m^2a
Hockey	6,185 m^2 x 8 years = 49,480 m^2a
Rugby	9,120 m^2 x 8 years = 72,960 m^2a
Tennis	699 m^2 x 8 years = 5,592 m^2a
Gaelic games	10,400 m^2 x 8 years = 83,200 m^2a
American football	5,530 m^2 x 8 years = 44,240 m^2a
Cricket	92 m^2 x 8 years = 736 m^2a
Bowls	800 m^2 x 8 years = 6,400 m^2a
Multi-sport	no fixed size – depends on sports, etc

For PEF studies of STSs used for sports surfacing, the user of this PEFCR shall indicate for which sport(s) the STS being studied can be used.

3.4 System boundary

The life cycle stages and processes to be included in the system boundary are defined in Table 10. Results shall be reported per detailed life cycle stages, e.g. 1.1 Yarn production, not per default life cycle stage (i.e., not per 1. Raw materials acquisition and pre-processing).

[9] The PEF method provides the option to define a declared unit. This often happens when the FU is difficult to define such as in intermediate products that they fulfil multiple functions. In this case, the declared unit is defined to represent an entire field to improve the usability of the PEF study and provide the users with the environmental impact of an STS for an entire sport's field.

Table 10: Life cycle stages considered

Default life cycle stage	Detailed life cycle stage	Short description of the processes included	
		For sports surfacing	**For landscaping applications**
1. Raw material acquisition and pre-processing	1.1. Yarn production	Includes the production of yarn, the input materials needed and their transport to the yarn manufacturing site. It also includes the transport of the yarn to the carpet manufacturing site.	
	1.2. Primary backing production	Includes the manufacturing of primary backing, the input materials needed, their transport to backing manufacturing site. It also covers the transport of the primary backing to the carpet manufacturing site.	
	1.3. Secondary backing production	Includes the manufacturing of secondary backing, the input materials needed, their transport to backing manufacturing site, and the transport of secondary backing to the carpet manufacturing site.	
	1.4. Raw material acquisition and pre-processing for performance infill	Includes the production of the input materials needed for the production of performance infill and their transport to the infill manufacturing site.	
	1.5. Sand acquisition	In case stabilising infill is used, it is sand, and this life cycle stage includes sand extraction.[10]	
	1.6. Raw material acquisition and pre-processing for shockpad	Includes the production of the input materials needed for the production of the shockpad and their transport to the shockpad manufacturing site.	
2. Manufacturing	2.1. Carpet manufacturing	The yarn is integrated into the artificial turf by being tufted (or woven) into a primary backing sheet. Secondary backing (often called coating) is added to the previous and helps hold the carpet yarns in place. The life cycle stage includes the production of carpet, and treatment of carpet manufacturing waste.	
	2.2. Manufacturing of performance infill	Includes the production of performance infill and treatment of performance infill manufacturing waste.	
	2.3. Shockpad manufacturing	Includes the production of the shockpad, and treatment of shockpad manufacturing waste.	

[10] When an infill is used just to provide weight and ballast to the surface it is 99% always sand. Occasionally one infill (e.g., rubber granulate) is used as the performance and stabilising infill (one layer).

3. Distribution stage	3.1. Storage and distribution of carpet	It covers the transport of the carpet from the carpet manufacturing site to the installation site.	It covers the transport of the carpet from the carpet manufacturing site to the installation site. Distribution centres and/or retail are also included.
	3.2. Storage and distribution of performance infill	It covers the transport of the performance infill from its manufacturing site to the installation site.	
	3.3. Storage and distribution of stabilising infill	It covers the transport of the stabilising infill from its source to the installation site.	It covers the transport of the stabilising infill from its source to the installation site.
	3.4. Storage and distribution of shockpad	It covers the transport of the shockpad from its manufacturing site to the installation site.	It covers the transport of the shockpad from its manufacturing site to the installation site.
4. Use stage	4.1. Installation	Includes installation of the synthetic turf system, namely combining all components of the system on site. In particular, it includes product losses during installation and their treatment. The construction of the base (to prepare the site for the installation of the STS) is site-specific and not product dependent. For this reason, the base is excluded from the scope of this PEFCR. The machinery for the installation of the carpet and shockpad is also considered product independent, and thus it is excluded from the scope of this PEFCR. Jointing and other auxiliary installation materials have a negligible contribution and are excluded based on the cut-off rule.	
	4.2. Operation	Includes the use of the synthetic turf system for sports surfacing. The maintenance operation can include routine mechanical maintenance (including watering when relevant), and specialist mechanical maintenance. Routine maintenance, which includes cleaning of the surfaces, levelling/redistribution of the infill, and brushing of the fibres, as well as specialist mechanical maintenance, which includes top dressing of infill to compensate for loss and compaction and chemical treatments, are product dependent activities and are included in the system boundary. The type of specialist maintenance depends on the STS.	There are no activities included in the use phase of landscaping applications.

5. End of life	5.1. End of life of carpet	Includes the carpet (yarn, primary backing and secondary backing) waste treatment (recycling, repurposing, incineration, landfilling). Carpet is treated in its entirety because recycling and repurposing occur for the carpet as whole.	Includes the carpet (yarn, primary backing and secondary backing) waste treatment (incineration, landfilling).
	5.2. End of life of performance infill	Includes the removal of the performance infill from the site and its waste treatments (recycling, repurposing, incineration, landfilling).	
	5.3. End of life of stabilising infill	Includes the removal of the stabilising infill from the site and its waste treatments (recycling, repurposing, incineration, landfilling).	Includes the removal of the stabilising infill from the site and its waste treatments (incineration, landfilling).
	5.4. End of life of shockpad	Includes the removal of the shockpad from the site and its waste treatments (recycling, incineration, landfilling).	Includes the removal of the shockpad from the site and its waste treatments (incineration, landfilling).

The system diagrams of synthetic turf systems for sports surfacing and landscaping applications are shown in Figure 3 and 4, respectively.

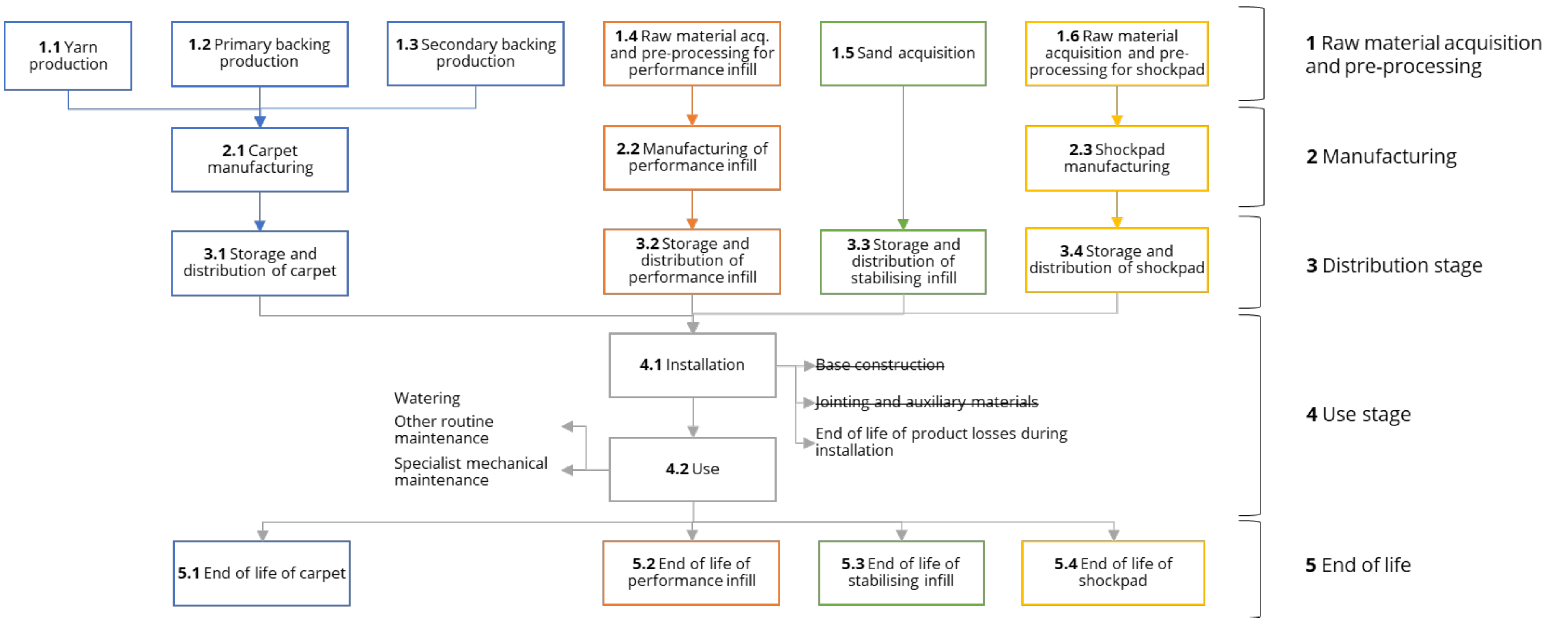


Figure 3: System diagram of synthetic turf systems for sports surfacing. Boxes displayed in blue are related to the carpet component; boxes in orange are related to the performance infill; boxes in green are associated with stabilising infill; boxes in yellow are related to the shockpad; and boxes in grey are associated with the entire synthetic turf system. Strikethrough text, i.e., base construction, jointing and auxiliary materials are excluded from the system boundary. The processes requiring company-specific data are documented in excel Annex_MandatoryData-Situation1processes_Sports_20230825.xlsx (section 5.1 and 5.2).

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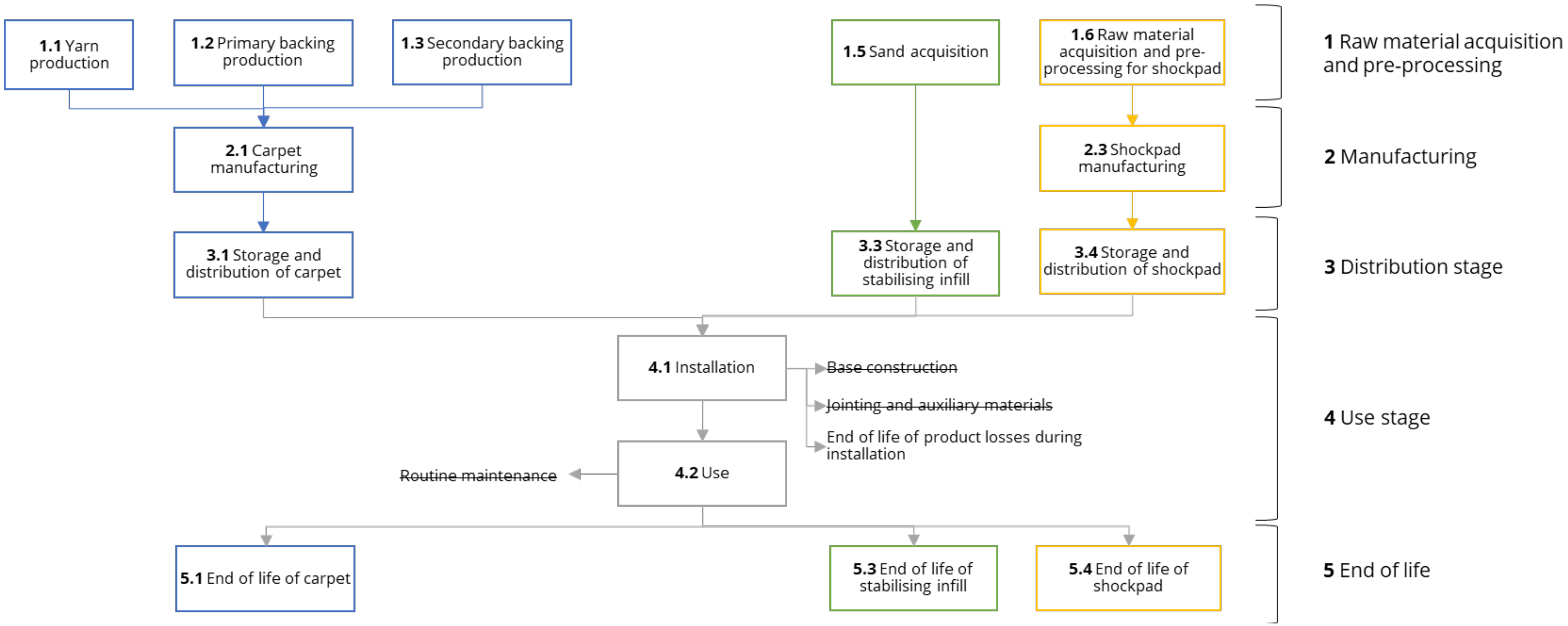

Figure 4: System diagram of synthetic turf systems for landscaping applications. Boxes displayed in blue are related to the carpet component; boxes in green are associated with stabilising infill; boxes in yellow are related to the shockpad; and boxes in grey are associated with the entire synthetic turf system. Strikethrough text, i.e., base construction, jointing and auxiliary materials and routine maintenance are excluded from the system boundary. The processes requiring company-specific data are documented in excel Annex_MandatoryData-Situation1processes_Landscape_20230825.xlsx (section 5.1 and 5.2).

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

- Capital goods, i.e. infrastructure and machinery, except for capital goods included in EF secondary datasets. The PEF method states that "Capital goods (including infrastructure) and their EoL should be excluded, unless there is evidence from previous studies that they are relevant." hence these were excluded.
- Tape and adhesives added during installation of synthetic turf systems. Tape and adhesives cumulatively contribute to less than 1% of the single score impact as reported in the supporting studies.
- Packaging production and waste treatment of carpet, performance infill and shockpad packaging were included in the 1st version of the PEF-RP studies and their contribution was below the cut-off rule so these are to be excluded for all applicants of this PEFCR.
- Packaging production and waste treatment of incoming materials used to manufacture components, e.g. packaging of yarn, weren't covered in the supporting studies. However, the order of magnitude of these is considered to be the same as the impacts of packaging of components, hence these were excluded on basis of the cut-off rule.
- Disassembly of the synthetic turf system at the end of life is an activity in situation 3 for applicants of the PEFCR and no secondary datasets were available for this hence this was excluded. But, on basis of expert judgement, disassembly of the STS at end-of life is expected to have negligible impacts.

No additional cut-off is allowed.

Each PEF study done in accordance with this PEFCR shall provide in the PEF study a diagram indicating the activities falling in situation 1, 2 or 3 of the data needs matrix. In the PEF-RP studies, data comes from various organisations so the situation under which an activity falls under can be different for each. Therefore, identifying situations 1, 2 and 3 for the PEF-RP studies would not be applicable.

3.5 List of EF impact categories

Each PEF study carried out in compliance with this PEFCR shall calculate the PEF-profile including all EF impact categories listed in Table 11.

Table 11: List of the impact categories to be used to calculate the PEF profile

EF impact category	Impact category indicator	Unit	Characterisation model
Climate change[11]	Global Warming Potential (GWP100)	kg CO_2 eq	Baseline model of 100 years of the IPCC (based on IPCC 2021)
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 eq	EDIP model based on the ODPs of the World Meteorological Organisation (WMO) over an infinite time horizon (WMO 2014 + integrations)
Human toxicity, cancer	Comparative Toxic Unit for humans (CTU_h)	CTU_h	Based on USEtox 2.1 model (Fantke et al. 2017), adapted as in (Saouter et al. 2018)
Human toxicity, non-cancer	Comparative Toxic Unit for humans (CTU_h)	CTU_h	Based on USEtox 2.1 model (Fantke et al. 2017), adapted as in (Saouter et al. 2018)
Particulate matter	Impact on human health	disease incidence	PM model (Fantke et al. 2016) in (UNEP/SETAC Life Cycle Initiative 2016)
Ionising radiation, human health	Human exposure efficiency relative to U^{235}	kBq ^{235}U eq	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al. 2000)
Photochemical ozone formation, human health	Tropospheric ozone concentration increase	kg NMVOC eq	LOTOS-EUROS model (van Zelm et al. 2008) as applied in ReCiPe 2008
Acidification	Accumulated Exceedance (AE)	mol H^+ eq	Accumulated Exceedance (Seppälä et al. 2006; Posch et al. 2008)
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N eq	Accumulated Exceedance (Seppälä et al. 2006; Posch et al. 2008)
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P eq	EUTREND model (Struijs et al. 2009) as applied in ReCiPe
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N eq	EUTREND model (Struijs et al. 2009) as applied in ReCiPe
Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTU_e)	CTU_e	Based on USEtox 2.1 model (Fantke et al. 2017), adapted as in (Saouter et al. 2018)
Land use[12]	Soil quality index[13]	Dimensionless (pt)	Soil quality index based on LANCA model (De Laurentiis et al. 2019) and on LANCA CF version 2.5 (Horn and Maier 2018)

[11] The indicator "Climate Change, total" is constituted by three sub-indicators: Climate Change, fossil; Climate Change, biogenic; Climate Change, land use and land use change. The sub-indicators are further described in section 5.10. The sub-categories 'Climate change –fossil', 'Climate change – biogenic' and 'Climate change - land use and land use change', shall be reported separately if they show a contribution of more than 5% each to the total score of climate change.

[12] Refers to occupation and transformation.

[13] This index is the result of the aggregation, performed by JRC, of 4 indicators (biotic production, erosion resistance, mechanical filtration, and groundwater replenishment) provided by the LANCA model for assessing impacts due to land use as reported in De Laurentiis et al, 2019.

EF impact category	Impact category indicator	Unit	Characterisation model
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 water eq of deprived water	Available WAter REmaining (AWARE) model (Boulay et al. 2018; UNEP/SETAC Life Cycle Initiative 2016)
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb eq	van Oers et al. 2002 as in CML 2002 method v4.8
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)[14]	MJ	van Oers et al. 2002 as in CML 2002 method v4.8

The full list of normalisation factors and weighting factors are available in ANNEX 1 – List of EF normalisation and weighting factors. The EF reference package v3.1 (https://eplca.jrc.ec.europa.eu/permalink/EF3_1/EF-v3.1.zip) shall be used.

The full list of characterisation factors is available at this link:

http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

3.6 Additional technical information

For sports surfacing, STS shall prove compliance with the EN standards applicable to synthetic turf surfaces (EN 15330-1: 2013) and sport's governing body standards.

3.7 Additional environmental information

3.7.1 Biodiversity

Biodiversity is a relevant issue for this PEFCR. However, we believe that most impacts affecting biodiversity are already well covered by the midpoint indicators covered in the EF impact categories listed in section 3.5, i.e. Climate change, Acidification, Freshwater, Terrestrial and Marine eutrophication, Freshwater ecotoxicity, Land use, and Water use. An exception are ecotoxicity impacts caused by plastic pollution of yarn fibre wear and migration of polymeric infill to the natural environment. To address this, additional environmental information on this is required (see detailed in the next section). Therefore, no reporting of biodiversity is required when implementing this PEFCR.

3.7.2 Microplastic pollution

Polymeric infill used on synthetic turf sport surfaces is considered by the European Commission as the largest source of releases of intentionally added microplastics in the environment (European Commission 2023a). In September 2023, the European Commission adopted measures to restrict intentionally added microplastics (European Commission 2023b). For infill material for sport pitches, the ban applies after 8 years to give pitch owners and managers the time to switch to alternatives and allow for most existing sport pitches to reach their end of life (European Commission 2023a). For this reason, this PEFCR still considers synthetic turf systems where polymeric infill is used. The approach documented further in this section aims at addressing the impact of microplastics resulting from the use of synthetic turf systems.

[14] In the EF flow list, and for the current recommendation, Uranium is included in the list of energy carriers, and it is measured in MJ.

Microplastic pollution is an issue of concern for the synthetic turf systems, due to potential migration of performance infill during the use phase. Fibre debris can also become a microplastic pollutant. Ability to control this is partly due to quality of yarn, but primarily down to how the surface is maintained. If field owner maintains the turf with correct equipment, fibre debris should be collected before it becomes a pollutant. Since the EF impact assessment method does not cover for **the impacts of microplastics on the environment**, the PEFCR includes an approach to address this for synthetic turf systems. The user of the PEFCR shall, at least, indicate the amount of potential yarn fibre debris and of polymeric infill lost to the natural environment per functional unit. Additionally, the potential freshwater ecotoxicity impacts may be quantified. The approach considered corresponds to the scientific state-of-the-art during the development of this PEFCR. However, scientific developments for addressing microplastic pollution as well as alignment with approaches taken by other PEFCRs should be considered in the future.

During the use and the end of life of the synthetic turf field, fibres of the carpet (for sports and landscape applications) and the polymeric infill (only for sports applications) can end up in the natural environment and thus become microplastic pollutants. Due to the lack of inventory data and impact assessment of microplastics, the following approach shall be used to estimate the amount of microplastic lost to the environment during the life cycle of the synthetic turf system. The impact of the leaked microplastics onto the environment can be estimated as a voluntary exercise.

As a minimum, the user shall estimate the amount of non-biodegradable carpet fibres and polymeric infill lost to the environment, with the help of primary or secondary data. As an additional, but voluntary, exercise, the user can calculate the potential impact of the microplastic pollutant to freshwater ecotoxicity to estimate the magnitude of environmental impact currently not considered in the assessment.

An Excel file (see OTHER ANNEXES*) is provided to assist in the calculation and reporting of this required additional environmental information.*

Note: In the excel file and in the section below, in orange fields, the user is asked for primary data. If not available, secondary (default) values are provided, which can be used instead. In the green fields, the user can perform the calculations. In grey text boxes, the application of the rules for the RP models is displayed, as examples.

Mandatory reporting requirement

Resulting from yarn fibres (relevant for sports and landscaping applications)

During the use phase, the yarn fibres can be damaged and loosen, especially in sports application and more so in high-use areas of the pitch and can end up outside of the field. The ability to control how much ends up in the natural environment is partly related to the quality of yarn, but also due to the maintenance of the surface and containment measures around the pitch. The latter two factors are not necessarily under the control of the synthetic turf producer and therefore secondary data is provided below.

The user of the PEFCR shall, as a minimum, report the amount of fibres in the carpet (Table 12). Together with default high-use areas per size of field (Table 13) and the corresponding wear rate of high-use and non-high use areas or applications with little and more wear (Table 14), the amount of fibres loosened can be estimated. Due to the lack of data, we assume that currently no containment measures to contain specifically the fibre debris are used. Hence, we assume that all fibre debris is currently ending up in the natural environment.

Important Note: For a landscape application, we only distinguish between little wear for residential use, and more wear for recreational use. Furthermore, the amount of fibres differ for landscaping applications and sports applications. Please keep that in mind when performing the calculations.

Table 12: Reporting on the amount of fibres in carpet per functional unit

Mandatory company-specific data
Amount of fibres per FU =

Table 13: Default values of high-usage area of field (%) per field size. This is only applicable for sports applications.

Sports field size	High-usage area of sports field (%)
Larger than 6000 m^2	15%
4000 to 6000 m^2	20%
2000 to 4000 m^2	40%
Smaller than 2000 m^2	60%

Table 14: Default values for fibre wear rate per non-high usage and high-usage areas (%) of total fibre material per year

Wear rate of the fibres for sports (% of the total fibre material per year):	**Wear rate of the fibres for landscaping:**
0.3% (non-high-use area) – average of 1.25% (high use area)	2.5% (little wear) for residential applications – 5% (more wear) for recreational applications over entire use[11]

Sports applications: Calculation of fibre loss to the natural environment

Loss of fibres to natural environment (kg/FU)

=

Mass of fibre (kg/FU) x [(High usage area of field (%) x wear rate of fibre per high usage area per year (%/year) x 8 years lifetime) + (Non-high usage area of field (%) x wear rate of fibre per non-high usage area

<u>Illustration of fibre loss calculation using the **sports representative product** as example:</u>

For the sports RP, the fibre wear is calculated as 0.047 kg per FU (i.e., per 8m^2a). Specifically:

- Amount of fibres (yarn) per FU: 1.338 kg
- High-usage area of field assumed: 15% (because field is 7000 m^2)
- Wear rate of fibres for non-high-usage area: 0.3%
- Wear rate of fibres for high-usage area: average 1.25%

$$\text{Loss of fibres to environment} = 1.338 \times ((15\% \times 1.25\% \times 8) + (85\% \times 0.3\% \times 8)) = 0.047 \text{ kg per FU}$$

That means that about 3.5% of fibre yarn is lost to the environment during the 8 years lifetime of the STS for sports surfacing.

Due to the uncertainty in the amounts of ware and high-usage area, it is assumed that the whole amount of yarn fibres is reaching EoL treatment. Thus, the EoL impact of yarn is slightly overestimated.

Landscaping applications: Calculation of fibre loss to the natural environment

As stated in the limitations, the whole amount of yarn fibres reaches EoL treatment.

loss of fibres to natural environment (kg/FU)

=

Mass of fibre (kg/FU) x Little or high wear rate of field depending on application (%)

Illustration of fibre loss calculation using the landscaping representative product as example:

For the landscaping RP, the fibre wear is calculated as 0.032 kg per FU and 0.064 kg per FU, for residential and recreational applications respectively, (i.e., per $8m^2a$). Specifically:

- Amount of fibres (yarn) per FU: 1.278 kg
- Wear rate of fibres for residential application (less wear) over entire use: 2.5%
- Wear rate of fibres for recreational application (more wear) over entire use: 5%

$$\text{Loss of fibres to environment (for residential)} = 1.278 \times 2.5\% = 0.032 \text{ kg per FU}$$

$$\text{Loss of fibres to environment (for recreational)} = 1.278 \times 5\% = 0.064 \text{ kg per FU}$$

That means that between 2.5 and 5% of fibre yarn is lost to the environment during the 8 years lifetime of the STS for landscaping applications.

Resulting from polymeric infill (relevant only for sports applications)

Performance infill (often polymeric material) is compacted and transported during the use of the field. Both, the compaction of infill within the field and its transport outside of the field require the refilling of infill to maintain the same performance (Figure 5). On the one hand, compaction of infill is caused by contact pressure, which increases its density, thus refill is needed to keep the intended performance of the infill. The field operator can de-compact the infill by harrowing and other measures, which can reduce the refill needed. On the other hand, infill can migrate outside of the field due to weather, run-off, due to sports being performed on it, and it can travel in clothes, shoes etc. To estimate how much of the infill is ending up in the natural environment, the user shall, as a minimum, report the amount of infill and refill. Assuming that refill is needed either due to compaction, or due to transport outside the field, one can make a preliminary estimate on how much infill is transported outside the field (Step 1). We assume that the maintenance instructions of the field manufacturer are followed and hence we use the best-case scenario of decompaction following the right maintenance measures. But not all infill that is transported outside the field ends up in the natural environment. Depending on specific containment measures, between 27-100%, including an assumed “intention behaviour gap”, of this transported flow ends up in the natural environment (Step 2).

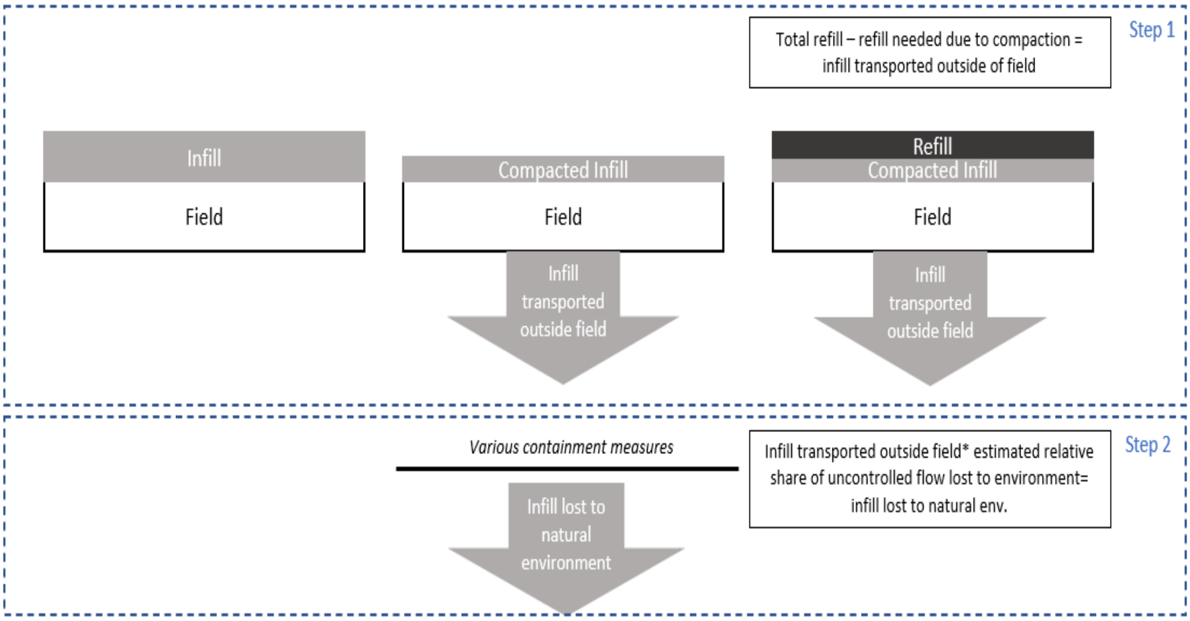

Figure 5: Illustration of approach to estimate the amount of infill lost to natural environment

Step 1: Report on infill & refill

The user of the PEFCR shall report as a minimum on the amount of infill and refill per FU (Table 15).

Table 15: Amount of infill and refill per FU

Mandatory company-specific data
Amount of infill (at installation) per FU =
Amount of refill (at use) per FU =

Regarding the compaction of infill, we assume that all fields are maintained as instructed (meaning regular harrowed for decompaction). The default value of 3 kg of compacted infill per FU with corrected maintenance is to be used.

Calculation of infill transported outside of the field

Infill transported outside of field (kg/FU)

=

Illustration of infill transported outside of the field using the **sports representative product** as example:

For sports surfacing, the migration of performance infill to the natural environment is calculated as 4.2kg per FU (i.e., per 8m^{2}a). Specifically:

- Total refill per FU: 7.2 kg
- Refill needed due to compaction: 3 kg

$$\text{Infill transported out of the field} = 7.2 - 3 = 4.2 \text{ kg per FU}$$

Step 2: Estimate how much of the transported infill is ending up in natural environment

The user of the PEFCR shall report, as a minimum, the planned / instructed containment measures for the synthetic turf field (Table 16). If the data is not known, an average default can be used as a preliminary estimate (Table 17). Each case represents various installed containment measures and the relative share of transported infill that cannot be contained, which is estimated to end up in the natural environment as a pollutant. Each case includes the new measure to the measures of the previous case, like a pyramid scheme. The overall assumption is that refill is needed due to transport outside of field and compaction hence, by subtracting the refill needed due to compaction from the total refill we can estimate the loss to the environment.

Estimating the effectiveness of measures to contain transported infill per FU

Table 16: Measures and their effectiveness to contain infill

If containment measures are known:			
Case	**Measures for containment of infill (each new measure contains the previous measure)**	**Estimated share of transported infill lost to environment**	**Including an expected "intention-behaviour" gap of 75% (75% of people do as instructed)**
Case A: Worst case scenario	No measures for containment	100% transported infill lost to environment	100%
Case B	Case A + Instalment of perimeter barrier preventing infill migration to field sides / or wide accumulation zones + Maintenance brush and tractor going to different fields	73% transported infill lost to environment	80%
Case C	Case B + Keeping the maintenance brush on the field (not used on other fields)	27% transported infill lost to environment	45%
Case D	Case C + Tractor Is brushed off twice a week	23% transported infill lost to environment	42%
Case E	Case D + Clothes/ shoes are brushed off	6% transported infill lost to environment	30%
Case F: Best case scenario	Case E + Filters fitted to drain (Full implementation of all measures)	3% transported infill lost to environment	27%

Table 17: Default measure and its effectiveness to contain infill

If containment measures are not known:			
Case	**Measures for containment of infill in field (each new measure is on top of the previous measure)**	**Estimated share of transported infill lost to environment**	**Including an expected "intention-behaviour" gap of 75% (75% of people do as instructed)**
Average Case	Only the 'architectural' measures are installed; not the behavioural measures.	86.5% transported infill lost to environment	90%

Calculation of infill lost to the natural environment

Infill lost to natural environment
=
Infill transported outside of field (kg/FU) x Estimated share of transported infill lost to environment (%)

The total amount of performance infill used in the field is 15.2 kg per 8 m^2a (8 kg at installation and 7.2 kg in total added during operation over the lifetime of the STS). Thus, 3.36 kg migration corresponds to 22% of the total infill used. The remaining infill that is not lost in the environment is treated at the EoL.

Illustration of infill lost to the natural environment using the **sports representative product** as example:

For sports surfacing, the migration of performance infill is calculated as 3.36 kg per FU (i.e., per 8m^2a). Specifically:

- Performance infill transported out of the field per FU: 4.2 kg
- Share of transported infill to the environment (Case B assumed): 80%

$$\text{Migration of infill} = 4.2 \times 80\% = 3.36 \text{ kg per FU}$$

Voluntary exercise to estimate the environmental impact of microplastic in the environment

Characterization factor of microplastics emissions to impact category freshwater ecotoxicity[15]:

Mean degradation: 3209 PAF.m^3.day / kg microplastic emitted

[15] Salieri et al. (2021) How Relevant Are Direct Emissions of Microplastics into Freshwater from an LCA Perspective? https://www.mdpi.com/2071-1050/13/17/9922

Calculations

Infill environmental impact of microplastic pollutants to impact category of freshwater ecotoxicity (in PAF.m^3.day)

=

(Infill lost to nat. environment (kg/FU) + Loss of fibres to natural environment (kg/FU)) x characterization

Illustration of freshwater ecotoxicity impact caused by microplastic pollutants calculated using the **sports representative product** as example:

For sports surfacing, Example for sports of calculating the freshwater ecotoxicity impact of the microplastics from fibres and infill losses in the environment:

- Fibres losses in natural environment per FU: 0.047 kg
- Infill losses in natural environment per FU: 3.36 kg

$$\text{Freshwater ecotoxicity microplastics} = (3.36 + 0.047) \times 3209 = 10934\ \text{PAF.}\,\text{m}^3\text{.}\,\text{day per FU}$$

3.8 Limitations

See below the list of limitations a PEF study will have, even if carried out in accordance with this PEFCR:

- The representative product is based on a common configuration of a football field, while the PEFCR is intended to cover all final applications of synthetic turf systems. Therefore, the supporting studies assessed synthetic turf systems for sports other than football, namely hockey and tennis.
- The current version of the PEFCR is modelled using the latest EF3.1 datasets. However, some of the secondary datasets were not available or had limitations, so proxies were used. See below the most obvious examples:
  - Performance infill in sports applications need to be produced from ELT with ambient grinding method. However, the ELT dataset that is available in the EF3.1 datasets is produced with the cryogenic method. For that reason, recycled rubber (the majority also generated by end-of-life tyres according to the EF3.1 dataset comment) from post-consumer SBR through ambient grinding was used instead of the ELT through cryogenic production.
  - Yarn in sports applications needs to be produced as mono-filament straight yarn with 50% in-line extrusion and 50% off-line extrusion. Due to non-availability of off-line extrusion, 100% in-line extrusion of mono-filament straight yarn was assumed.
  - Few waste treatment processes of plastics (mainly for landfilling) were modelled using proxies, because polymer specific EF-compliant datasets were not available.
- Although, based on expert judgement, we expect their relative contribution to be negligible, production and end-of-life of packaging of incoming materials were not covered. However, since these weren't covered in the PEF-RP or in the supporting studies, there is no evidence that these have negligible impact. These are to be included in the future to investigate if below the cut-off rule.

- Losses of stabilising and performance infill during installation were not included, due to lack of data.
- The user of the PEFCR shall, at least, indicate the amount of potential yarn fibre debris and of polymeric infill lost to the natural environment per functional unit. Additionally, the potential freshwater ecotoxicity impacts may be quantified. The approach considered corresponds to the scientific state-of-the-art during the development of this PEFCR. However, scientific developments for addressing plastic pollution as well as alignment with approaches taken by other PEFCRs should be considered in the future.
- Migration of microplastics through use of performance infill is site-specific, affected by the climate and by the incorporation of migration risk design measures of the field (CEN/TR 17519:2020).The migration (losses to the environment) of microplastics through use of performance infill has been assessed and is provided as additional environmental information (see 3.7). However, a number of assumptions had to be made such as the fraction of high-use area per sports application for fibre wear and the migration rate for performance infill. The performance infill sent to end-of-life treatment considers subtraction the infill migration but this was not done for fibre wear.
- Microplastics migration to the environment due to carpet/fibre loss during installation is not considered due to lack of data but it's considered negligible when compared to the migration during operation.
- The fully aggregated EF3.1 datasets limit the availability of appropriate datasets that can be used. For instance, the tufting of carpet EF3.1 dataset already includes latex as a backing material and cannot be disaggregated. There are several examples like that in which the material and the service are only provided as an aggregated dataset.

3.8.1 Comparisons and comparative assertions

Provided that PEF studies will be compliant with the rules stipulated in this PEFCR:

- A comparison can only be done for Synthetic turf systems of a sub-category but not across STS of different sub-categories, i.e. sports and landscaping.
- Although the RP was modelled using a virtual product for football surfacing, the sports benchmark results are applicable for all sports applications.
- A synthetic turf system is composed of various components. In case no valid PEFCR is available for the product category the component is part of, PEF results of components to be used in synthetic turf systems shall follow the rules included in this PEFCR to make sure that results are comparable.

3.8.2 Data gaps and proxies

See below the data gaps and proxies listed on basis of the second version of the PEF-RP studies:

- Manufacturing of yarn in sports applications was modelled using *100% in-line extrusion of mono-filament straight yarn* (instead of 50% in-line and 50% offline extrusion);
- Manufacturing of yarn in landscaping applications (combined PE and PP) was modelled using *100% in-line extrusion of mono-filament straight PE yarn* as a proxy. For the part of PP yarn, all datasets were available so it was modelled accurately as

50% in-line extrusion of mono-filament texturized PP yarn and 50% off-line extrusion of mono-filament texturized PP yarn;

- Manufacturing inputs and losses of secondary backing were not included due to lack of data;
- Performance infill recycled input was modelled using recycled rubber from post-consumer SBR through ambient grinding as a proxy for ELT. SBR is used to represent the virgin material (when applying the circular footprint formula (CFF) there is always a part of the impact allocated to the virgin material);
- Manufacturing of shockpads was modelled using *Foaming* as a proxy;
- In a number of cases transport of raw materials to manufacturing was based on the European average data (as defined in section 4.4.3.4 of European Commission (2021)), which consists of truck, train and barge transport. It is possible that not all of these transport nodes are relevant in the specific case. The places where European average transport was used are listed in Annex 4.1;
- No losses of stabilising infill and performance infill during installation were included, due to lack of data;
- Cleaning of plastic infills has been used as a proxy during sand recovery at end of life;
- *Landfilling of plastic waste* was used as proxy for PP and PE landfill;
- *Landfilling and incineration of inert waste* have been used as proxies for the $CaCO_3$ filler, used in the secondary backing, at the end of life; and
- Data for disassembly of synthetic turf systems was not made available in secondary datasets. For this reason, this is considered a data gap and not included in assessments following this PEFCR.

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

The identification of the most relevant impact categories, life cycle stages, processes and elementary flows was carried out following the instructions in section 6.3 of Annex I of the Commission's Recommendation (European Commission 2021). The identification was based on the outcomes of the PEF-RP studies and checked against the six supporting studies. Regarding the latter, it should be noted that the supporting studies were carried out with a combination of EF 2.0 and EF 3.0 datasets because EF 3.1 datasets where not available then. For this reason, this was considered when analysing the outcomes of supporting studies.

4.1 Most relevant EF impact categories

As prescribed in section 6.3.1 of European Commission (2021), the most relevant impact categories per RP were identified as all impact categories that cumulatively contribute to at least 80% to the total environmental impact starting from the largest to the smallest contribution and on basis of normalised and weighted results.

The most relevant impact categories for the sub-category **sports surfacing** in scope of this PEFCR are the following:

- Climate change
- Particulate matter

- Resource use, fossils
- Acidification
- Resource use, minerals and metals[16]
- Water use[17]

The most relevant impact categories for the sub-category **landscaping application** in scope of this PEFCR are the following:

- Climate change
- Resource use, fossils
- Particulate matter
- Acidification
- Resource use, minerals and metals
- Water use[17]

It should be noted that the differences in most relevant impact categories between sports and landscaping applications is due to the different representative products. The RP for sports surfacing includes the carpet (yarn, primary and secondary backing), stabilizing and performance infills, and shockpad. While the RP for landscaping applications only includes the carpet.

4.2 Most relevant life cycle stages

As prescribed in section 6.3.2 of European Commission (2021), the most relevant life cycle stages per RP are those that cumulatively contribute to at least 80% to any of the most relevant impact categories (see section 4.1) starting from the largest to the smallest contribution with characterised results. In case the use stage accounts for more than 50% of the total impact, the procedure was re-run with the exclusion of the use stage. In this case, the list of most relevant life cycle stages is those selected through the latter procedure plus the use stage.

On basis of the RP study of synthetic turf systems for sports surfacing the most relevant life cycle stages (LCS) for the sub-category **sports surfacing** in scope of this PEFCR are the following:

- LCS 1.1 Yarn production
- LCS 1.3 Secondary backing production
- LCS 2.2 Manufacturing of performance infill
- LCS 4.2 Operation

On basis of the RP study of synthetic turf systems for landscaping applications, The most relevant life cycle stages for the sub-category **landscaping application** in scope of this PEFCR are the following:

- LCS 1.1 Yarn production
- LCS 1.3 Secondary backing production

[16] This impact category was not above the 80% threshold for sports applications. However, it has been added to be consistent with the list of most relevant impact categories identified for the sub-category for landscaping applications.

[17] Although Water use was not identified as most relevant in the PEF-RP study for sports surfacing, we expect it to become a hotspot for STS that need watering during the use stage. Water use is particularly relevant for systems: i) using organic infills, which need to be kept moist to prevent them from wind erosion; ii) designed to be used with water, e.g. to reduce the risk of carpet burns.

- LCS 3.1 Storage and distribution of carpet
- LCS 5.1 End of life of carpet

4.3 Most relevant processes

As prescribed in section 6.3.3 of European Commission (2021), the most relevant processes are those that collectively contribute to at least 80% to any of the most relevant impact categories, from the highest to the smallest contribution. Identical processes taking place in different life cycle stages (e.g. transportation, electricity use) were accounted for separately. Identical processes taking place within the same life cycle stage were accounted for together.

The most relevant processes for the sub-category sports surfacing in scope of this PEFCR are listed in Table 18. The most relevant processes for the sub-category landscaping application in scope of this PEFCR are listed in Table 19.

4.4 Most relevant elementary flows

As prescribed in section 6.3.4 European Commission (2021), the most relevant elementary flows are elementary flows contributing cumulatively at least with 80% to the total impact for each most relevant processes, starting from the most contributing to the less contributing ones. This analysis shall be reported separately for each most relevant impact category.

There are no most relevant elementary flows to be reported. Specifically:

- The EF3.1 datasets are fully aggregated and thus no direct elementary flows are available. Specifically, the European Commission (2021) states that "Elementary flows belonging to the background system of a most relevant process may dominate the total impact, therefore, if disaggregated datasets are available, the user of the PEF method should in addition identify the most relevant direct elementary flows for each most relevant process."
- No direct elementary flows were modelled as part of the representative STS.

It should be noted that, when the disaggregated EF3.1 datasets become available, the identification of the most relevant direct elementary flows should be performed by the user of the PEFCR.

Table 18: List of the most relevant processes for the sub-category sports surfacing

Most relevant impact category	Most relevant processes
Climate change	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS2.2 Manufacturing of performance infill)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS2.2 Manufacturing of performance infill)
	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS4.2 Operation)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS4.2 Operation)
	PE granulates {EU+EFTA+UK} | Polymerisation of ethylene | production mix, at plant | 0.91- 0.96 g/cm3, 28 g/mol per repeating unit | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | straight yarn | LCI result (from LCS1.1 Yarn production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Incineration of ELT granulate {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | ELT granulate | LCI result (from LCS5.2 EOL of performance infill)
	Articulated lorry transport, Euro 4, Total weight >32 t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight / 24,7t payload capacity | LCI result (from LCS3.3 S&D of stabilising infill)
Particulate matter	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS2.2 Manufacturing of performance infill)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS2.2 Manufacturing of performance infill)

Most relevant impact category	Most relevant processes
	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS4.2 Operation)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS4.2 Operation)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
Resource use, fossils	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS2.2 Manufacturing of performance infill)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS2.2 Manufacturing of performance infill)
	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS4.2 Operation)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS4.2 Operation)
	PE granulates {EU+EFTA+UK} | Polymerisation of ethylene | production mix, at plant | 0.91- 0.96 g/cm3, 28 g/mol per repeating unit | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | straight yarn | LCI result (from LCS1.1 Yarn production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Incineration of ELT granulate {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | ELT granulate | LCI result (from LCS5.2 EOL of performance infill)
	Repurposing of sports surfacing carpet – Avoided production of carpet manufacturing for landscaping applications (from LCS5.1 EOL of carpet)

Most relevant impact category	Most relevant processes
Acidification	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS4.2 Operation)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS4.2 Operation)
	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS2.2 Manufacturing of performance infill)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS2.2 Manufacturing of performance infill)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Articulated lorry transport, Euro 4, Total weight >32 t {EU+EFTA+UK} | diesel driven, Euro 4, cargo | consumption mix, to consumer | more than 32t gross weight / 24,7t payload capacity | LCI result (from LCS3.3 S&D of stabilising infill)
	Incineration of ELT granulate {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | ELT granulate | LCI result (from LCS5.2 EOL of performance infill)
	Repurposing of sports surfacing carpet – Avoided production of carpet manufacturing for landscaping applications (from LCS5.1 EOL of carpet)
Resource use, minerals and metals	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS2.2 Manufacturing of performance infill)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS4.2 Operation)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS2.2 Manufacturing of performance infill)

Most relevant impact category	Most relevant processes
	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS4.2 Operation)
	Green pigment {GLO} | production mix, at plant | Pigment for colouration of plastic granules prior to spinning for yarn production. | LCI result - LCS1.1 Yarn production (from LCS1.1 Yarn production)
Water use	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS4.2 Operation)
	Specialist mechanical maintenance {EU+EFTA+UK} | technology mix | production mix, at plant | 1 m2 | LCI result (from LCS4.2 Operation)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS4.2 Operation)
	Rubber, recycled {GLO} | post-consumer mechanical recycling of styrene-butadiene rubber (SBR) through ambient grinding | production mix, at plant | Erec/ErecEoL, efficiency 98% | LCI result (from LCS2.2 Manufacturing of performance infill)
	Styrene-butadiene rubber (SBR), fossil fuel- based {GLO} | copolymerisation of butadiene with styrene | production mix, at plant | petrochemical based | LCI result (from LCS2.2 Manufacturing of performance infill)
	PE granulates {EU+EFTA+UK} | Polymerisation of ethylene | production mix, at plant | 0.91- 0.96 g/cm3, 28 g/mol per repeating unit | LCI result (from LCS1.1 Yarn production)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.2 Primary backing production)

Table 19: List of the most relevant processes for the sub-category landscaping application

Most relevant impact category	Most relevant processes
Climate change	Polyethylene (PE), petrochemical based {GLO} | mix of fossil-based HDPE, LDPE and LLDPE | production mix, at plant | 100% fossil-based | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | straight yarn | LCI result (from LCS1.1 Yarn production)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.1 Yarn production)
	PE granulates {EU+EFTA+UK} | Polymerisation of ethylene | production mix, at plant | 0.91- 0.96 g/cm3, 28 g/mol per repeating unit | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | texturized yarn | LCI result (from LCS1.1 Yarn production)
	Off-line extrusion of mono-filament {EU+EFTA+UK} | Processing dataset, parameterized | texturized yarn | LCI result (from LCS1.1 Yarn production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Waste incineration of PE {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | polyethylene waste | LCI result (from LCS5.1 EOL of carpet)
	Incineration of styrene-butadiene-styrene (SBS) latex {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | SBS latex | LCI result (from LCS5.1 EOL of carpet)
	Waste incineration of PP {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | polypropylene waste | LCI result (from LCS5.1 EOL of carpet)
	Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (from LCS3.1 S&D of carpet)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.2 Primary backing production)
	Electricity grid mix 1kV-60kV {CN} | technology mix | consumption mix, to consumer | 1kV - 60kV | LCI result (from LCS2.1 Carpet manufacturing)
Resource use, fossils	Polyethylene (PE), petrochemical based {GLO} | mix of fossil-based HDPE, LDPE and LLDPE | production mix, at plant | 100% fossil-based | LCI result (from LCS1.1 Yarn production)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | straight yarn | LCI result

Most relevant impact category	Most relevant processes
	PE granulates {EU+EFTA+UK} | Polymerisation of ethylene | production mix, at plant | 0.91- 0.96 g/cm3, 28 g/mol per repeating unit | LCI result (from LCS1.1 Yarn production)
	PP granulates {EU+EFTA+UK} | polymerisation of propene | production mix, at plant | 0.91 g/cm3, 42.08 g/mol per repeating unit | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | texturized yarn | LCI result (from LCS1.1 Yarn production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.2 Primary backing production)
	Waste incineration of PE {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | polyethylene waste | LCI result (from LCS5.1 EOL of carpet)
	Waste incineration of PP {EU+EFTA+UK} | waste-to-energy plant with dry flue gas treatment, including transport and pre-treatment | production mix, at consumer | polypropylene waste | LCI result (from LCS5.1 EOL of carpet)
Particulate matter	Polyethylene (PE), petrochemical based {GLO} | mix of fossil-based HDPE, LDPE and LLDPE | production mix, at plant | 100% fossil-based | LCI result (from LCS1.1 Yarn production)
	Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (from LCS1.1 Yarn production)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.1 Yarn production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (from LCS3.1 S&D of carpet)
	Electricity grid mix 1kV-60kV {CN} | technology mix | consumption mix, to consumer | 1kV - 60kV | LCI result (from LCS2.1 Carpet manufacturing)
Acidification	Polyethylene (PE), petrochemical based {GLO} | mix of fossil-based HDPE, LDPE and LLDPE | production mix, at plant | 100% fossil-based | LCI result (from LCS1.1 Yarn production)
	Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (from LCS1.1 Yarn production)

Most relevant impact category	Most relevant processes
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | straight yarn | LCI result (from LCS1.1 Yarn production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Transoceanic ship, containers {GLO} | heavy fuel oil driven, cargo | consumption mix, to consumer | 27.500 dwt payload capacity, ocean going | LCI result (from LCS3.1 S&D of carpet)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.2 Primary backing production)
Resource use, minerals and metals	Polyethylene (PE), petrochemical based {GLO} | mix of fossil-based HDPE, LDPE and LLDPE | production mix, at plant | 100% fossil-based | LCI result (from LCS1.1 Yarn production)
	Green pigment {GLO} | production mix, at plant | Pigment for colouration of plastic granules prior to spinning for yarn production. | LCI result (from LCS1.1 Yarn production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
Water use	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.2 Primary backing production)
	Weaving of primary backing {EU+EFTA+UK} | service, Backing fabric, weaved | production mix, at plant | service, Backing fabric, weaved | LCI result (from LCS1.2 Primary backing production)
	Styrene-butadiene-styrene (SBS) latex, petrochemical based {GLO} | emulsion polymerisation of styrene, and 1,3-butadiene | production mix, at plant | petrochemical based | LCI result (from LCS1.3 Secondary backing production)
	Polyethylene (PE), petrochemical based {GLO} | mix of fossil-based HDPE, LDPE and LLDPE | production mix, at plant | 100% fossil-based | LCI result (from LCS1.1 Yarn production)
	Polypropylene (PP), petrochemical based {GLO} | polymerisation of bio-fossil propylene | production mix, at plant | petrochemical based | LCI result (from LCS1.1 Yarn production)
	In-line extrusion of mono-filament yarn {EU+EFTA+UK} | Processing dataset, parameterized | straight yarn | LCI result (from LCS1.1 Yarn production)

5 Life cycle inventory

All newly created datasets shall be EF or ILCD-EL compliant according to rules in section 5.5.

In case sampling is needed, it shall be conducted as specified in section 5.7 of this PEFCR. However, sampling is not mandatory and any user of this PEFCR may decide to collect the data from all the plants, without performing sampling. Production data shall be based on the company and the manufacturing sites it has, whereas transport data to model the distance to be travelled from factory to customer can be site-specific, i.e. specific from the site where the input material comes from, in case this can be verified.

Attributional modelling is adopted in this PEFCR. This represents process-based modelling intended to provide a static representation of average conditions, excluding market-mediated effects.

5.1 List of mandatory company-specific data

The user shall collect the following company-specific data:

- guaranteed lifetime per component;
- the activity data of the bill of materials (BoM) for each component and the material type; when using (partly) recycled materials, the recycled content R_1 is also mandatory company-specific data;
- product-dependent activities occurring during the use phase, such as refill of performance infill or watering of the STS.

For companies producing more than one product the activity data used (including the BoM) shall be specific to the product in scope of the study.

See detailed data requirements in Excel annexes:

- Annex_MandatoryData-Situation1processes_Landscape_20230825.xlsx for landscaping and
- Annex_MandatoryData-Situation1processes_Sports_20230825.xlsx for sports.

5.2 List of processes expected to be run by the company

The list of processes expected to be run by the user of the PEFCR include:

- Yarn manufacturing
- Primary backing manufacturing
- Carpet manufacturing
- Shockpad manufacturing

Installation, although it is an activity that could be run by a company, is product independent and thus it is not included in the list of processes expected to be run by the user of the PEFCR.

See detailed data requirements in Excel annexes:

- Annex_MandatoryData-Situation1processes_Landscape_20230825.xlsx for landscaping
- Annex_MandatoryData-Situation1processes_Sports_20230825.xlsx for sports.

5.3 Data quality requirements

The data quality of each dataset and the total PEF study shall be calculated and reported.

The calculation of the DQR shall be based on the following formula with four criteria:

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

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

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

5.3.1 Company-specific datasets

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

1. Select the most relevant activity data (AD) and direct elementary flows (ef): most relevant activity data are the ones linked to sub-processes (i.e. secondary datasets) that account for at least 80% of the total environmental impact of the company-specific dataset, listing them from the most contributing to the least contributing one. Most relevant direct elementary flows are defined as those direct elementary flows contributing cumulatively at least with 80% to the total impact of the direct elementary flows.

2. Calculate the DQR criteria TeR, TiR, GR and P for each most relevant activity data and each most relevant direct elementary flow. The values of each criterion shall be assigned based on Table 20.

    a) Each most relevant direct elementary flow consists of the amount and elementary flow naming (e.g. 40 g carbon dioxide). For each most relevant elementary flow, the user of the PEFCR shall evaluate the 4 DQR criteria named TeR_{ef}, TiR_{ef}, TeR_{ef}, P_{ef}. For example, the user of the PEFCR shall evaluate the timing of the flow measured, for which technology the flow was measured and in which geographical area.

    b) For each most relevant activity data, the 4 DQR criteria shall be evaluated (named TiR_{AD}, P_{AD}, GR_{AD}, TeR_{AD}) by the user of the PEFCR.

    c) Considering that the data for the mandatory processes shall be company-specific, the score of P cannot be higher than 3, while the score for TeR, TiR and GR cannot be higher than 2 (The DQR score shall be ≤1.5).

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

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

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

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

5. The user of the PEFCR shall calculate the total DQR of the newly developed dataset using Equation 2, where $\overline{TeR}$, $\overline{GR}$, $\overline{TiR}$ and $\overline{P}$ are the weighted average calculated as specified in point (4).

$$DQR = \frac{\overline{TeR}+\overline{GR}+\overline{TiR}+\overline{P}}{4} \quad \text{Equation 2}$$

Table 20: How to assess the value of the DQR criteria for datasets with company-specific information

Rating	P_{ef} and P_{AD}	TiR_{ef} and TiR_{AD}	TeR_{ef} and TeR_{AD}	GR_{ef} and GR_{AD}
1	Measured/calculated and externally verified	The data refers to the most recent annual administration period with respect to the EF report publication date	The elementary flows and the activity data exactly the technology of the newly developed dataset	The activity data and elementary flows reflects the exact geography where the process modelled in the newly created dataset takes place
2	Measured/calculated and internally verified, plausibility checked by reviewer	The data refers to maximum 2 annual administration periods with respect to the EF report publication date	The elementary flows and the activity data is a proxy of the technology of the newly developed dataset	The activity data and elementary flows) partly reflects the geography where the process modelled in the newly created dataset takes place
3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer	The data refers to maximum three annual administration periods with respect to the EF report publication date	Not applicable	Not applicable
4-5	Not applicable	Not applicable	Not applicable	Not applicable

P_{ef}: Precision for elementary flows; **P_{AD}**: Precision for activity data; **TiR_{ef}**: Time Representativeness for elementary flows; **TiR_{AD}**: Time representativeness for activity data; **TeR_{ef}**: Technology representativeness for elementary flows; **TeR_{AD}**: Technology representativeness for activity data; **GR_{ef}**: Geographical representativeness for elementary flows; **GR_{AD}**: Geographical representativeness for activity data.

5.4 Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific data (listed in section 5.1) shall be evaluated using the Data Needs Matrix (see Table 21). The user of the PEFCR shall apply the DNM to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the user of the PEFCR (company) has on the specific process. The following three cases are found in the DNM and are explained below:

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

Table 21: Data Needs Matrix (DNM)[18]. *Disaggregated datasets shall be used.

<table>
<tr><th></th><th></th><th>Most relevant process</th><th>Other process</th></tr>
<tr><td rowspan="2">Situation 1: process run by the company using the PEFCR</td><td>Option 1</td><td colspan="2">Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5)[19]
Calculate the DQR values (for each criterion + total)</td></tr>
<tr><td>Option 2</td><td></td><td>Use default secondary dataset in PEFCR, in aggregated form (DQR≤3.0)
Use the default DQR values</td></tr>
<tr><td rowspan="3">Situation 2: process not run by the company using the PEFCR but with access to company-specific information</td><td>Option 1</td><td colspan="2">Provide company-specific data (as requested in the PEFCR) and create a company-specific dataset, in aggregated form (DQR≤1.5)
Calculate the DQR values (for each criterion + total)</td></tr>
<tr><td>Option 2</td><td>Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤3.0) *
Re-evaluate the DQR criteria within the product specific context</td><td></td></tr>
<tr><td>Option 3</td><td></td><td>Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets (DQR≤4.0) * Use the default DQR values.</td></tr>
</table>

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

[19] Company-specific datasets shall be made available to the EC.

		Most relevant process	Other process
Situation 3: process not run by the company using the PEFCR and without access to company-specific information	Option 1	Use default secondary data set in aggregated form (DQR≤3.0) Re-evaluate the DQR criteria within the product specific context	
	Option 2		Use default secondary data set in aggregated form (DQR≤4.0) Use the default DQR values

5.4.1 Processes in situation 1

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

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

Situation 1/Option 1

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

Situation 1/Option 2

For the non-most relevant processes only, if the user of the PEFCR decides to model the process without collecting company-specific data, then the user shall use the secondary dataset listed in the PEFCR together with its default DQR values listed here.

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

5.4.2 Processes in situation 2

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

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

Situation 2/Option 1

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

Situation 2/Option 2

The user of the PEFCR shall use company-specific activity data for transport and shall substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets, starting from the default secondary dataset provided in the PEFCR.

Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.

The user of the PEFCR shall make the DQR context-specific by re-evaluating TeR and TiR using the Table 22. The criteria GR shall be lowered by 30%[20] and the criteria P shall keep the original value.

Situation 2/Option 3

The user of the PEFCR shall apply company-specific activity data for transport and shall substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets, starting from the default secondary dataset provided in the PEFCR.

Please note that the PEFCR lists all dataset names together with the UUID of their aggregated dataset. For this situation, the disaggregated version of the dataset is required.

In this case, the user of the PEFCR shall use the default DQR values. If the default dataset to be used for the process is not listed in the PEFCR, the user of the PEFCR shall take the DQR values from the original dataset.

Table 22: How to assess the value of the DQR criteria when secondary datasets are used.

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

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

5.4.3 Processes in situation 3

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

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

Situation 3/Option 1

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

Situation 3/Option 2

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

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

5.5 Datasets to be used

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

1. Use an EF compliant dataset available on one of the nodes of the Life Cycle Data Network[21];
2. Use an EF compliant dataset available in a free or commercial source;
3. Use another EF compliant dataset considered to be a good proxy. In such case this information shall be included in the "limitations" section of the PEF report.
4. Use an ILCD-EL compliant dataset. These datasets shall be included in the "limitations" section of the PEF report. A maximum of 10% of the single overall score may be derived from ILCD-EL compliant datasets. The nomenclature of the elementary flows of the dataset shall be aligned with the EF reference package used in the rest of the model[22].
5. If no EF compliant or ILCD-EL compliant proxy is available, it shall be excluded from the PEF study. This shall be clearly stated in the PEF report as a data gap and validated by the PEF study and PEF report verifiers.

5.6 How to calculate the average DQR of the study

To calculate the average DQR of the PEF study, the user of the PEFCR shall calculate separately the TeR, TiR, GeR and P for the PEF study as the weighted average of all most relevant processes, based on their relative environmental contribution to the total single overall score. The calculation rules explained in section 4.6.5.8 of Annex I of the Commission Recommendation on the use of the Environmental Footprint methods to measure and communicate the life cycle environmental performance of products and organisation (European Commission 2021) shall be used.

[21] http://eplca.jrc.ec.europa.eu/LCDN/

[22] http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml

5.7 Sampling procedure

A sampling procedure may be needed to limit the data collection only to a representative sample. Examples of cases when the sampling procedure may be needed are in case multiple production sites are involved in the production of the same product. The user of this PEFCR method shall (i) specify in the PEF report if sampling was applied, (ii) follow the requirements described in this section and (iii) indicate which approach was chosen.

According to the PEF method (European Commission 2021), the following aspects shall be considered when identifying the number of sub-populations (Nsp) to consider:

- Geographical distribution of sites expressed as number of countries in which the sites/plants are located (g);
- Technologies involved expressed as number of technologies (t); and
- Production capacity of the companies/ sites taken into consideration expressed as number of classes of capacity of companies (c).

$$Nsp = g \times t \times c$$

Since the production capacity is not considered to be significantly different to affect environmental performance of synthetic turf systems' production, only the number of countries in which the sites/plants are located (g) and the number of technologies (t) are considered relevant for applicants of this PEFCR.

Example (adapted from the PEF method with a hypothetical case for sampling of yarn suppliers)**:**

40 yarn manufacturers are distributed across three different countries (20 in China, 15 in Belgium, and 5 in France). There are two different yarn techniques used, and these differ in a relevant way (China: 20 off-line extrusion; Belgium: 10 off-line extrusion and 5 in-line extrusion; France: 5 in-line extrusion).

Table 23: Identification of the sub-population for this example

Sub-population	Country		Yarn production technology	
1	China	20	Off-line extrusion	20
2			In-line extrusion	0
3	Belgium	15	Off-line extrusion	10
4	Belgium		In-line extrusion	5
5	France	5	Off-line extrusion	0
6			In-line extrusion	5

In this case, it is possible to identify a maximum of 6 sub-populations with g = 3 (three countries), and t = 2 (two different yarn production techniques):

$$Nsp = g \times t \times c = 3 \times 2 = 6$$

For each sub-population, the size of sample shall be calculated based on the total production of the sub-population. According to European Commission (2021), "the user of the PEF method shall identify the percentage of production to be covered by each sub-population. The percentage of production to be covered by each sub-population shall not be lower than 50%, expressed in the relevant unit. This percentage determines the sample size within the sub-population."

In case the user of this PEFCR uses sampling, the table below shall be populated in the PEF report.

Table 24: Sampling information to be provided

Sub-population	Country	Technology	Number of sitesin the sub-population	Total production of the sub-population
1	*Country A*	*Technology X*	*x*	*a*
2	*Country B*	*Technology Y*	*y*	*b*

The representative sample to be modelled in the scope of a PEF study following this PEFCR corresponds to the sum of the sub-samples at sub-population level.

5.8 Allocation rules

Other than the allocation of the water and energy and outputs of solid waste and wastewater at manufacturing sites, there is no other need for allocation foreseen in the life cycle of synthetic turf systems and of their individual components.

Table 25: Allocation rules

Process	Allocation rule	Modelling instructions	Allocation factor
Manufacturing process	Physical allocation	The output products (per m^2 or per kg) shall be used.	*To be determined by the companies as company-specific data*

5.9 Electricity modelling

The following electricity mix shall be used in hierarchical order:

a) Supplier-specific electricity product shall be used if for a country there is a 100% tracking system in place, or if:
   i. available, and
   ii. the set of minimum criteria to ensure the contractual instruments are reliable is met.

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

c) The 'country-specific residual grid mix, consumption mix' shall be used. Country-specific means the country in which the life cycle stage or activity occurs. This may be an EU country or non-EU country. The residual grid mix prevents double counting with the use of supplier-specific electricity mixes in a) and b).

d) As a last option, the average EU residual grid mix, consumption mix (EU-28 +EFTA), or region representative residual grid mix, consumption mix, shall be used.

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

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

They represent the minimum features necessary to use supplier-specific mix within PEF studies.

Set of minimum criteria to ensure contractual instruments from suppliers

A supplier-specific electricity product/ mix may only be used if the user of the PEF method ensures that the contractual instrument meets the criteria specified below. If contractual instruments do not meet the criteria, then country-specific residual electricity consumption-mix shall be used in the modelling.

The list of criteria below is based on the criteria of the GHG Protocol Scope 2 Guidance – An amendment to the GHG Protocol Corporate Standard – Mary Sotos – World Resource Institute. A contractual instrument used for electricity modelling shall:

Criterion 1 – Convey attributes

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

Criterion 2 – Be a unique claim

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

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

<u>Modelling 'country-specific residual grid mix, consumption mix':</u>

Datasets for residual grid mix, consumption mix, per energy type, per country and per voltage are made available by data providers.

If no suitable dataset is available, the following approach should be used:

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

- Activity data related to non-EU country consumption mix per detailed energy type shall be determined based on:
    a) Domestic production mix per production technologies;
    b) Import quantity and from which neighbouring countries;
    c) Transmission losses;
    d) Distribution losses;
    e) 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 (<u>www.iea.org</u>).

- Available LCI datasets per fuel technologies. The LCI datasets available are generally specific to a country or a region in terms of:

a) fuel supply (share of resources used, by import and/ or domestic supply);
b) energy carrier properties (e.g. element and energy contents);
c) technology standards of power plants regarding efficiency, firing technology, flue-gas desulphurisation, NOx removal and de-dusting.

Allocation rules:

The allocation rules for electricity are defined in Table 26.

Table 26: Allocation rules for electricity

Process	Physical relationship	Modelling instructions
Manufacturing process	Main unit of output product, e.g. kg for yarn, and m^2 for carpet	In case the user of the PEFCR has several manufacturing facilities, then the sales ratios produced in different locations shall be used

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

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

a) If the production (and related electricity consumption) of a product occurs in a separate site (building), the energy type physical related to this separated site may be used.

b) If the production (and related electricity consumption) of a product occurs in a shared space with specific energy metering or purchase records or electricity bills, the product-specific information (measure, record, bill) may be used.

c) If all the products produced in the specific plant are supplied with a publicly available PEF study, the company wanting to make the claim shall make all PEF studies available. The allocation rule applied shall be described in the PEF study, consistently applied in all PEF studies connected to the site and verified. An example is the 100% allocation of a greener electricity mix to a specific product.

On-site electricity generation:

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

No contractual instruments have been sold to a third party: the own electricity mix (combined with LCI datasets) shall be modelled.

Contractual instruments have been sold to a third party: the 'country-specific residual grid mix, consumption mix' (combined with LCI datasets) shall be used.

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

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

If not possible, direct substitution shall be used. The country-specific residual consumption electricity mix shall be used as substitution[23].

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[24] shall be modelled under sub-category 3 (incl. connected soil emissions, derived products, residues). The emission flows ending with '(biogenic)' shall be used.
   A simplified modelling approach shall be used when modelling foreground emissions. "Only the emission 'methane (biogenic)' is modelled, while no further biogenic emissions and uptakes from atmosphere are included. If methane emissions can be both fossil or biogenic, the release of biogenic methane shall be modelled first and then the remaining fossil methane."
3. **Climate change – land use and land use change**: This sub-category accounts for carbon uptakes and emissions (CO_2, CO and CH_4) originating from carbon stock changes caused by land use change and land use. This sub-category includes biogenic carbon exchanges from deforestation, road construction or other soil activities (including soil carbon emissions). For native forests, all related CO_2 emissions are included and modelled under this sub-category (including connected soil emissions, products derived from native forest[25] and residues), while their CO_2 uptake is excluded. The emission flows ending with '(land use change)' shall be used.

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

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

[24] 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.

[25] Following the instantaneous oxidation approach in IPCC 2013 (Chapter 2).

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 (BSI 2011b), 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[26].

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

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

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

1. where the country of production is known and the previous land use is known, the GHG emissions and removals arising from land use change shall be those resulting from the change in land use from the previous land use to the current land use in that country (additional guidelines on the calculations can be found in PAS 2050-1:2012) (BSI 2012b);
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) (BSI 2012b);

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

3. where neither the country of production nor the former land use is known, the GHG emissions arising from land use change shall be the weighted average of the average land use change emissions of that commodity in the countries in which it is grown.

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

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

The sum of the three sub-categories shall be reported. The sub-category 'Climate change-biogenic' shall not be reported separately. The sub-category 'Climate change-land use and land transformation' shall not be reported separately.

5.11 Modelling of end of life and recycled content

The end of life of products used during the manufacturing, distribution, retail, the use stage or after use shall be included in the overall modelling of the life cycle of the organisation. Overall, this should be modelled and reported at the life cycle stage where the waste occurs. This section provides rules on how to model the end of life of products as well as the recycled content.

The Circular Footprint Formula (CFF) is used to model the end of life of products as well as the recycled content and is a combination of "material + energy + disposal", i.e.:

Material

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

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

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

with the following parameters:

- **A:** allocation factor of burdens and credits between supplier and user of recycled materials.
- **B:** allocation factor of energy recovery processes. It applies both to burdens and credits. It shall be set to zero for all PEF studies.
- **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 consider 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 functional unit) 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 functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.
- **E_V:** specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material.
- **E^*_V:** specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.
- **E_{ER}:** specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, etc.).
- **$E_{SE, heat}$ and $E_{SE, elec}$:** specific emissions and resources consumed (per functional unit) that would have arisen from the specific substituted energy source, heat and electricity respectively.
- **E_D:** specific emissions and resources consumed (per functional unit) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.
- **$X_{ER, heat}$ and $X_{ER, elec}$:** the efficiency of the energy recovery process for both heat and electricity.
- **LHV:** lower heating value of the material in the product that is used for energy recovery.

Modelling recycled content (if applicable)

The following part of the Circular Footprint Formula is used to model the recycled content:

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

The R_1 values applied shall be supply-chain specific or default (R_1 = 0 for all materials except for end-of-life tyres (ELT); in that case, it should be R_1 = 1), in relation with the DNM. Material-specific values based on supply market statistics are not accepted as a proxy and therefore shall not be used. The applied R_1 values shall be subject to PEF study verification.

When using supply-chain specific R_1 values other than 0, traceability throughout the supply chain is necessary. The following guidelines shall be followed when using supply-chain specific R1 values:

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

Further discussion on the application of the CFF and the point of substitution

It is important to mention that the CFF formula always needs to be applied when a secondary material substitutes a primary material. When there is such a case, the point of substitution needs to be identified. Chapter 4.4.8.4 of the PEF method European Commission (2021) describes that as: "it is necessary to determine the point of substitution to apply the "material" part of the formula. The point of substitution corresponds to the point in the value chain where secondary materials substitute primary materials".

An example where the point of substitution was applied in this PEFCR is in the production of performance infill. Performance infill is made by recycled end-of-life tyres. The point of substitution has been applied at the performance infill manufacturer. Thus, the CFF formula was applied at the performance infill manufacturer, allocating the burden between the recycled rubber from ELT material and the primary (virgin) rubber material. Therefore, even in the case where 100% recycled content (R1=1) is specified, there is always a part of the material that is primary (virgin).

There could be other special cases where a producer of an STS component is both the recycler and the producer of the STS component. An example can be a shockpad producer that purchases PE foam scrap (waste) to manufacture a shockpad (to be used at an STS). The point of substitution and the CFF needs to be applied at the level of shockpad production. This example can be an unclear case since both the recycling of the PE scrap into a usable material and transformation of that material into a shockpad take place in the same place, the shockpad producer. As a side note, the granulation/cleaning of the scrap (waste) material could also be considered as "recycling". The point of substitution needs to be applied after the "recycling" process and before the shockpad production. In this example, the input of PE foam scrap that enters the "recycling" process is almost burden "free" and only consists of collection and transportation. The CFF is not applied at this point. Then the scrap material is then processed into something usable, even if the only processing occurred was cleaning the scrap. The output of that process can be considered as the "recycled material" which is then used for shockpad production. The CFF needs to be applied at this point of shockpad production allocating the impact between the "recycled material" and the primary material. This is described as point of substitution at level 1 in chapter 4.4.8.4 of the PEF method.

Another relevant topic could be how to deal with pre-consumer scrap – i.e., scrap generated during manufacturing. Information on this can be found in chapter 4.4.8.8 of the PEF method European Commission (2021).

6 Life cycle stages

The following sub-sections describe the life cycle stages included in the scope of this PEFCR. They cover all technical requirements and assumptions to be applied by the user of the PEFCR, as well as the processes taking place in each life cycle stage (according to the models of the representative products). In case different rules are applicable for sports and landscape applications, that is made explicit with vertical modelling rules.

The user of the PEFCR shall report the DQR values (for each criterion + total) for all the datasets used. Furthermore, the user of the PEFCR shall always check the utilisation ratio applied in the default transport datasets and adapt it accordingly. In the default transport datasets used, empty returns are already considered in the default utilisation ratio. The waste of products used during the manufacturing shall be included in the modelling.

The data used for the RP studies can be used as guidance for new products implementing this PEFCR (see Excel files entitled Data_PEF RP landscape_20230825.xlsx and Data_PEF RP sports_20230825.xlsx).

6.1 Raw material acquisition and pre-processing

This life cycle stage is further sub-divided into the following life cycle stages:

- Yarn production (section 6.1.1)
- Primary backing production (section 6.1.2)
- Secondary backing production (section 6.1.3)
- Raw material acquisition and pre-processing for performance infill (section 6.1.4)
- Sand acquisition (section 6.1.5)
- Raw material acquisition and pre-processing for shockpad (section 6.1.6)

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

Packaging on the bill of materials and of the finished components was assessed in the RP and supporting studies and its contribution was below the cut-off so these do not need to be collected or modelled for PEF studies following this PEFCR.

6.1.1 Yarn production

Yarn is often composed of a base polymer, a masterbatch and a mix of processing aids. Users of the PEFCR may or may not manufacture yarn used in synthetic turf systems, therefore PEFCR considers both situations. For companies that do not manufacture yarn, EF-compliant datasets for yarn production will be available, covering a wide range of resins and manufacturing technologies. Due to the high contribution of yarn manufacturing, companies which manufacture yarn shall provide company-specific data. The PEF-RP models represented both situations.

Figure 6: Image of pile yarn

The user of the PEFCR shall follow the data needs matrix (section 5.4) for understanding how to model yarn. For a PEF study of a complete STS or of a carpet, the user of the PEFCR shall, as a minimum, indicate what are the base polymer, source, yarn type and yarn profile. Additionally, the production method, the masterbatch and the production aids may also be specified (see Table 27). In case the user of the PEFCR does not specify the additives and production aids used, those modelled in the RP model shall be used. Furthermore, the user of the PEFCR shall adapt the electricity mix in the extrusion process and the transport modes and distance.

Table 27: Variability of yarn

Base polymer	Source	Additives	Yarn type	Yarn profile	Production method[27]	Production aids
Polyethylene (PE) Polyolefin (LSR) Polypropylene (PP) Polyamide Polyethylene terephthalate (PET)	Petrochemical based Bio-based blended Petro/bio-based blended –Recycled - post consumer–Recycled - post industrial Blends of above	HALs based UV stabiliser Pigments Anti-static Flame retardancy Heat reflectors Filler	Mono-filament Slit film / fibrillated	Straight Texturized Knit-de-knit Twisting	In-line extrusion Off-line extrusion	Spin oil

[27] Polymer losses during yarn production shall be considered. Unless company-specific data is available, 0.5% of input material losses should be considered.

6.1.2 Primary backing production

This life cycle stage consists of the production of primary backing (see Figure 7). There is wide variability in primary backings (see Table 28). For that reason, the user of the PEFCR shall, as a minimum, indicate the material(s) and source(s) of the primary and its manufacturing technique.

Figure 7: Image of primary backings

Table 28: Variability of primary backing

Type	Material	Source	Manufacturing
Single-layer backing Fleeced backing Dual-layer backing Multi-layer backing	Polypropylene Polyester Glass fibre scrim Polyolefin Combination of above	Petrochemical based Bio-based blended Petro/bio-based blended –Recycled - post consumer–Recycled - post industrial Blends of above	Woven Non-woven Knitted Needle-punched Combination of above

Losses of polymer used in primary backing production have to be accounted for. The amount of losses to consider is often documented in the EF-compliant dataset of the manufacturing process used. For instance, *weaving* specifies 5% losses. Transport and their waste treatment shall also be included.

Data in Excel annex for primary backing are to be adopted by the user of the PEFCR in case no company-specific data is available.

6.1.3 Secondary backing production

This life cycle stage consists of the production of secondary backing materials (see Figure 8). There is wide variability in secondary backings (see Table 29). For that reason, the user of the PEFCR shall indicate the materials and sources used for the production of secondary backing.

Figure 8: Image of secondary backings

Table 29: Variability of secondary backing

Material	Source

SBS latex Polyurethane Polyolefin No secondary backing Acrylics	Petrochemical based Bio-based blended Petro/bio-based blended Recycled - post consumer Recycled - post industrial Blends of above

Losses of material used in secondary backing production should be included, when available to the user of the PEFCR.

6.1.4 Raw material acquisition and pre-processing for performance infill

This life cycle stage covers for the production of the input materials used in the production of performance infill. In case an STS does not require performance infill, the life cycle stage will be empty.

A wide range of materials can be used for performance infill (see Table 30). For that reason, the user of the PEFCR shall indicate if performance infill is used and, if that is the case, what material it is and of what source. If the input material is (partly) recycled, the user shall specify the recycled content R_1.

Table 30: Variability of incoming materials to produce performance infill

Infills	Source
ELT granulate Latex coated ELT granulate Polyurethane coated ELT granulate Acrylic coated ELT granulate Virgin EPDM granulate Recycled (manufacturing scape) EPDM granulate TPE granulate TPV granulate Granulate from recycled PE Polyurethane coated sand Acrylic coated sand Cork Coconut fibre + cork granulate Timber granulate Nut husks granulate Olive stone granulate Zeolite granulate Polylactic acid-based bio-plastics Biodegradable infill	Virgin Recycled Reused

Often, EF-datasets will only be available for the finished performance infill material, hence not allowing a breakdown between raw material acquisition and manufacturing on this component. In that case, performance infill should be modelled in Manufacturing of performance infill (LCS 2.2).

6.1.5 Sand acquisition

The inclusion of stabilising infill depends on the end application of the synthetic turf system. If included, stabilising infill is always sand. The different origins of sand are shown in Table 31.

Table 31: Variability of stabilising infill

Type	Origin	Source
No stabilising infill Sand	new from supplier (quarried) new from supplier - (dredged river-sand) new from supplier (dredged open water) reused, cleaned on site prior to reuse reused, removed from site for processing prior to reuse	Virgin Reused

The user of the PEFCR shall indicate if stabilising infill is used. The EF-compliant dataset *Sand, dredged river sand {GLO} | dredging with vessel | production mix, at plant | sand 0/2 | LCI result* (UUID 091bfd31-77f4-418a-bd14-d80ffb88c23e) shall be used, as this was also the dataset used for sand in the sports PEF-RP model.

6.1.6 Raw material acquisition and pre-processing for shockpad

This life cycle stage covers for the production of the input materials used in the production of shockpads. Shockpads may or may not be used in synthetic turf systems. In case an STS does not require shockpad, the life cycle stage will be empty. In case the STS being studied includes shockpad, in this life cycle stage the user of the PEFCR shall list its bill of materials and, for each, the recycled content R_1, if applicable.

The variability of shockpads is shown in Table 32. The user of the PEFCR shall indicate if a shockpad is needed and, if so, they shall determine its material composition and source.

Figure 9: Image of shockpad installed in a synthetic turf system

Table 32: Variability of shockpad incoming materials

Shockpad material	Site produced multi-component	Source
Polyethylene granulate Polyethylene chip (manufacturing scrap) Polyurethane granulate(manufacturing scrap) Polypropylene beads Acrylonitrile Butadiene Rubber (NBR) Polyamide filaments, with a geo-composite fabric PP granulate ELT granulate + PUR binder (preformed in factory) Plastic waste granulate Polymeric waste granulate	ELT granulate + binder ELT granulate + binder + stones ELT granulate & agglomerated plastic waste granulate + binder	Virgin Recycled Blend virgin/ recycled materials

There are special shockpads called E-layers or ET-decke which are laid in-situ i.e., during installation, using special machinery. The activity of using this special machinery is to be modelled in LCS 2.3 Manufacturing of shockpad.

6.2 Manufacturing

This life cycle stage is further sub-divided into the following life cycle stages:

- Synthetic carpet manufacturing (section 6.2.1)
- Manufacturing of performance infill (section 6.2.2)
- Shockpad manufacturing (section 6.2.3)

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

The synthetic turf carpet manufacturing losses were calculated based on company-specific data. For sports applications, losses from carpet manufacturing are incinerated. For landscaping applications, losses from carpet manufacturing are landfilled and incinerated using the European average shares.

The shockpad manufacturing losses were modelled as defined in the EF dataset foaming.

For performance infill manufacturing, only aggregated EF datasets were available which include the raw material and the manufacturing.

6.2.1 Manufacturing of synthetic turf carpet

In carpet manufacturing sites, it is often not possible to identify the inputs and outputs per manufacturing step, i.e. for tufting, coating and drying individually. For this reason, total inputs and outputs for the carpet manufacturing site can be used and allocated to the area of carpet produced.

Figure 10: Image of carpet production

Figure 11: Image of application of secondary coating

There is wide variability in carpet production techniques (see Table 33). As a minimum, the user of the PEFCR shall indicate the method of carpet manufacturing.

Table 33: Variability of carpet production

Method	Application method of secondary coating	Curing/drying fixation
Tufted Woven Knitted	Liquid roll Spray coating Hot melt Lamination	In-line oven Ambient cooling Climate chamber Combination of above

6.2.2 Manufacturing of performance infill

This life cycle stage covers for the production of performance infill. In case an STS does not require performance infill, the life cycle stage will be empty. In case performance infill is needed, this can be polymeric infill, organic infill or a blend.

Figure 11: Image of performance infill

A wide range of materials can be used for performance infill (see section 6.1.4). There are various manufacturing methods for the production of performance infill: ambient granulation; cryogenic granulation; extrusion; and pelletisation.

In this life cycle stage, the user of this PEFCR should indicate, as a minimum, the amount and type of material used. If known, the user of the PEFCR should also specify the various manufacturing methods for the production of performance infill used. Alternatively and if company-specific data is available, the user of this PEFCR can create a company-specific dataset to model the manufacturing of the performance infill used in the synthetic turf system under study.

6.2.3 Manufacturing of shockpad

Shockpads may or may not be used in synthetic turf systems. If they are used, there is wide variability in production techniques (see Table 34). As a minimum, the user of the PEFCR shall indicate the method of shockpad manufacturing.

Table 34: Variability of shockpad production

Method	Site produced multi-component method
Foaming Fused expanded Injection moulding Granulate + binder preformed in factory Agglomeration	Mixed and laid *in situ*

There are special shockpads called E-layers or ET-decke which are laid in-situ i.e., during installation, using special machinery. The activity of using this special machinery is to be modelled in this life cycle stage.

6.3 Storage and distribution

Storage and distribution stage includes transport from factory to final client (including consumer transport). The location of the final client is defined as the user of the synthetic turf system, i.e. the installation site.

This life cycle stage is further sub-divided into the following life cycle stages:

- Storage and distribution of synthetic carpet
- Storage and distribution of performance infill

- Storage and distribution of stabilising infill
- Storage and distribution of shockpad

For sports surfacing, the individual STS components are directly transported to the installation site, i.e. the final client. For this reason, there is no additional storage needed. In case no supply-chain-specific information is available for one or several transport parameters, then the default transport scenario documented in the Excel annex shall be applied.

For landscaping applications, the user of the PEFCR shall include in this life cycle stage the transport from factory to final client (including consumer transport). In case no specific information is available, the default scenario outlined in section 4.4.3.5 of European Commission (2021) shall be used as a basis (see Excel annex). The following values shall be determined by the user of the PEFCR (specific information shall be used, unless it is not available):

- Ratio between products sold through retail, distribution centre (DC) and directly to the final client; the following ratios have been assumed:
  a) Products sold through retail: one third
  b) Products sold through DC: one third
  c) Products sold directly to the client: one third
- For factory to final client: Ratio between local, intracontinental and international supply chains; the following ratios have been assumed:
  a) Intracontinental: 13% (EU artificial turf supply share - AMI Consulting 2018)
  b) International: 87% (Global artificial turf supply share)
- For factory to retail: distribution between intracontinental and international supply chains; the following ratios have been assumed:
  a) Intracontinental: 13% (EU artificial turf supply share - AMI Consulting 2018)
  b) International: 87% (Global artificial turf supply share)

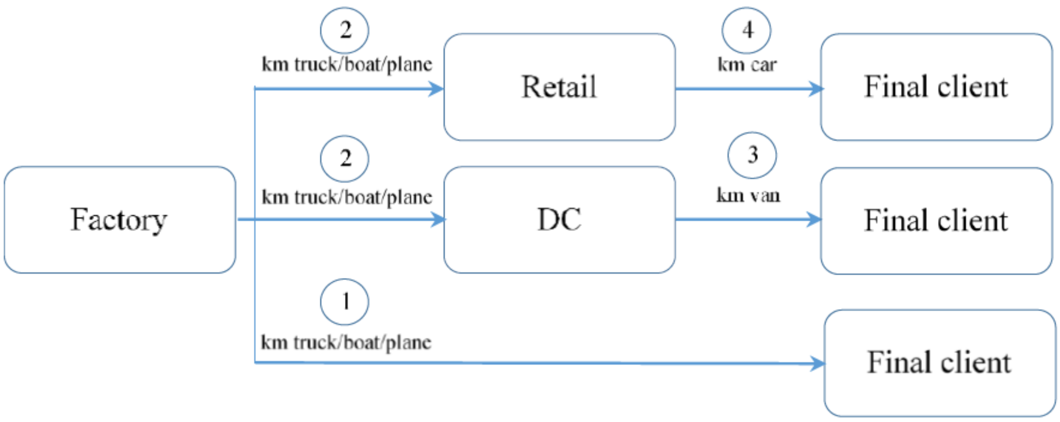

Figure 12: Diagram of transport routes of STS components from factory to final client, i.e., installation site

For direct distribution from factory to final client (route 1 in Figure 13), to retail or DC (route 2 in Figure 13), the following apply:

- local supply chain: 1,200 km by truck (>32 t, EURO 4, 0.64 utilisation ratio),
- intracontinental supply chain: 3,500 km by truck (>32 t, EURO 4, 0.64 utilisation ratio), and

- international supply chain: 1,000 km by truck (>32 t, EURO 4, 0.64 utilisation ratio) and 18,000 km by ship (transoceanic container). Note that for specific cases, plane or train may be used instead of ship.

For distribution from DC to final client (route 3 in Figure 13), a round trip of 250 km by van (lorry <7.5t, EURO 3, utilisation ratio of 20%).

For distribution from retail to final client (route 4 in Figure 13), the following apply:

- 62%: 5 km, by passenger car (average),
- 5%: 5 km round trip, by van (lorry <7.5t, EURO 3 with utilisation ratio of 20%), and
- 33%: no impact modelled.

There are no product losses during distribution. The waste of products during distribution and retail shall be included in the modelling.

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

6.4 Use stage

6.4.1 Installation

The installation stage covers any machinery, materials and losses arising from installation of the complete synthetic turf system.

Installation machinery is mostly product independent so it shall be excluded from the system boundary. An exception is the installation of in-situ shockpads such as E-layers or ET-decke, which require the use of special machinery. This shall be modelled in LCS 2.3 Manufacturing of shockpad. Installation jointing materials, such as tape and adhesives, have only negligible contribution hence they are excluded based on the 3% cut-off rule. This is also confirmed by the supporting studies in which the jointing materials result in below 1% of the total impact.

Installation waste treatment shall be included in the modelling. For sports applications, installation losses include carpet losses and shockpad losses. For landscaping applications, installation losses include carpet losses. In landscaping applications the installation losses are significant due to cutting of the carpet in different shapes. For both applications, sports and landscaping, the installation losses are landfilled and incinerated using the European average shares.

The sports performance characteristics of a sports surfacing system are provided by the combined characteristics of the playing surface, any infill within the playing surface and the shockpad. The selection of the correct combination of each is complex and the responsibility of the sports surface system designer. All components that influence the sports performance properties of the sports surfacing system fall within the scope of this PEF.

Some forms of shockpad are also designed to act as structural component of the base on which the sports surfacing system is laid (often replacing an asphalt layer). If a PEF study is undertaken on a field's base construction using such a sports surfacing system, the shockpad should not be included within the PEF calculations for the base.

There is a preparatory layer (base) needed to install the STS but this is not in scope of the PEFCR. The base materials should be excluded when implementing this PEFCR because the choice and quantity of base materials used are site- and climate-specific, not product-dependent. However, if the applicant implementing the PEFCR has site-specific information on the installation phase, these can be added for a more complete assessment, but impact of the base shall be provided separately to allow for a fair comparison of results with other systems not including a base. In that case, the base can be composed of, to name a few: asphalt base & stone foundation, unbound aggregate foundation, factory manufactured polypropylene drainage cell above stone foundation, concrete slab, or sand / lava foundation.

Figure 14: Installation of shockpad

Figure 16: Installation of carpet

Figure 17: Installation of stabilising infill

Figure 18: Installation of in-laid lines

Figure 19: Installation of performance infill

Figure 20: Painting lines

For a PEF study on STS for sports surfacing the user of the PEFCR shall make the same assumptions as done in the PEF-PR study, namely:

- Installation losses of 1.67% and 1.87% for the carpet and shockpad, respectively.
- No installation losses of stabilising infill and performance infill were modelled due to lack of data.
- The waste from the installation losses is sent to incineration and landfill, using European average shares.

For a PEF study on STS for landscaping application, the user of the PEFCR shall assume the following:

- Product losses during installation for landscaping applications are much larger, about 20% according to the TS.
- No losses of stabilising infill.
- The waste from the installation losses is sent to incineration and landfill, using European average shares.

Table 35: Variability of installation methods

Shockpad	Carpet	Lines	Stabilising & performance infill
Mixed and paved in-situ Loose laid Seamed with jointing tape & adhesive Shockpad integrated to carpet rolls Shockpad integrated to carpet tiles	Adhesive + jointing tape Hot melt adhesive + jointing tape Stitched or sown Bonded to shockpad or base - spray application Bonded to shockpad or base - wipe / squeegee application Velcro Interlocking tiles	In-laid lines Spray gun for painted lines Cut in lines	Spreading machine

6.4.2 Operation

The application, landscaping or sports surfacing, affects the modelling of the operation of the synthetic turf systems. For sports surfacing, the activities required during operation also depend on the following:

- the operational usage, e.g. how many hours per week and how many players per hour (see Table 36 for default data to be used);
- on the surface area, which includes not only the actual field of play but also the perimeter run-offs around it;
- on the field design, components used and how much infill migration occurs, if applicable (ESTC 2020);
- on the type of turf used; and
- on the type of infill used and/or the climate and/or sports application, e.g. sometimes watering of the fields is needed.

The last bullet above is product-dependent and/or application-specific. Some sports surfaces require watering, and some infills require watering. In that case, watering shall be included in the PEF results calculation. The user of the PEFCR shall also model the amount of performance infill added throughout the period of operation i.e. 8 years as per the functional unit. In cases where durability of some components might be different, for instance 16 years lifetime for a shockpad, that only affects the amount of shockpad component to be produced and disposed to be modelled per functional unit; it will not affect the modelling of the operation.

The use stage was modelled with the main function approach, i.e. with processes related to the main function of the product.

In sports surfacing

Use stage consists of land occupation and of two types of maintenance - routine and specialist mechanical maintenance - which were identified as typical for football fields and are not necessarily applicable for other sports and landscape application. Land occupation is also product independent and shall, for this reason and according to European Commission (2021), be excluded from the system boundary.

Table 36: Average operational usage of sports surfacing

Operational usage	Football	Hockey	Tennis	Rugby	Gaelic games	American football	Cricket	Bowls	Multi-sport
Players per hour	25	24	4	31	32	24	3*	16	15
Carpeted Surface area (m^2)	7,000	6,185	699	9,120	10,400	5,530	92	800	variable
Operational (hours per week)	40	40	40	40	40	40	7.5$	40	60

** 2 batting and 1 bowling, all others on natural turf outfield*

$ Based on 15 h/wk. for six months per year

For sports surfacing, it was assumed that:

- Routine maintenance is modelled as:
    a) 4 times per week for long pile surfaces i.e. whose pile length is equal to or greater than 30mm, and
    b) 2 times per week for short pile surfaces i.e. whose pile length is shorter than 30mm.
- Specialist maintenance requires top dressing of performance infill to compensate for compaction. When company-specific data is not available, specialist maintenance of 16 hours of machinery per 7000 m^2 per year shall be used. For specialist mechanical maintenance the relevant EF3.1 dataset was used. It was assumed to be applied one time per year for the duration of the STS lifetime (8 years).
- For stabilising infill no losses were considered so all infill that is placed on the field is also assumed to reach the EoL of the STS.
- For performance infill, the migration losses were considered. The remaining amount that is not migrated was assumed to reach the EoL.

In landscaping applications

In landscaping applications, the use stage depends on the expectations of owner. In some cases it is purely decorative, so no maintenance needed. In commercial use (resorts, etc.), users may vacuum-clean. However, since this is a product-independent activity, this shall be excluded from PEF calculations according to this PEFCR. Land occupation is also product independent and shall, for this reason and according to European Commission (2021), be excluded from the system boundary. Consequently, no activities are modelled in the use stage of STSs used in landscaping applications.

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

6.5 End of life

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

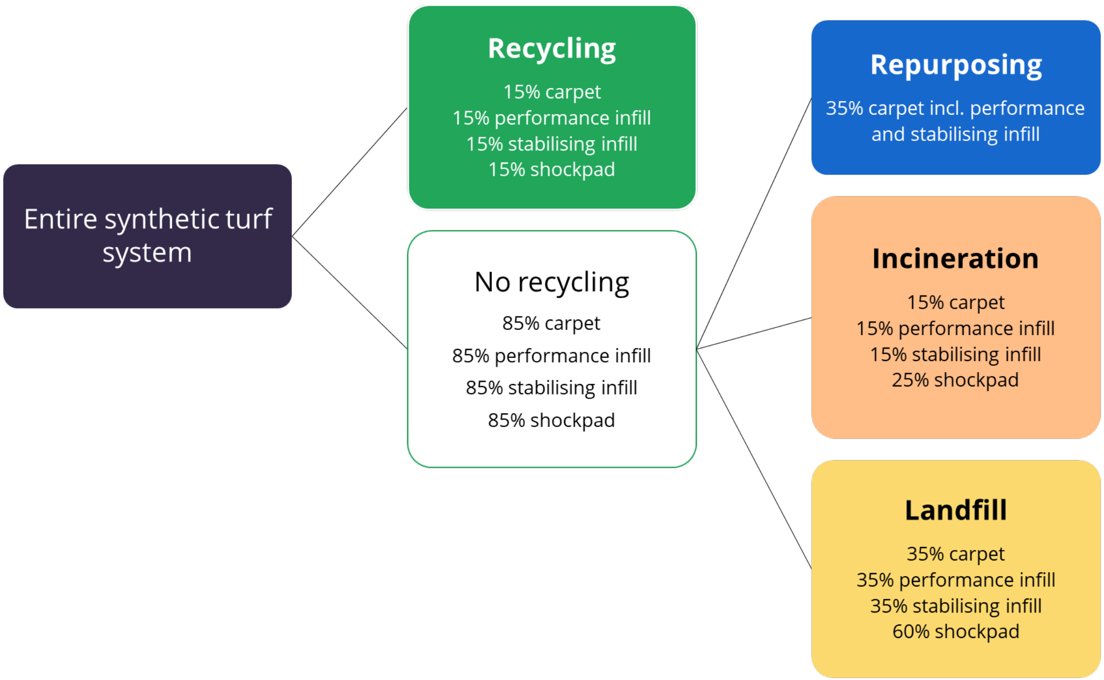

Figure 13: End of life pathway of synthetic turf systems used in sports surfacing

End of life of STSs **for sports surfacing** was modelled on basis of the average end of life scenario for these in Europe, according to information provided by the Technical Secretariat (see Figure 20):

- 15% of all components is recycled. The percentage of synthetic turf systems sent to recycling was derived by comparing current recycling capacity in Europe and number of fields removed annually. During recycling, it is assumed that all sand and performance infill included in the turf system during the deconstruction phase is recovered and recycled, with only negligible losses. It is considered that the waste recycled results in high quality recycled materials. Specifically, the recycled performance infill replaces virgin rubber and the recycled stabilizing infill replaces primary sand. In the case of the recycled waste carpet results in high quality recycled products used by different industries, such as the synthetic turf, construction, furniture and other industries. Examples of products produced with recycled carpet are trekboards, nailor boards, pavers and grass pavers. The main alternatives that the recycled carpet products will replace are hardwood or recycled plastics. Finally, the recycled shockpad replaces virgin PE granulates.
- 35% of the discarded carpets is repurposed, i.e. recovered from a synthetic turf field during the deconstruction phase. It is cleaned, repaired and used in a commercial or residential landscape application, batting cage, or soil amendment. This second use is different from the first. For this reason, it shall be modelled as recycling according to European Commission (2021). Due to the wide variability of applications of repurposed

carpets, we assume that the avoided material (E*v) is the finished carpet modelled in the RP used for landscaping (see 3.2.2). The quality of this is of similar quality to that of new carpet, so the quality of secondary outgoing material (Q_{Sout}/Q_p) is considered 1. Another aspect when repurposing is the migration of the stabilising and polymeric infill to the environment. Since this is modelled for the life cycle of the repurposed carpet, it is not considered in the model of the sports synthetic turf system. Finally, 20% losses were accounted for repurposing. The source of the losses is the carpet being cut in different shapes and sizes before is sent to the final client.

- For all waste remaining after repurposing and recycling, 30% ends up at incineration and 70% ends up landfilled.

A guideline to recycle, reuse, repurpose and remove synthetic turf systems is provided by the synthetic turf council (Synthetic Turf Council 2017).

The main markets in **landscaping** are domestic use (homeowners) with small areas. Most of these will dispose the product in a similar way to household carpets, i.e. as kerbside collection of municipal solid waste. For this reason, it is assumed that the majority of synthetic turf systems are not recycled or repurposed at the end of life. The waste destination at the end of life of STS used for landscaping is based on municipal waste treatment incineration and landfill shares on EU, 45% and 55% respectively, following the values in European Commission (2021), Annex C (European Commission 2020).

This default life cycle stage is further sub-divided into the following detailed life cycle stages:

- End of life of carpet
- End of life of performance infill
- End of life of stabilising infill
- End of life of shockpad

For both RPs, additional scenarios were modelled to assess the effect of different EoL destinations on the overall environmental footprint of STS: 100% repurposing/recycling, 100% incineration, and 100% landfill.

The end of life shall be modelled using the Circular Footprint Formula and with the rules provided in section 5.11 of this PEFCR.

Before selecting the appropriate R_2 value, the user of the PEFCR shall carry out an evaluation for recyclability of the material. The PEF study shall include a statement on the recyclability of the materials/ products. The statement on recyclability shall be provided together with an evaluation for recyclability that includes evidence for the following three criteria (as described by ISO 14021:1999, section 7.7.4 'Evaluation methodology'):

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

Point 1 and 3 can be proven by recycling statistics (country specific) derived from industry associations or national bodies. Approximation to evidence at point 3 can be provided by applying for example the design for recyclability evaluation outlined in EN 13430 Material recycling (Annexes A and B) or other sector-specific recyclability guidelines if available[28].

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

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

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

The applied R_2 values shall be subject to the PEF study verification.

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

6.5.1 End of life of carpet

Carpet (yarn, primary backing and secondary backing) is being treated as a whole at the end of life. For sports surfacing end of life carpet is treated as follows:

- 15% recycling: recycled carpet results in high quality recycled products used by different industries, such as the synthetic turf, construction, furniture and other industries. Examples of products produced with recycled carpet are trekboards, nailor boards, pavers and grass pavers. The main alternatives that the recycled carpet products will replace are hardwood (in the case of trekboards) or recycled plastics (in the case of nailor boards, pavers and grass pavers).
- 35% repurposing: due to the wide variability of applications of repurposed carpets, we assume that the avoided material (E*v) is the finished carpet modelled in the RP used for landscaping. The quality of this is of similar quality to that of new carpet, so the quality of secondary outgoing material (Q_{Sout}/Q_p) is considered 1. Another aspect when repurposing is the migration of the stabilising and polymeric infill to the environment. Since this is modelled for the life cycle of the repurposed carpet, it is not considered in the model of the sports synthetic turf system. 20% losses were accounted in repurposing. The source of the losses is the carpet being cut in different shapes and sizes before is sent to the final client. Losses are treated as incineration (45%) and landfill (55%).
- Fibre wear is calculated to be 0.0599 kg per 8m2a (4.5%). Due to the uncertainty in the amounts of percentages of fibre ware and high-usage area in the field, it is assumed that the whole amount of yarn fibres is reaching EoL treatment. Thus, the EoL impact of yarn is slightly overestimated.

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

- The remaining carpet that is not recycled or repurposed is incinerated (15%) and landfilled (35%).

For landscaping applications, the end-of-life carpet is treated as kerbside waste that is incinerated (45%) and landfilled (55%).

6.5.2 End of life of performance infill

Performance infill used in sports surfacing is treated as follows:

- 15% recycling: the recycled performance infill replaces virgin rubber.
- 35% repurposing (with the rest of the carpet) as discussed in section 6.5.1.
- 3.36 kg per 8 m2a migration losses during operation were accounted.
- The remaining infill that is not recycled, repurposed or migrated is incinerated (15%) and landfilled (35%).

It should be noted that the total amount of infill used is 15.2 kg per 8 m2a (8 kg at installation and 7.2 kg in total added during operation over the lifetime of the STS), Migration (losses to the environment) of performance infill to the environment is calculated to be 3.36 kg per 8 m2a. The remaining amount of infill is treated at the end of life as incineration and landfilling.

6.5.3 End of life of stabilising infill

Stabilising infill used in sports surfacing is treated as follows:

- 15% recycling: the recycled stabilizing infill replaces primary sand (river dredged).
- 35% repurposing (with the rest of the carpet) as discussed in section 6.5.1.
- The remaining infill that is not recycled or repurposed is incinerated (15%) and landfilled (35%).

6.5.4 End of life of shockpad

Shockpad used in sports surfacing is not being repurposed. It is treated as follows:

- 15% recycling: the recycled shockpad replaces virgin PE granulates.
- The remaining amount is incinerated (25%) and landfilled (60%).

7 PEF results

7.1 Benchmark values

Table 37, Table 39 and Table 41 include the characterised, normalised, and weighed and single score results of the RP for synthetic turf system for sports surfacing. The characterised, normalised, and weighed and single score results of the RP for synthetic turf system for landscaping applications are displayed in Table 38, Table 40 and Table 42. Single score results are based on the weighting factors provided in ANNEX 1 – List of EF normalisation and weighting factors.

Please note that the benchmark results do not include base materials because the preparatory layer which are out of the scope of the PEFCR. Only product losses during installation and their waste disposal. Results are presented for the life cycle excluding the use stage (thus, excluding installation and operation), as well as for the total life cycle stage.

Table 37: Characterised benchmark values for 8 m^2a of the RP for synthetic turf system for sports surfacing

Impact category	Unit	Life cycle excl. use stage	Total life cycle
Acidification	mol H^+ eq	1.35E-01	2.33E-01
Climate change	kg CO_2 eq	2.95E+01	4.45E+01
Ecotoxicity, freshwater	CTU_e	2.42E+02	3.43E+02
Particulate matter	disease inc.	3.54E-06	6.55E-06
Eutrophication, marine	kg N eq	2.92E-02	4.83E-02
Eutrophication, freshwater	kg P eq	3.90E-04	3.96E-04
Eutrophication, terrestrial	mol N eq	3.20E-01	5.36E-01
Human toxicity, cancer	CTU_h	2.50E-08	3.31E-08
Human toxicity, non-cancer	CTU_h	1.87E-07	2.81E-07
Ionising radiation	kBq U^{235} eq	9.07E-01	1.63E+00
Land use	Pt	3.55E+01	7.55E+01
Ozone depletion	kg CFC-11 eq	1.23E-06	1.24E-06
Photochemical ozone formation	kg NMVOC eq	8.23E-02	1.40E-01
Resource use, fossils	MJ	3.95E+02	6.04E+02
Resource use, minerals and metals	kg Sb eq	6.47E-05	1.01E-04
Water use	m^3 depriv.	7.78E+00	1.50E+01

Table 38: Characterised benchmark values for 8 m^2a of the RP for synthetic turf system for landscaping applications

Impact category	Unit	Life cycle excl. use stage	Total life cycle
Acidification	mol H^+ eq	7.83E-02	7.78E-02
Climate change	kg CO_2 eq	1.20E+01	1.23E+01
Ecotoxicity, freshwater	CTU_e	1.47E+02	1.46E+02
Particulate matter	disease inc.	1.51E-06	1.50E-06
Eutrophication, marine	kg N eq	1.99E-02	1.98E-02
Eutrophication, freshwater	kg P eq	3.01E-04	3.04E-04
Eutrophication, terrestrial	mol N eq	2.11E-01	2.10E-01
Human toxicity, cancer	CTU_h	8.31E-09	8.29E-09
Human toxicity, non-cancer	CTU_h	7.49E-08	7.50E-08
Ionising radiation	kBq U^{235} eq	5.44E-01	4.96E-01
Land use	Pt	2.15E+01	2.14E+01
Ozone depletion	kg CFC-11 eq	1.62E-06	1.62E-06
Photochemical ozone formation	kg NMVOC eq	5.63E-02	5.60E-02
Resource use, fossils	MJ	2.10E+02	2.06E+02
Resource use, minerals and metals	kg Sb eq	6.36E-05	6.36E-05
Water use	m^3 depriv.	8.53E-01	8.81E-01

Table 39: Normalised benchmark values for 8 m^2a of the RP for synthetic turf system for sports surfacing

Impact category	Life cycle excl. use stage Normalised results [person eq.]	Total life cycle Normalized results [person eq.]
Acidification	2.42E-03	4.19E-03
Climate change	3.90E-03	5.89E-03
Ecotoxicity, freshwater	4.27E-03	6.04E-03
Particulate matter	5.95E-03	1.10E-02
Eutrophication, marine	1.50E-03	2.47E-03
Eutrophication, freshwater	2.43E-04	2.46E-04
Eutrophication, terrestrial	1.81E-03	3.03E-03
Human toxicity, cancer	1.45E-03	1.92E-03
Human toxicity, non-cancer	1.45E-03	2.18E-03
Ionising radiation	2.15E-04	3.85E-04
Land use	4.33E-05	9.22E-05
Ozone depletion	2.35E-05	2.37E-05
Photochemical ozone formation	2.02E-03	3.43E-03
Resource use, fossils	6.07E-03	9.29E-03
Resource use, minerals and metals	1.02E-03	1.59E-03
Water use	6.78E-04	1.31E-03

Table 40: Normalised benchmark values for 8 m^2a of the RP for synthetic turf system for landscaping applications

Impact category	Life cycle excl. use stage Normalized results [person eq.]	Total life cycle Normalized results [person eq.]
Acidification	1.41E-03	1.40E-03
Climate change	1.59E-03	1.62E-03
Ecotoxicity, freshwater	2.59E-03	2.58E-03
Particulate matter	2.53E-03	2.52E-03
Eutrophication, marine	1.02E-03	1.01E-03
Eutrophication, freshwater	1.87E-04	1.89E-04
Eutrophication, terrestrial	1.19E-03	1.19E-03
Human toxicity, cancer	4.81E-04	4.80E-04
Human toxicity, non-cancer	5.82E-04	5.83E-04
Ionising radiation	1.29E-04	1.17E-04
Land use	2.63E-05	2.61E-05
Ozone depletion	3.09E-05	3.09E-05
Photochemical ozone formation	1.38E-03	1.37E-03
Resource use, fossils	3.24E-03	3.17E-03
Resource use, minerals and metals	1.00E-03	1.00E-03
Water use	7.44E-05	7.68E-05

Table 41: Weighted and single score benchmark values for 8 m^2a of the RP for synthetic turf system for sports surfacing

Impact category	Life cycle excl. use stage Weighted results	Total life cycle Weighted results
Acidification	1.50E-04	2.60E-04
Climate change	8.22E-04	1.24E-03
Ecotoxicity, freshwater	8.20E-05	1.16E-04
Particulate matter	5.33E-04	9.86E-04
Eutrophication, marine	4.43E-05	7.32E-05
Eutrophication, freshwater	6.79E-06	6.90E-06
Eutrophication, terrestrial	6.72E-05	1.13E-04
Human toxicity, cancer	3.09E-05	4.08E-05
Human toxicity, non-cancer	2.67E-05	4.02E-05
Ionising radiation	1.08E-05	1.93E-05
Land use	3.44E-06	7.32E-06
Ozone depletion	1.49E-06	1.49E-06
Photochemical ozone formation	9.63E-05	1.64E-04
Resource use, fossils	5.05E-04	7.73E-04
Resource use, minerals and metals	7.67E-05	1.20E-04
Water use	5.77E-05	1.11E-04
Weighted results as single score	**2.52E-03**	**4.07E-03**

Table 42: Weighted and single score benchmark values for 8 m^{2}a of the RP for synthetic turf system for landscaping applications

Impact category	Life cycle excl. use stage Weighted results	Total life cycle Weighted results
Acidification	8.74E-05	8.68E-05
Climate change	3.35E-04	3.42E-04
Ecotoxicity, freshwater	4.97E-05	4.95E-05
Particulate matter	2.27E-04	2.26E-04
Eutrophication, marine	3.02E-05	3.00E-05
Eutrophication, freshwater	5.24E-06	5.30E-06
Eutrophication, terrestrial	4.43E-05	4.41E-05
Human toxicity, cancer	1.03E-05	1.02E-05
Human toxicity, non-cancer	1.07E-05	1.07E-05
Ionising radiation	6.46E-06	5.88E-06
Land use	2.09E-06	2.07E-06
Ozone depletion	1.95E-06	1.95E-06
Photochemical ozone formation	6.58E-05	6.55E-05
Resource use, fossils	2.69E-04	2.64E-04
Resource use, minerals and metals	7.55E-05	7.55E-05
Water use	6.33E-06	6.54E-06
Weighted results as single score	**1.23E-03**	**1.23E-03**

7.2 PEF profile

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

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

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

7.3 Communication vehicle

For the purpose of communicating the outcome of the PEFCR in a more simplified way, a communication vehicle has been developed. In the Recommendation 2021/2279 of the European Commission, a communication vehicle is defined as "all the possible ways that may be used to communicate the results of the EF study to the stakeholders (e.g. labels, environmental product declarations, green claims, websites, infographics, etc.)".

Synthetic Turf Surface products fall within the construction sector, where the communication through Environmental Product Declarations (EPDs) is common practice. It facilitates the communication of the conducted LCA study and its results to a broader audience. Therefore, the communication vehicle proposed follows an EPD-style format. It presents the main information of the study and present the main environmental impacts in the most relevant impact categories in a simplified way. There is a separate communication vehicle for sports and landscape applications since these are different sub-categories in the PEFCR. This cannot replace the full PEF study reporting or any review requirements, but instead should be seen as an additional and optional information leaflet.

The communication vehicle proposed complies with the principles of transparency, availability and accessibility, reliability, completeness, comparability and clarity, as described in the Commission Communication on Building the Single Market for Green Products, since these are principles of the PEF method as well as of the PEFCRs. However, there is no template for communication vehicle prescribed by the European Commission, thus, it is up to the user to check if the communication vehicle is in line with the various EU directives and regulations.

The communication vehicle templates are Word documents, one for each sports and landscaping applications. These are enclosed as annexes.

8 Verification

The verification of a PEF study/ report carried out in compliance with this PEFCR shall be done according to all the general requirements included in Section 9 of the Annex I of the Commission Recommendation (European Commission 2021), including part A of that Annex, and the requirements listed below.

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

In case policies implementing the PEF method define specific requirements regarding verification and validation of PEF studies, reports and communication vehicles, the requirements in said policies shall prevail.

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

1. the verifier(s) shall check if the correct version of all impact assessment methods was used. For each of the most relevant 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 impact categories shall be verified. In particular, the verifier(s) shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with[29]. This may also be done indirectly, for example:
    a) Export the EF-compliant datasets from the LCA software used to do the PEF study and run them in Look@LCI[30] to obtain LCIA results. If Look@LCI results are within a deviation of 1% from the results in the LCA software, the verifier(s) may assume that the implementation of the characterisation factors in the software used to do the PEF study was correct.
    b) Compare the LCIA results of the most relevant processes calculated with the software used to do the PEF study with the ones available in the metadata of the original dataset. If the compared results are within a deviation of 1%, the verifier(s) may assume that the implementation of the

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

[30] https://eplca.jrc.ec.europa.eu/LCDN/developer.xhtml

characterisation factors in the software used to do the PEF study was correct.

2. cut-off applied (if any) fulfils the requirements at section 4.6.4 of Annex I of the Commission's Recommendation (European Commission 2021).
3. all datasets shall be checked against the data requirements (sections 4.6.3 and 4.6.5. of Annex I of the Recommendation (European Commission 2021))
4. For all most relevant processes (as defined in section 6.3.3 of Annex I), the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them shall also be validated in the same way. The verifier(s) shall check that the most relevant processes are identified as specified in section 6.3.3 of Annex I of the Commission's Recommendation (European Commission 2021);
5. For at least 30% (in number) of all other processes (corresponding to 20% of the processes as defined in section 6.3.3 of Annex I of the Commission's Recommendation (European Commission 2021)) the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them shall also be validated in the same way;
6. The verifier(s) shall check that the datasets are correctly implemented in the software (i.e. LCIA results of the dataset in the software are within a deviation of 1% to the ones in the metadata). At least 50% (in number) of the datasets used to model most relevant processes and 10% of those used to model other processes shall be checked.

In particular, verifier(s) shall verify if the DQR of the process satisfies the minimum DQR as specified in the DNM for the selected processes.

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

The verification of the PEF report shall be carried out by randomly checking enough information to provide reasonable assurance that the PEF report fulfils all the conditions listed in section 8 of Annex I of the Commission's Recommendation (European Commission 2021), including part A of that Annex.

Currently, there are several actors developing and updating their tools to adopt the rules for product environmental foot printing documented in this PEFCR. Tools can ease the effort and significantly reduce the costs involved in calculating PEF results. In this context, it is important to guarantee that tools claiming compliance with this PEFCR meet a list of requirements. Other verification requirements are product / PEF study specific.

"The International EPD® System allows the use of pre-verification of LCA and EPD tools to facilitate the development of EPDs. The application of these tools leads to a simplified verification process since certain elements of the LCA cannot be further influenced by those developing the EPD and verification of these elements is needed only once. Please note that while using a pre-verified tool simplifies the procedure for developing an EPD, it does not replace the need for fulfilling verification requirements (…)."

The TS took inspiration from the pre-verified tools for EPD development of the International EPD® Systems and identified the verification and validation requirements that can be met by the integration of a specific PEFCR in a software tool. Having this as a pre-requisite would significantly reduce the efforts and costs for verification of specific studies/assessments.

For this reason, in this section we consider two situations:

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

The verification of a PEF study/ report carried out in compliance with this PEFCR shall be done according to all the general requirements included in section 8 of the Annex I, including part A of this Annex, and the requirements listed below.

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

In case policies implementing the PEF method define specific requirements regarding verification and validation of PEF studies, reports and communication vehicles, the requirements in said policies shall prevail.

The data checks shall include, but should not be limited to, the activity data used, the selection of secondary subprocesses, the selection of the direct elementary flows and the CFF parameters. For example, if there are 5 processes and each one of them includes 5 activity data, 5 secondary datasets and 10 CFF parameters, then the verifier(s) has to check at least 4 out of 5 processes (70%) and, for each process, (s)he shall check at least 4 activity data (70% of the total amount of activity data), 4 secondary datasets (70% of the total amount of secondary datasets), and 7 CFF parameters (70% of the total amount of CFF parameters), i.e. the 70% of each of data that could be subject to a check.

The verification of the PEF report shall be carried out by randomly checking enough information to provide reasonable assurance that the PEF report fulfils all the conditions listed in section 9 of Annex I, including part A of this Annex.

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

The verifier(s) shall validate the accuracy and reliability of the quantitative information used in the calculation of the study. This shall be done according to the verification requirements documented in section 8.

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

The aim of the verification of a tool is to check the compliance with this PEFCR. A tool is verified based on the tool itself as well as the first PEF report and the first PEF verification report based on the tool. The tool owner shall arrange for the verification of the tool. A real product or a virtual product e.g., recalculate the RP model in the tool, may be used for the first verification.

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

The verification section of the PEFCR template of the most recent version of the PEF method1 was taken as a starting point (text highlighted in grey is the text currently included in the PEFCR report template). These were further categorized in: "Pre-verification of the tool" vs "Additional verification requirements to be met by specific PEF studies conducted using a pre-verified tool" (see Table 43).

Table 43: Verification requirements for PEF assessments conducted in a pre-verified tool. Adapted from section 8.

Original bullet in section 8	Pre-verification of the tool	Additional verification requirements to be met by specific PEF studies conducted using a pre-verified tool
1	The verifier(s) 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 impact categories shall be verified. In particular, the verifier(s) shall check that the characterisation factors correspond to those included in the EF impact assessment method the study declares compliance with . This may also be done indirectly, for example: a) Export the EF-compliant datasets from the LCA software used to do the PEF study and run them in Look@LCI to obtain LCIA results. If Look@LCI results are within a deviation of 1% from the results in the LCA software, the verifier(s) may assume that the implementation of the characterisation factors in the software used to do the PEF study was correct.	This may also be done indirectly, for example: b) Compare the LCIA results of the most relevant processes calculated with the software used to do the PEF study with the ones available in the metadata of the original dataset. If the compared results are within a deviation of 1%, the verifier(s) may assume that the implementation of the characterisation factors in the software used to do the PEF study was correct.
2		Cut-off applied (if any) fulfils the requirements at section 4.6.4 of Annex I of the Commission's Recommendation (European Commission 2021). The verifier(s) shall check if a maximum of 10% of the single overall score is derived from ILCD entry-level compliant datasets.
3	All secondary datasets included by default in the tool shall be checked against the data requirements (sections 4.6.3 and 4.6.5. of Annex I of the Recommendation (European Commission 2021))	All other datasets i.e., secondary datasets not originally included in the tool and all new created datasets, shall be checked against the data requirements (sections 4.6.3 and 4.6.5. of Annex I of the Recommendation (European Commission 2021))
4	The verifier(s) shall check if list of mandatory-specific data required in this PEFCR is required to fill in in the pre-verified tool.	The verifier(s) shall validate all related activity data and datasets used to model 100% of the mandatory company-specific data required in this PEFCR (see section 5.1). For all most relevant processes (as defined in

Original bullet in section 8	Pre-verification of the tool	Additional verification requirements to be met by specific PEF studies conducted using a pre-verified tool
	CFF parameters included in Annex C (European Commission 2020) and added to the model as default values and datasets used to model them shall also be validated.	section 6.3.3 of Annex I of the Commission's Recommendation (European Commission 2021)), the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them that are either not documented or different from those included in Annex C shall also be validated in the same way. The verifier(s) shall check that the most relevant processes are identified as specified in section 6.3.3 of Annex I of the Commission's Recommendation (European Commission 2021);
5		For at least 30% (in number) of all other processes (corresponding to 20% of the processes as defined in section 6.3.3 of Annex I of the Commission's Recommendation (European Commission 2021)) the verifier(s) shall validate all related activity data and the datasets used to model these processes. If relevant, CFF parameters and datasets used to model them that are either not documented or different from those included in Annex C shall also be validated in the same way.
6	The verifier(s) shall check that the secondary datasets included in the tool are correctly implemented in the software (i.e. LCIA results of the dataset in the software are within a deviation of 1% to the ones in the metadata).	The verifier(s) may additionally check a few datasets used to model most relevant processes and other processes.
	Universal model created for allowing for product-specific calculations to be verified in the tool. The LCA model used in the tool is parameterised for the bill of potential materials and/or activities in a way which allows the user of the tool, to modify a pre-defined selection of input data or choose from a pre-defined menu of activities connected to a specific product life cycle in order to produce product-specific PEF results. The output of a pre-verified PEFCR-compliant tool is a list of characterized and single score results per life cycle stage.	

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

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

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

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

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ANNEX 1 – List of EF normalisation and weighting factors

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

Table 44: List of normalisation and weighting factors for adopted in this study. Sources: Sources: (Crenna et al. 2019), (Sala et al. 2018); https://eplca.jrc.ec.europa.eu/permalink/EF3_1/Normalisation_Weighting_Factors_EF_3.1.xlsx

Impact category	Unit	Normalisation factors [person eq.]	Weighting factors [%]
Acidification	mol H^+ eq.	5.56E+01	6.20%
Climate change	kg CO_2 eq.	7.55E+03	21.06%
Ecotoxicity, freshwater	CTU_e	5.67E+04	1.92%
EF-particulate matter	disease incidences	5.95E-04	8.96%
Eutrophication, freshwater	kg P eq.	1.61E+00	2.80%
Eutrophication, marine	kg N eq.	1.95E+01	2.96%
Eutrophication, terrestrial	mol N eq.	1.77E+02	3.71%
Human toxicity, cancer	CTU_h	1.73E-05	2.13%
Human toxicity, non-cancer	CTU_h	1.29E-04	1.84%
Ionising radiation	kBq U^{235} eq.	4.22E+03	5.01%
Land use	pt	8.19E+05	7.94%
Ozone depletion	kg CFC-11 eq.	5.23E-02	6.31%
Photochemical ozone formation	kg NMVOC eq.	4.09E+01	4.78%
Resource depletion, fossils	MJ	6.50E+04	8.32%
Resource depletion, minerals and metals	kg Sb eq.	6.36E-02	7.55%
Water use	m^3 water eq of deprived water	1.15E+04	8.51%

ANNEX 2 – PEF study template

See below a checklist listing all the items that shall be included in PEF studies compliant with this PEFCR, using the PEF study template available as part E of the Commission's Recommendation annexes 1 and 2 (European Commission 2021):

Acronyms

Definitions

1. Summary
2. General
3. Goal of the study
4. Scope of the study
    - 4.1. Functional/declared unit and reference flow
    - 4.2. System boundary
    - 4.3. Environmental Footprint impact categories
    - 4.4. Additional information
    - 4.5. Assumptions and limitations
5. Life cycle inventory analysis
    - 5.1. Modelling choices
    - 5.2. Handling multi-functional processes
    - 5.3. Data collection
    - 5.4. Data quality requirements and rating
6. Impact assessment results [confidential, if relevant]
    - 6.1. PEF results
    - 6.2. Additional information
7. Interpreting PEF results
8. Validation statement

ANNEX I of the validation statement

ANNEX II of the validation statement – CONFIDENTIAL REPORT

ANNEX III of the validation statement – EF COMPLIANT DATASET

ANNEX 3 – Review reports of the PEFCR and PEF-RP studies

Annex 3.1 – Review statement of the PEFCR

Product Environmental Footprint Category Rules (PEFCR) for "Synthetic Turf Sports & Landscape Surfaces"

CRITICAL REVIEW REPORT

Review Panel

Name of the member	Affiliation	Role
Max Sonnen	Ecomatters BV	Chair and LCA/PEF expert
Céline Alexandre	RDC Environment	LCA/PEF expert
Mickael Benetti	Fédération Internationale de Football Association (FIFA)	Synthetic turf expert

Review Scope

The task of the review panel was to assess the compliance of the PEFCR document against the following requirements.

- The PEFCR is developed in accordance with the requirements provided in the PEF method and Annex 1 and Annex II adopted by the Commission on 16 December 2021 - C(2021) 9332 final.
- The PEFCR supports the creation of credible, relevant, and consistent PEF profiles.
- The PEFCR scope and the representative products are adequately defined;
- The functional unit, allocation and calculation rules are adequate for the product category and sub-categories under consideration;
- Datasets used in the PEF-RPs and the supporting studies are relevant, representative, reliable, and in compliance with data quality requirements.
- The Data Needs Matrix is correctly implemented;
- The selected additional environmental information is appropriate for the product category and sub-categories under consideration;
- The model of the RP(s) and corresponding benchmark(s) represent correctly the product categories or sub-categories;

Review Process

The review has been performed in three distinct rounds: first, second, final.

The first round was carried out in July and August 2021 on a previous version of the PEFCR document and against the requirements of the PEF method. The panel made several comments, most of which were satisfactorily addressed by the Technical Secretariat in an updated PEFCR version.

Originally Kathryn Severn of The Football Foundation was part of the review panel in the role as industry expert. In March 2022 she left that position and was not able to continue in the review panel. She was replaced by Mickael Benetti.

The second round was performed between October and November 2023 on the second PEFCR version. This version applies the requirements or the PEF method 2021 and the results or the remodelling carried out on the representative products during 2022 and 2023. The panel made other comments which were promptly addressed by the Technical Secretariat in the final PEFCR version.

The final round was performed in December 2023 and January 2024 on the final PEFCR version. In this version, some smaller corrective actions were made in response to the remaining comments from the second review. All corrective actions were reviewed and approved.

The full list of the comments made in the two review rounds and the related responses and corrective actions from the Technical Secretariat are documented in the enclosed spreadsheet "PEFCR Synthetic Turf Review Panel Comments Responses Final".

Review Statement

We hereby confirm that, following the PEFCR examination, we have not established any relevant deviations by the above-referenced PEFCR document with respect to the requirements identified in the review scope.

We confirm we have been independent in our roles as reviewers, we have not been involved in the preparation of the PEFCR, RP's or related supporting studies and we have no conflicts of interest regarding this review.

The PEFCR validity is set until 31.12.2025.

We acknowledge the commitment undertaken by Technical Secretariat in developing this PEFCR and the good and constructive collaboration with the TS members during the review.

Yours sincerely,

January 29th, 2024

Max Sonnen	Céline Alexandre	Mickael Benetti
		Mickaël BENETTI

Annex 3.2 –Review statement of the PEF-RP studies

Representative Product (RP) "Synthetic Turf Sports & Landscape Surfaces"

CRITICAL REVIEW REPORT

Review Panel

Name of the member	Affiliation	Role
Max Sonnen	Ecomatters BV	Chair and LCA/PEF expert
Céline Alexandre	RDC Environment	LCA/PEF expert
Mickael Benetti	Fédération Internationale de Football Association (FIFA)	Synthetic turf expert

Review Scope

The task of the review panel was to assess the compliance of the RP reports (RP sports and RP landscaping) against the following requirements.

- The PEF-RP and related PEF-RP report are in compliance with the requirements in section 8.4 of Annex I of the PEF method;
- That the review comments on the first PEF-RP and supporting studies are addressed, reasons for non-implementation are provided;
- That any new dataset, updated default activity data and all assumptions that are at the basis of the requirements in the second draft PEFCR are implemented correctly;
- That the instructions given in sections A.2.4., A.3.2.7., A.4.2, A.4.3., A.4.4.3, A.6.1. and 4.4.9.4 are followed;
- That the GHG emissions and removals are calculated and reported following the rules of section A.4.2.9.

Review Process

The review has been performed in three distinct rounds: first, second, final.

The first round was carried out in July and August 2021 on a first version of the RP report and against the requirements of the PEF method. The panel made several comments, most of which were satisfactorily addressed by the Technical Secretariat in an updated PEFCR version.

The second round was performed between October and November 2023 on the second RP report. This version applies the requirements or the PEF method 2021. The panel made other comments which were promptly addressed by the Technical Secretariat in the final RP reports.

The final round was performed in December 2023 and January 2024 on the final RP reports. In this version, some smaller corrective actions were made in response to the remaining comments from the second review. All corrective actions were reviewed and approved.

The full list of the comments made in the two review rounds and the related responses and corrective actions from the Technical Secretariat are documented in the enclosed spreadsheet "RP Synthetic Turf Review Panel Comments Responses Final”.

Review Statement

We hereby confirm that, following the RP examination, we have not established any relevant deviations by the above-referenced RP reports with respect to the requirements identified in the review scope.

We confirm we have been independent in our roles as reviewers, we have not been involved in the preparation of the PEFCR, RP, or related supporting studies and we have no conflicts of interest regarding this review.

We acknowledge the commitment undertaken by Technical Secretariat in developing this RP and the good and constructive collaboration with the TS members during the review

Yours sincerely,

January 24th, 2024

Max Sonnen	Céline Alexandre	Mickael Benetti
		Mickaël BENETTI

ANNEX 4 – Definition of the models of the Representative Products

Annex 4.1 - Representative product for sports surfacing

As mentioned in section 3.2.1, globally, contact sports are the largest end-use application of synthetic turf, accounting for 47% of demand. 80% of installations are designed for football or multi-sports use where football is a key consideration. Therefore, a common configuration of a football surface including all components was selected as representative product for sports surfacing. The RP includes all components used in the synthetic turf system: carpet, performance infill, stabilising infill and shockpad.

The supporting studies will study other sports applications and other combinations of different components of STS. We believe that the RP and supporting studies together will provide sufficient insights to set appropriate data requirements and to identify hotspots across all synthetic turf systems for sports surfacing.

The PEF-RP model was developed by averaging the data provided by four companies in the Technical Secretariat, which manufacture synthetic turf products. Enclosed you can see an Excel file including all data used and referred to further below in this section.

Table 45: Most common configuration of football field manufactured by each TS member and virtual product derived on their basis

Component	Most common configuration of STS manufacturers in the Technical Secretariat				Virtual product
Pile yarn	Polyethylene monofilament	Polyethylene monofilament	Polyethylene monofilament	Polyethylene monofilament	Polyethylene monofilament
Pile height	45 mm	50 mm	45 mm	50 mm	48 mm
Pile weight	1338 g/m²	1300 g/m²	1314 g/m²	1400 g/m²	1338 g/m²
Primary backing	Polypropylene 240 g/m²	Polypropylene 250 g/m²	Polypropylene 270 g/m²	Polypropylene 250 g/m²	Polypropylene 252.5 g/m²
Secondary backing (dry)	SBS latex (70%) and $CaCO_3$ filler (30%) 1000 g/m²	SBS latex (70%) and $CaCO_3$ filler (30%) 1000 g/m²	SBS latex (70%) and $CaCO_3$ filler (30%) 1000 g/m²	SBS latex (70%) and $CaCO_3$ filler (30%) 1000 g/m²	SBS latex (70%) and $CaCO_3$ filler (30%) 1000 g/m²
Performance infill	ELT 0.8 – 3.0 mm 8 kg/m²	ELT 0.8 – 3.0 mm 5 kg/m²	ELT 0.8 – 3.0 mm 9 kg/m²	ELT 0.8 – 3.0 mm 10 kg/m²	ELT 0.8 – 3.0 mm 8 kg/m²
Stabilising infill	Sand 0.2 – 0.8 mm 22 kg/m²	Sand 0.2 – 0.8 mm 20 kg/m²	Sand 0.2 – 0.8 mm 20 kg/m²	Sand 0.2 – 0.8 mm 15 kg/m²	Sand 0.2 – 0.8 mm 19.25 kg/m²
Shockpad	PE foam 10 mm thick 420 g/m²	15 mm insitu rubber pad	PE foam 10 mm thick 590 g/m²	PE foam 10 mm thick 590 g/m²	PE foam 10 mm thick 533 g/m²

Below we describe all assumptions, data gaps and proxies used in modelling of each life cycle stage.

4.1.1 Yarn production

In the PEF-RP yarn production is modelled as monofilament yarn, straight, 50% in-line and 50% off-line extrusion. The yarn composition has been modelled using the average data provided by three companies of the TS and is a mix of yarn for sports and landscaping applications.

Both manufactured in-house and purchased yarn were modelled using:

Fossil-based polyethylene resin,

100% virgin material,

Modelled using the EF dataset 100% in-line extrusion, monofilament, straight yarn (50% off-line extrusion for monofilament straight yarn was not available, thus 100% in-line extrusion was assumed),

Polyethylene losses were accounted for, as defined in the Extrusion in-line dataset (0.5%),

Fluoropolymer was used as a proxy for fluoro-elastomer,

Transport of yarn incoming materials from supplier to the yarn manufacturing plant was modelled using average European transport,

Transport of yarn from the yarn manufacturing plant to the carpet manufacturing plant was modelled using the average European transport.

Table 1 (Excel Annex) documents the inventory of yarn production, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 15 (Excel Annex) includes the transport of incoming materials and the transport of yarn to carpet manufacturing sites.

4.1.2 Primary backing production

This life cycle stage consists of production of primary backing, woven, which was modelled as:

Fossil-based polypropylene,

Manufactured from 100% virgin material,

Polypropylene was modelled as a global dataset,

Manufacturing process weaving was modelled using the EF dataset,

Polypropylene 1.5% losses were accounted for from weaving,

Transport of polypropylene from supplier to primary backing manufacturing plant was modelled using average European transport,

Transport of primary backing to carpet plant was included based on average European transport data,

Transport of waste to treatment and waste treatment of polypropylene was included.

Table 2 (Excel Annex) documents the inventory of primary backing production, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 16 (Excel Annex) includes the transport of incoming materials, transport of production waste and the transport of primary backing to carpet manufacturing sites.

4.1.3 Secondary backing production

This life cycle stage consists of production of secondary backing, which was modelled as:

Fossil-based SBS latex,

Manufactured from 100% virgin material,

$CaCO_3$ was used as filler,

Manufacturing inputs were not included, due to lack of data,

Manufacturing losses were not included, due to lack of data, Transport of incoming materials SBS latex and CaCO3 filler from supplier to primary backing manufacturing plant was modelled using average European transport,

Transport to carpet plant was included based on average European transport data.

Table 3 (Excel Annex) documents the inventory of secondary backing production, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 17 (Excel Annex) includes the transport of secondary backing to carpet manufacturing sites.

4.1.4 Raw material acquisition and pre-processing for performance infill

Companies participating in the PEF-RP study all use the same performance infill and do not manufacture it, therefore it was modelled using exclusively secondary EF-compliant data. Since only aggregated EF-datasets were available at the time of conducting this study, it was not possible to split performance infill into life cycle stages representing raw materials acquisition and pre-processing and manufacturing.

Therefore, performance infill is modelled and reported under manufacturing of performance infill.

4.1.5 Sand acquisition

Companies participating in the PEF-RP study all use the same stabilising infill and do not manufacture it, therefore it was modelled using secondary EF-compliant data. The assumptions in this life cycle stage include:

EF dataset Sand, dredged river sand was used to represent stabilising infill.

Table 4 (Excel Annex) documents the inventory of sand raw material acquisition and pre-processing, parameter values applied in Circular Footprint Formula and datasets used in the model.

4.1.6 Raw material acquisition and pre-processing for shockpad

Companies participating in the RP study use comparable shockpads and do not manufacture them, therefore it was modelled with secondary EF-compliant data. 100% virgin, fossil-based polyethylene resin is used.

Table 5 (Excel Annex) documents the inventory of shockpad raw material acquisition and pre-processing, parameter values applied in Circular Footprint Formula and datasets used in the model.

4.1.7 Manufacturing of carpet

For the PEF-RP model, carpet manufacturing was entirely based on company-specific information and represents tufting technology, followed by liquid roll coating and in-line oven drying. The assumptions in this life cycle stage include:

Cumulative electricity, heat and water consumption for tufting, coating and drying was provided, thus it is not possible to identify the individual contribution of each manufacturing step,

Manufacturing waste and their transport to treatment are accounted, based on primary data,

Based on provided data, treatment of manufacturing waste was modelled as incineration.

Table 6 (Excel Annex) documents the inventory of carpet manufacturing, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 20 (Excel Annex) documents the transport of carpet manufacturing waste to treatment.

4.1.8 Manufacturing of performance infill

Companies participating in the PEF-RP study all use the same performance infill and do not manufacture it, therefore it was modelled using secondary EF-compliant data. The assumptions in this life cycle stage are:

Both raw materials and manufacturing of performance infill are included, as it was not possible to split aggregated EF-compliant datasets,

ELT was modelled as recycled rubber from post-consumer SBR through ambient grinding. According to the EF3.1 dataset, the majority of recycled rubber was generated by end-of-life tyres,

Styrene-butadiene rubber (SBR) was used as a proxy for virgin rubber used for tyre production,

Average European transport from supplier to the performance infill manufacturing site was assumed,

The recycled content R1 is equal to 1.

The A factor was selected to be equal to 0.8 (chapter 4.4.8.2 of the PEF method (European Commission 2021)). According to the PEF method A=0.8 indicates "high offer of recyclable materials and low demand: the formula focuses on recycled content".

Table 7 (Excel Annex) documents the inventory of performance infill manufacturing, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 18 (Excel Annex) includes the transport of incoming materials to the performance infill manufacturing site.

4.1.19 Manufacturing of shockpad manufacturing

Companies participating in the RP study use comparable shockpads and do not manufacture them, therefore it was modelled with secondary EF-compliant data.

The assumptions of this life cycle stage include:

Foaming EF dataset was used to represent manufacturing of shockpads,

Polyethylene losses in shockpad manufacturing were accounted for, as defined in the foaming EF dataset (2.5%).

Table 8 (Excel Annex) documents the inventory of shockpad manufacturing, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 19 (Excel Annex) includes the transport of incoming materials to the shockpad manufacturing site.

4.1.10 Storage and distribution of carpet

In the PEF-RP study for sports surfacing no infrastructure or energy usage of distribution centres was modelled. The TS informed that for sports surfacing the components often go directly to the installation site, so they were either stored at the manufacturing site or transported to installation site.

Table 21 summarises the distribution of carpet. The average EU local supply chain from factory to final client was assumed.

4.1.11 Storage and distribution of performance infill

In the PEF-RP study for sports surfacing no infrastructure or energy usage of distribution centres was modelled. The TS informed that for sports surfacing the components often go directly to the installation site, so they were either stored at the manufacturing site or transported to installation site.

Table 22 summarises the distribution of performance infill. The average EU local supply chain from factory to final client was assumed.

4.1.12 Storage and distribution of stabilising infill

In the PEF-RP study for sports surfacing no infrastructure or energy usage of distribution centres was modelled. The TS informed that for sports surfacing the components often go directly to the installation site, so they were either stored at the manufacturing site or transported to installation site.

Table 23 summarises the distribution of stabilizing infill. The average EU local supply chain from factory to final client was assumed.

4.1.13 Storage and distribution of shockpad

In the PEF-RP study for sports surfacing no infrastructure or energy usage of distribution centres was modelled. The TS informed that for sports surfacing the components often go directly to the installation site, so they were either stored at the manufacturing site or transported to installation site.

Table 24 summarises the distribution of shockpad. The average EU local supply chain from factory to final client was assumed.

4.1.15 Installation

The following assumptions were made in the PEF-RP study:

Installation losses:

Carpet – 1.67%,

Shockpad – 1.87%,

No losses of stabilising infill and performance infill were included, due to lack of data.

Based on company-specific information the waste from installation were sent either to incineration or landfill (using European share). The distances to waste treatment were modelled using company-specific information.

Table 9 (Excel Annex) documents the inventory of installation, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 25 (Excel Annex) documents the transport of installation waste to treatment.

4.1.16 Operation

Operation consists of routine maintenance, as well as specialist maintenance, which were identified as typical for football fields and are not necessarily applicable for other sports and landscape application.

It was assumed that:

Average operational usage per week is:

Number of players per hour: 25

Surface area: 7000 m2

Operational hours: 40

Lifetime of the synthetic turf system is 8 years,

Specialist maintenance requires top dressing of performance infill to compensate for compaction:

7.2 kg/m2 of performance infill is added over the lifetime of the field,

The average EU local supply chain from factory to final client was assumed for the additional performance infill,

Specialist maintenance requires 16 hours of machinery per field (7000 m2) per year. For specialist mechanical maintenance the relevant EF3.1 dataset was used. It was assumed to be applied one time per year for the duration of the STS lifetime (8 years).

Routine maintenance requires 1 hour of machinery per 10 hours of usage of the field. For 40 hours usage per week, routine maintenance will be applied 4 times (4 hours per week). The routine maintenance EF3.1 dataset was used. It was assumed to be applied 4 times per week, for 52 weeks per year, for 8 years of STS lifetime.

For stabilising infill no losses were considered so all infill that is placed on the field is also assumed to reach the EoL of the STS.

For performance infill, the migration losses were considered. The remaining amount was assumed to reach the EoL.

Yarn fibre losses were considered. However, it was assumed that the whole amount of fibre yarn reaches EoL (as stated in the limitations).

Table 10 (Excel Annex) documents the inventory of operation, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 26 (Excel Annex) documents the transport of the additional performance infill required during the operation over the lifetime of the STS.

4.1.17 End of life

End of life of STSs **for sports surfacing** was modelled on basis of the average end of life scenario for these in Europe, according to information provided by the Technical Secretariat (see Figure 20):

- 15% of all components, except for primary and secondary backing[31] is recycled. The percentage of synthetic turf systems sent to recycling was derived by comparing current recycling capacity in Europe and number of fields removed annually. During recycling, it is assumed that all sand and performance infill included in the turf system during the deconstruction phase is recovered and recycled, with only negligible losses. It is considered that the waste recycled results in high quality recycled materials. Specifically, the recycled performance infill replaces virgin rubber and the recycled stabilizing infill replaces primary sand. In the case of the recycled waste carpet results in high quality recycled products used by different industries, such as the synthetic turf, construction, furniture and other industries. Examples of products produced with recycled carpet are trekboards, nailor boards, pavers and grass pavers. The main alternatives that the recycled carpet products will replace are hardwood or recycled plastics. Finally, the recycled shockpad replaces virgin PE granulates.
- 35% of the discarded carpets is repurposed, i.e. recovered from a synthetic turf field during the deconstruction phase. It is cleaned, repaired and used in a commercial or residential landscape application, batting cage, or soil amendment. This second use is different from the first. For this reason, it shall be modelled as recycling according to European Commission (2021). Due to the wide variability of applications of repurposed

[31] Primary and secondary backing cannot currently be recycled because these two cannot be disassembled and are often made of different materials.

carpets, we assume that the avoided material (E*v) is the finished carpet modelled in the RP used for landscaping (see 3.2.2). The quality of this is of similar quality to that of new carpet, so the quality of secondary outgoing material (Q_{Sout}/Q_p) is considered 1. Another aspect when repurposing is the migration of the stabilising and polymeric infill to the environment. Since this is modelled for the life cycle of the repurposed carpet, it is not considered in the model of the sports synthetic turf system. Finally, 20% losses were accounted for repurposing. The source of the losses is the carpet being cut in different shapes and sizes before is sent to the final client.

- For all waste remaining after repurposing and recycling, 30% ends up at incineration and 70% ends up landfilled.

4.1.17.1 End of life of carpet

The carpet (yarn, primary backing and secondary backing) is treated as a whole at the end of life. The following assumptions were made when modelling end of life:

Recycling of plastic was used as a proxy for recycling of carpet, 50% hardboard and 50% recycled plastic were assumed to be substituted (E*v) by the recyclable materials from the recycling of carpet,

For the hardboard being avoided, it was assumed to have half the width than that of recycled carpet,

The carpet modelled in the RP for landscaping applications was used as E*v for repurposing of carpet, with QSout/Qp equal to 1 and amount per m2,

Repurposing includes the landfilling and incineration of the carpet cutting losses (20%),

Landfilling of plastic waste was used as a proxy for landfilling of polyethylene (yarn) and polypropylene (primary backing),

Landfilling of inert material and incineration of inert material was assumed for the landfill and incineration of the $CaCO_3$ secondary backing filler respectively.

Table 11 documents the inventory of the end of life of carpet, parameter values applied in Circular Footprint Formula and datasets used in the model.

4.1.17.2 End of life of performance infill

The following assumptions were made when modelling end of life of performance infill:

Grading of plastic infills and cleaning of plastic infills were used for recycling of ELT,

Grading losses were accounted for, as defined in the EF dataset (3.5%),

SBR was modelled as E*v for the recycling of ELT,

Repurposing includes the landfilling and incineration of the carpet cutting losses (20%),

The total amount of infill used is 15.2 kg per 8 m2a (8 kg at installation and 7.2 kg in total added over the lifetime of the STS),

Migration (losses) of performance infill to the environment is calculated to be 3.36 kg per 8 m2a. The remaining amount of infill is treated at the end-of-life treatment.

Table 12 documents the inventory of the end of life of performance infill, parameter values applied in Circular Footprint Formula and datasets used in the model.

4.1.17.3 End of life of stabilising infill

The following assumptions were made when modelling end of life of stabilising infill:

Grading of sand and cleaning of plastic infills proxy were used for recycling of sand,

Grading losses were accounted for, as defined in the EF sand grading dataset (4%),

Dredged river sand was modelled as E*v for the recycling of sand,

Landfill and incineration of inert material was used for the sand grading losses,

Repurposing includes the landfilling and incineration of the carpet cutting losses (20%).

Table 13 documents the inventory of the end of life of stabilising infill, parameter values applied in Circular Footprint Formula and datasets used in the model.

4.1.17.4 End of life of shockpad

The following assumptions were made when modelling end of life of shockpad:

Recycling of post-industrial polyethylene foam was used for recycling of polyethylene foam,

PE granulates was used as avoided product in recycling,

Landfilling of plastic waste was used as a proxy for landfilling of PE.

Table 14 documents the inventory of the end of life of shockpad, parameter values applied in Circular Footprint Formula and datasets used in the model.

Annex 4.2 – Representative product for landscaping applications

The PEF-RP model was developed by averaging the data of the four most common sold landscaping synthetic turf systems of one Technical Secretariat members, which manufacture synthetic turf products. Enclosed you can see an Excel file including all data used and referred to further below in this section.

Table 46: Most common landscape configuration of the four most sold landscape systems produced by a TS member

Component	Most common landscape configurations				Virtual product
Pile yarn	PE: 60% PP: 40%	PE: 75% PP: 25%	PE: 70% PP: 30%	PE: 65% PP: 35%	Polyethylene: 67.5% Polypropylene: 32.5%
Pile height	30 mm	40 mm	38 mm	29 mm	34 mm
Pile weight	1335 g/m^2	1320 g/m^2	1876 g/m^2	581 g/m^2	1278 g/m^2
Primary backing	Polypropylene 161 g/m^2	Polypropylene 183 g/m^2	Polypropylene 183 g/m^2	Polypropylene 183 g/m^2	Polypropylene 177.5 g/m^2
Secondary backing (dry)	SBS latex (60%) and $CaCO_3$ filler (40%) 800 g/m^2	SBS latex (60%) and $CaCO_3$ filler (40%) 800 g/m^2	SBS latex (60%) and $CaCO_3$ filler (40%) 800 g/m^2	SBS latex (60%) and $CaCO_3$ filler (40%) 800 g/m^2	SBS latex (60%) and $CaCO_3$ filler (40%) 800 g/m^2

Below we describe all assumptions, data gaps and proxies used in modelling of each life cycle stage.

4.2.1 Yarn production

In the PEF-RP model for landscaping applications, yarn production is modelled as monofilament yarn, texturized PP and straight PE, 50% in-line and 50% off-line extrusion. The yarn composition has been modelled using the average data provided by three companies of the TS and is a mix of yarn for sports and landscaping applications.

Yarn was modelled using:

100% virgin fossil-based polyethylene resin and polypropylene resin;

100% in-line extrusion, monofilament, straight yarn for PE (50% off-line was not available, thus 100% in-line extrusion was assumed);

50% in-line extrusion, monofilament, texturized yarn for PP;

50% off-line extrusion, monofilament, texturized yarn for PP;

Polyethylene and polypropylene losses were accounted for, as defined in the Extrusion (in-line and off-line) datasets (0.5%);

Fluoropolymer was used as a proxy for fluoroelastomer;

Transport of yarn incoming materials from supplier to the yarn manufacturing plant was modelled as a mix of average European transport and average non-European transport, based on the market shares of polyethylene and polypropylene documented in Ecoinvent;

Transport of yarn from the yarn manufacturing plant to the carpet manufacturing plant was modelled using the average European transport.

Table 1 (Excel Annex) documents the inventory of yarn production, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 7 (Excel Annex) includes all transport of yarn to carpet manufacturing sites.

4.2.2 Primary backing production

Primary backing, woven, is not manufactured by the companies participating in the PEF-RP study. It was modelled as:

Fossil-based polypropylene;

Manufactured from 100% virgin material;

Polypropylene was modelled as a mix of European and non-European dataset, based on their market shares documented in Ecoinvent;

Manufacturing process weaving was modelled using the EF dataset;

Polypropylene 1.5% losses were accounted for from weaving;

Transport of polypropylene from supplier to primary backing manufacturing plant was modelled as a mix of average European transport and average non-European transport, based on the market shares of polyethylene and polypropylene documented in Ecoinvent.

Transport to carpet plant was included based on average European data.

Table 2 (Excel Annex) documents the inventory of primary backing production, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 8 (Excel Annex) documents the transport of incoming materials and the transport of primary backing to carpet plant.

4.2.3 Secondary backing production

Secondary backing is not manufactured by companies participating in the PEF-RP study. It was modelled as:

Fossil-based SBS latex;

Manufactured from 100% virgin material;

$CaCO_3$ was used as filler;

Manufacturing inputs were not included, due to lack of data;

Manufacturing losses were not included, due to lack of data;

Transport of incoming materials SBS latex and $CaCO_3$ filler from supplier to primary backing manufacturing plant was modelled as a mix of average European transport and average non-European transport, based on the market shares of polyethylene and polypropylene documented in Ecoinvent;

Transport to carpet plant was included based on average European data.

Table 3 (Excel Annex) documents the inventory of secondary backing production, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 9 (Excel Annex) documents the transport of incoming materials and the transport of secondary backing to carpet plant.

4.2.4 Carpet manufacturing

For the PEF-RP model, carpet manufacturing was entirely based on company-specific information and represents tufting technology, followed by liquid roll coating and in-line oven drying. The assumptions in this life cycle stage include:

Cumulative electricity consumption for tufting, coating and drying was provided, thus it is not possible to identify the individual contribution of each manufacturing step;

Manufacturing waste and their transport to treatment are accounted, based on primary data;

Treatment of manufacturing waste was modelled as landfill and incineration.

Table 4 (Excel Annex) documents the inventory of carpet manufacturing, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 10 (Excel Annex) documents the transport of carpet manufacturing waste to treatment.

4.2.5 Storage and distribution of carpet

In the PEF-RP study for landscaping applications the energy usage of distribution centres and retail was modelled using default values as defined in section 4.4.5 of European Commission (2021) as discussed earlier. According to the TS, there are three distribution channels of the finished carpet for landscaping applications:

Transporting of finished carpet from the manufacturing site directly to the customer;

Cutting of the carpet in smaller pieces in the manufacturing site and transporting to retail;

Transporting from the manufacturing site to a middle company that performs the carpet cutting into smaller pieces and then transporting to retail. Operations of a potential middle company have not been modelled due to lack of relevant data. Any potential cutting is assumed to take place at the factory.

The following have been modelled:

Ratio between products sold through retail, distribution centre (DC) and directly to the final client; the following ratios have been assumed:

Products sold through retail: one third

Products sold through DC: one third

Products sold directly to the client: one third

For factory to final client: Ratio between local, intracontinental and international supply chains; the following ratios have been assumed:

Intracontinental: 13% (EU artificial turf supply share - AMI Consulting 2018)

International: 87% (Global artificial turf supply share)

For factory to retail: distribution between intracontinental and international supply chains; the following ratios have been assumed:

Intracontinental: 13% (EU artificial turf supply share - AMI Consulting 2018)

International: 87% (Global artificial turf supply share)

Inventory data are summarized in Table 11 (Excel Annex).

4.2.6 Installation

The following assumptions were made in the PEF-RP study:

The construction of the base and the materials needed for that were not considered because these are location-specific and product-independent;

Adhesives and jointing film materials were not included because they are product independent;

Installation machinery was not included because it is product independent;

20% carpet installation losses;

Based on information provided by the TS, the waste (losses) from installation is assumed to end up in municipal waste kerbside collection (using European shares).

Waste treatment of cutting losses which were modelled the same as final disposal at the end of life of the STS.

Table 5 (Excel Annex) documents the inventory of carpet installation, parameter values applied in Circular Footprint Formula and datasets used in the model. Table 12 (Excel Annex) includes the data used for the transport of installation waste to waste treatment facilities.

4.2.7 Use stage

In landscaping applications, the use stage depends on the expectations of owner. In some cases it is purely decorative so no maintenance needed. In commercial use (resorts, etc.), users may vacuum-clean. However, since this is a product-independent activity, this shall be excluded from PEF calculations. Land occupation is also product independent and shall, for this reason and according to European Commission (2021), be excluded from the system boundary. Consequently, no activities are modelled in the use stage of STSs used in landscaping applications.

Further, it was assumed that the lifetime of the synthetic turf system is 8 years, as per the functional unit.

4.2.8 End of life of carpet

The main markets in landscaping are domestic use (homeowners) with small areas. Most of these will dispose the product in a similar way to household carpets, i.e., as kerbside collection of municipal solid waste. For this reason, it is assumed that the majority of synthetic turf systems are not recycled or repurposed at the end of life. The waste destination at the end of life of STS used for landscaping is based on municipal waste treatment incineration and landfill shares on EU, 45% and 55% respectively, following the values in Annex C (European

Commission 2020). EOL treatment processes impacts have been allocated to the weight of the different components (yarn, primary and secondary backing) per m2 of carpet.

The following assumptions were made in the RP study:

For yarn, Landfilling of plastic waste was used as a proxy for landfilling of polyethylene and polypropylene;

For primary backing, Landfilling of plastic waste was used as a proxy for landfilling of polypropylene;

For secondary backing:

Incineration of inert materials was used as a proxy for the CaCO3 filler; and

Landfilling of inert materials was used as a proxy for the CaCO3 filler.

The inventories of end-of-life treatment of carpet (yarn, primary packing and secondary backing), parameter values applied in Circular Footprint Formula and datasets used in the model are documented in Table 6 (Excel Annex).

Annex 5 – Supporting files available on request

The following Excel files referred to in this document are available from the ESTC. Requests should be sent to info@estc.info.

5.1 Excel file: Microplastics calculations

5.2 Excel file: List of mandatory company-specific data and of processes expected to be r un by the company- Sports applications

5.3 Excel file: List of mandatory company-specific data and of processes expected to be r un by the company- landscape applications

5.3 Excel file: Worksheet - PEF-RP model data used

Annex 6 - Templates for summary communication reports

Summary report

Product Environmental Footprint (PEF) analysis

Synthetic turf sports surface

Synthetic turf system name	
Manufacturer/supplier	
Date of report	

1 Introduction

Product Environmental Footprint (PEF) is a method of life cycle assessment (LCA) developed by the European Commission. PEF provides a standardised way of quantifying the environmental impacts of products (goods or services) by considering their entire life cycle, from raw material extraction to final waste management.

PEF Category Rules (PEFCR) describe how a PEF analysis should be undertaken for a specific product sector. The Category Rules for synthetic turf surfaces (*Synthetic Turf Product Environmental Footprint Category Rules* - 2024 edition) have been developed by the EMEA Synthetic Turf Council (ESTC) in cooperation with the European Commission. The Rules are available at ESTC Product Environmental Footprint. The PEF analysis detailed in this report has undertaken in accordance with these Category Rules.

The Product Environmental Footprint methodology describes 16 impact categories that need to be assessed during each life cycle stage of a product's life. The results for the 16 impact categories are tabulated in Section 5 of this report. The PEF methodology also allows the key impact categories for a specific product group to be defined. During the development of the PEFCR for synthetic turf surfaces, the following six impact categories were identified as being the most significant:

Acidification	An EF impact category that considers the environmental impact caused be the acidifying of substances in the environment, which can lead to forest decline and lake acidification.
Climate change[1]	An aggregated EF category that assesses the potential for greenhouse gas emissions.
Particulate matter	An EF impact category that assesses the adverse effects on human health caused by the emissions of particulate matter and their precursors (e.g. NOx, SOx, NH3).
Resources used (fossil fuels)	An EF impact category the assesses the use of non-renewable fossil based natural resources (e.g. natural gas, coal, oil).
Resources used (minerals & metals)	An EF impact category that assessed the use of non-renewable abiotic natural resources (e.g. minerals and metals).
Water use	An EF impact category that assesses the use of water during the life of a synthetic turf surface, and how that use effects the aquatic ecosystem.

The PEF values for the six key impact categories are reported in Section 3 of this report.

[1] Note: the sub-indicators 'Climate change – biogenic' and 'Climate change - land use and land transformation' are not reported separately because their contributions to the total climate change impact, based on the PEF CR benchmark results, are less than 5% each."

Addition impact categories

The potential for microplastic pollution during the use and end-of-life phases of a synthetic turf surface has been identified as an additional relevant environmental concern, outside of the mandatory impact categories of a PEF analysis. Therefore, the *Synthetic Turf PEFCR*, requires the mass of potential microplastic leakage (polymeric infill and fibre debris) from a synthetic turf surface to be assessed and reported. The Category Rules describe how this is done and the results obtained are given in Section 3.

Overall Weighted PEF Result

The PEF methodology also for an overall weighted result to be reported as a single score. Weighting is a step that aids the interpretation and communication of a PEF analysis. The PEF results are multiplied by a set of weighting factors, which reflect the perceived relative importance of the impact categories being considered. This allows weighted EF results to be directly compared across impact categories, and also summed across impact categories, to obtain a single overall score.

The Overall Weighted PEF result for the synthetic turf surface described in this report is also given in Section 3 of this report.

Product description

Section 4 of this report describes each of the components used to make the synthetic turf surface, and the location(s) in which they are produced. In some cases, the component may be produced in more than one location. If any of the components or production locations change, this report does not apply to it.

Notes:

1. The information detailed in this report is based on data supplied by the manufacturers of the various components making up the synthetic turf surface. Those supplying the data assume full responsibility for its accuracy and the results reported.

2. For a PEF analysis to comply with the category rules, it has to be independently verified by an external auditor. Details of this reports verification are given in Section 2.9.

3. The synthetic turf sports system described in this report should comply with European Standard EN 15330[2]: Parts 1 – 6, and any applicable sports' governing body standards.

Representative product

The development of the *Synthetic Turf Product Environmental Footprint Category Rules* required the PEF analysis of a 'representative product' to identify the most relevant impact categories, life cycle stages, processes and elementary flows, etc. The representative product could either be a real product or a virtual product, based on European averages. For synthetic turf, a virtual product was selected, and it was based on the largest market sector a football turf surface.

[2] EN 15330: Surfaces for sports areas — Synthetic turf and needle-punched surfaces primarily designed for outdoor use

The PEF values for this representative product can be used as benchmark against which real products can be compared. The PEF report for the representative product can be downloaded from ESTC Product Environmental Footprint.

System boundaries

System boundaries define the aspects included or excluded from the study. The system boundaries defined in the PEFCR for synthetic turf are:

Raw material acquisition and pre-processing Yarn production Primary backing production Stabilising infill production Shockpad production	**Manufacturing** Turf carpet production Performance infill production Stabilising infill production Shockpad production	**Distribution stage** Turf carpet Performance infill production Stabilising infill Shockpad
Use stage Installation Operation	**End of life** Turf carpet Performance infill Stabilising infill Shockpad	

Figure 1 shows the principal life cycle stages of a synthetic turf surface.

ESTC consumer guide to interrupting a PEF report

ESTC has produced a guide to interrupting a PEF report and understanding the relevance of the PEF data. This is available at ESTC Product Environmental Footprint.

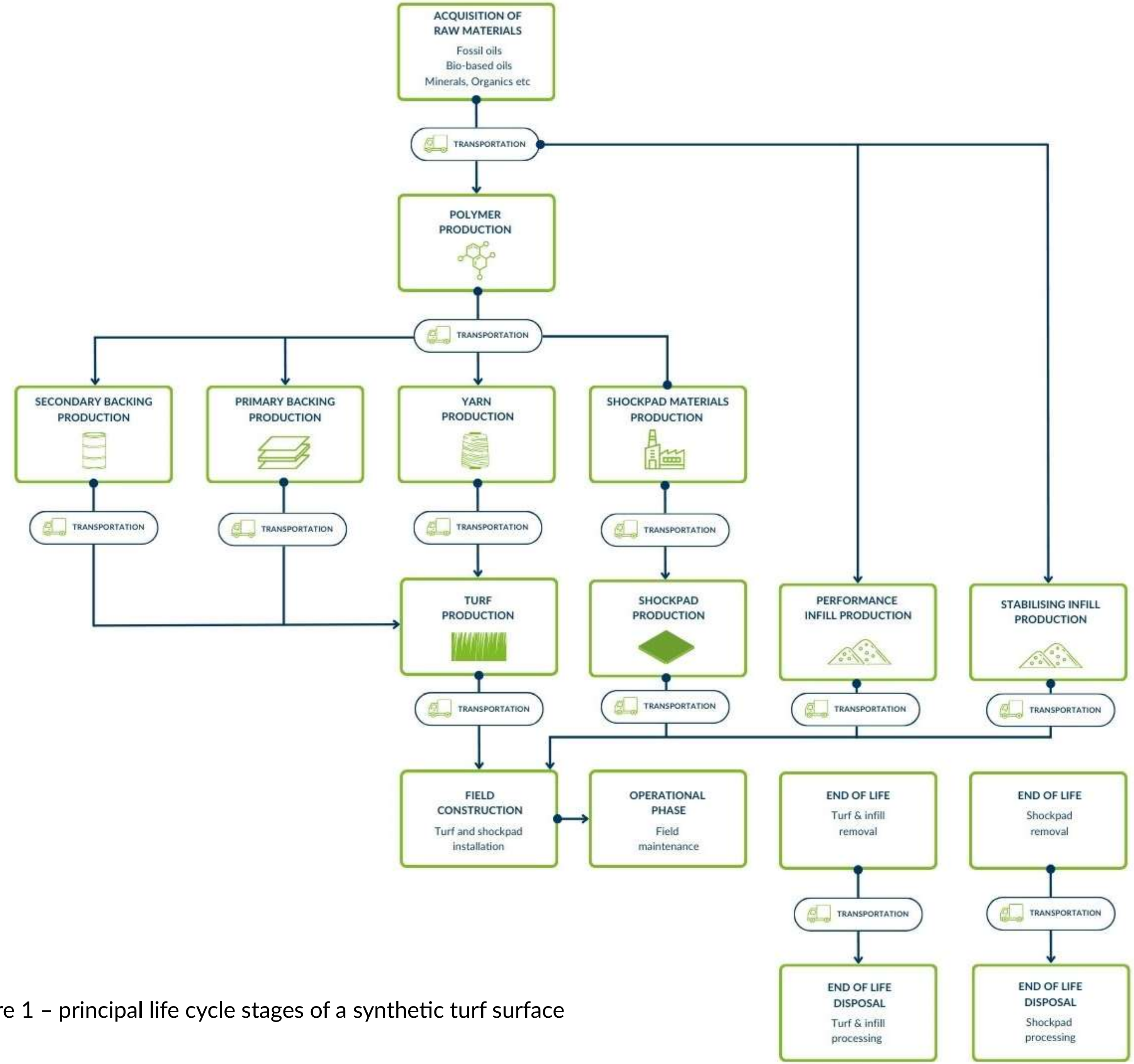

Figure 1 – principal life cycle stages of a synthetic turf surface

2	Report details		
2.1	**Product name:** (add hyperlink to product website)		
2.2	**Application** (describe intended sport application(s))		
2.3	**Date of report:**		
2.4	**Company commissioning this PEF study:**		
2.5	**Geographical scope:** (default is EU+EFTA+UK)		
2.6	**Functional unit (FU):**	**Area**	1 m^2
		Primary sport's use (football, hockey, tennis, etc)	
		Service life (assuming correct levels of use and maintenance)	Eight years
2.7	**Summary report prepared by:**	**Name**	
		Position	

2.8 Period of report validity

This report remains valid for a period of five years from the date of publication of the PEF Category Rules (June 2024), or until the Category Rules are next updated, whichever comes sooner.

2.9 Report verification

To comply with the requirements of the PEF CR for synthetic turf surfaces a PEF analysis needs to be independently verified; this is requirements of the European Commission. The verifiers is also required to confirm that this summary report accurately details the information generated by the PEF analysis.

Verification company	
Verifier's name	
Verification report number / hyperlink	

3 Summary of results per functional unit

	EF category	Unit	Result
3.1	Overall weighted PEF results as a single score	$x10^{-3}$ Pts	
3.2	Acidification	mol H+ eq	
3.3	Climate change[3]	kg CO^2 eq	
3.4	Particulate matter	Disease inc.	
3.5	Resources used (fossil fuels)	MJ	
3.6	Resources used (minerals & metals)	kg Sb eq	
3.7	Water use	m^3 depriv.	
3.8	Potential microplastic loss to the environment – mandatory additional information		
3.8.1	Estimated potential fibre debris loss to the environment	kg/Functional Unit	
3.8.2	Estimated potential polymeric infill loss to the environment	kg/ Functional Unit	

[3] Note: the sub-indicators 'Climate change – biogenic' and 'Climate change - land use and land transformation' are not reported separately as their contribution to the total climate change impact, based on the PEF CR benchmark results, were less than 5% each."

4	Synthetic turf product declaration[4]				
4.1	Synthetic turf system name				
4.2	System supplier				
4.3	Synthetic turf carpet product name / code				
4.4	Shockpad product name (if applicable) and supplier				
4.5	Stabilising infill product name (if applicable) and supplier				
4.6	**Synthetic turf carpet**				
4.6.1	Method of manufacturing				
4.6.2	Manufacturing location(s)				
4.6.3	Percentage of production for each manufacturing location				
4.6.4	Pile height (mm)				
4.6.5	Total carpet weight (g/m^2)				
4.6.6	Tufts/m^2				
4.6.7	Filaments/m^2				
4.6.7	Pile weight (g/m^2)				

[4] If multiple single components are used in the synthetic turf surface or the PEF analysis is based on components manufactured in more than one location, details of each must be listed.

4.7	**Synthetic turf pile yarns**				
4.7.1	Manufacturing location(s)				
4.7.2	Percentage of production for each manufacturing location				
4.7.3	Pile yarn polymer				
4.7.54	Pile profile / shape				
4.7.5	Pile yarn dtex				
4.7.6	Pile thickness (Կm)				
4.8	**Primary backing**				
4.8.1	Product name				
4.8.2	Manufacturing location(s)				
4.8.3	Percentage of production for each manufacturing location				
4.8.4	Primary backing weight (g/m^2)				
4.9	**Secondary backing**				
4.9.1	Product type				
4.9.2	Manufacturing location(s)				
4.9.3	Percentage of production for each manufacturing location				
4.9.4	Wet application weight (g/m^2)				

4.10	**Performance infill (if used)** [5]				
4.10.1	Product type				
4.10.2	Production location				
4.10.3	Application rate (kg/m^2)				
4.11	**Stabilising infill (if used)** [5]				
4.11.1	Product type				
4.11.2	Production location				
4.11.3	Application rate (kg/m^2)				
4.12	**Shockpad (if used)** [5]				
4.12.1	Product name				
4.12.2	Product description				
4.12.3	Manufacturing location(s)				
4.12.4	Percentage of production for each manufacturing location				
4.12.5	Shockpad thickness (mm)				

[5] Some synthetic turf sports surfaces do not contain performance infill or stabilising infill. Some may not incorporate a shockpad

5 Characterized results per impact category and life cycle stage per functional unit

	Impact category	Unit	Complete life cycle	LCS 1.1 Yarn production	LCS 1.2 Primary backing production	LCS 1.3 Secondary backing production	LCS 1.4 RMA & PP [6] for perform. infill	LCS 1.5 Sand acquisition	LCS 1.6 RMA & PP for shockpad	LCS 2.1 Turf carpet production	LCS 2.2 Perform. Infill production	LCS 2.3 Shockpad production
5.1	Acidification	mol H+ eq										
5.2	Climate change	kg CO^2 eq										
5.3	Ecotoxicity, freshwater	CTUe										
5.4	Particulate matter	Disease in.										
5.5	Eutrophication, marine	kg N eq										
5.6	Eutrophication, freshwater	kg P eq										
5.7	Eutrophication, terrestrial	mol N eq										
5.8	Human toxicity, cancer	CTUh										
5.9	Human toxicity, non-cancer	CTUh										
5.10	Ionising radiation	kBq U-235 eq										
5.11	Land use	Pt										
5.12	Ozone depletion	kg CFC11 eq										
5.13	Photochemical ozone formation	kg NMVOC eq										
5.14	Resource use, fossils	MJ										
5.15	Resource use, minerals, and metals	kg Sb eq										
5.16	Water use	m3 depriv.										

[6] RMA = raw material acquisition PP = pre-production

	Impact category	Unit	LSC 3.1	LCS 3.2	LCS3.3	LCS3.4	LCS 4.1	LCS 4.2	LCS 5.1	LCS 5.2	LCS 5.3	LCS 5.4
			S&D[7] of Turf carpet	S&D of performance infill	S&D of stabilising infill	S&D of shockpad	Installation	Operation (Use)	EOL of turf carpet	EOL of performance infill	EOL of stabilising infill	EOL of shockpad
5.17	Acidification	mol H+ eq										
5.18	Climate change	kg CO2 eq										
5.19	Ecotoxicity, freshwater	CTUe										
5.20	Particulate matter	CTUh										
5.21	Eutrophication, marine	kg N eq										
5.22	Eutrophication, freshwater	kg P eq										
5.23	Eutrophication, terrestrial	mol N eq										
5.24	Human toxicity, cancer	CTUh										
5.25	Human toxicity, non-cancer	CTUh										
5.26	Ionising radiation	kBq U-235 eq										
5.27	Land use	Pt										
5.28	Ozone depletion	kg CFC11 eq										

[7] S & D = storage and distribution

Summary report

Product Environmental Footprint (PEF) analysis

Synthetic turf landscaping surface

Synthetic turf system name	
Manufacturer/supplier	
Date of report	

1 Introduction

Product Environmental Footprint (PEF) is a method of life cycle assessment (LCA) developed by the European Commission. PEF provides a standardised way of quantifying the environmental impacts of products (goods or services) by considering their entire life cycle, from raw material extraction to final waste management.

PEF Category Rules (PEFCR) describe how a PEF analysis should be undertaken for a specific product sector. The Category Rules for synthetic turf surfaces (*Synthetic Turf Product Environmental Footprint Category Rules* - 2024 edition) have been developed by the EMEA Synthetic Turf Council (ESTC) in cooperation with the European Commission. The Rules are available at ESTC Product Environmental Footprint. The PEF analysis detailed in this report has undertaken in accordance with these Category Rules.

The Product Environmental Footprint methodology describes 16 impact categories that need to be assessed during each life cycle stage of a product's life. The results for the 16 impact categories are tabulated in Section 5 of this report. The PEF methodology also allows the key impact categories for a specific product group to be defined. During the development of the PEFCR for synthetic turf surfaces, the following six impact categories were identified as being the most significant:

Acidification	An EF impact category that considers the environmental impact caused be the acidifying of substances in the environment, which can lead to forest decline and lake acidification.
Climate change[1]	An aggregated EF category that assesses the potential for greenhouse gas emissions.
Particulate matter	An EF impact category that assesses the adverse effects on human health caused by the emissions of particulate matter and their precursors (e.g. NOx, SOx, NH3).
Resources used (fossil fuels)	An EF impact category the assesses the use of non-renewable fossil based natural resources (e.g. natural gas, coal, oil).
Resources used (minerals & metals)	An EF impact category that assessed the use of non-renewable abiotic natural resources (e.g. minerals and metals).
Water use	An EF impact category that assesses the use of water during the life of a synthetic turf surface, and how that use effects the aquatic ecosystem.

The PEF values for the six key impact categories are reported in Section 3 of this report.

[1] Note: the sub-indicators 'Climate change – biogenic' and 'Climate change - land use and land transformation' are not reported separately because their contributions to the total climate change impact, based on the PEF CR benchmark results, are less than 5% each."

Addition impact categories

The potential for microplastic leakage during the use and end-of-life phases of synthetic turf surface has been identified as an additional relevant environmental concern, outside of the mandatory impact categories of a PEF analysis. Therefore, the *Synthetic Turf PEFCR*, requires the mass of potential microplastic leakage (polymeric infill and fibre debris) from a synthetic turf surface to be assessed and reported. The Category Rules describe how this is done and the results obtained are given in Section 3.

Overall Weighted PEF Result

The PEF methodology also for an overall weighted result to be reported as a single score. Weighting is a step that aids the interpretation and communication of a PEF analysis. The PEF results are multiplied by a set of weighting factors, which reflect the perceived relative importance of the impact categories being considered. This allows weighted EF results to be directly compared across impact categories, and also summed across impact categories, to obtain a single overall score.

The Overall Weighted PEF result for the synthetic turf surface described in this report is also given in Section 3 of this report.

Product description

Section 4 of this report describes each of the components used to make the synthetic turf surface, and the location(s) in which they are produced. In some cases, the component may be produced in more than one location. If any of the components or production locations change, this report does not apply to it.

Notes:

1. The information detailed in this report is based on data supplied by the manufacturers of the various components making up the synthetic turf surface. Those supplying the data assume full responsibility for its accuracy and the results reported.

2. For a PEF analysis to comply with the category rules, it has to be independently verified by an external auditor. Details of this reports verification are given in Section 2.9.

Representative product

The development of the *Synthetic Turf Product Environmental Footprint Category Rules* required the PEF analysis of a 'representative product' to identify the most relevant impact categories, life cycle stages, processes and elementary flows, etc. The representative product could either be a real product or a virtual product, based on European averages. For synthetic turf a virtual product was selected; and it was based on arithmetic average of the four most commonly sold products produced by Technical Secretariate members that oversaw the development of the PEF CR.

The PEF values for this representative product can be used as benchmark against which real products can be compared. The PEF report for the representative product can be downloaded from ESTC Product Environmental Footprint.

System boundaries

System boundaries define the aspects included or excluded from the study. The system boundaries defined in the PEFCR for synthetic turf are:

Raw material acquisition and pre-processing Yarn production Primary backing production Stabilising infill production Shockpad production	**Manufacturing** Turf carpet production Performance infill production Stabilising infill production Shockpad production	**Distribution stage** Turf carpet Performance infill production Stabilising infill Shockpad
Use stage Installation Operation	**End of life** Turf carpet Performance infill Stabilising infill Shockpad	

Figure 1 shows the principal life cycle stages of a synthetic turf surface.

ESTC consumer guide to interrupting a PEF report

ESTC has produced a guide to interrupting a PEF report and understanding the relevance of the PEF data. This is available at ESTC Product Environmental Footprint.

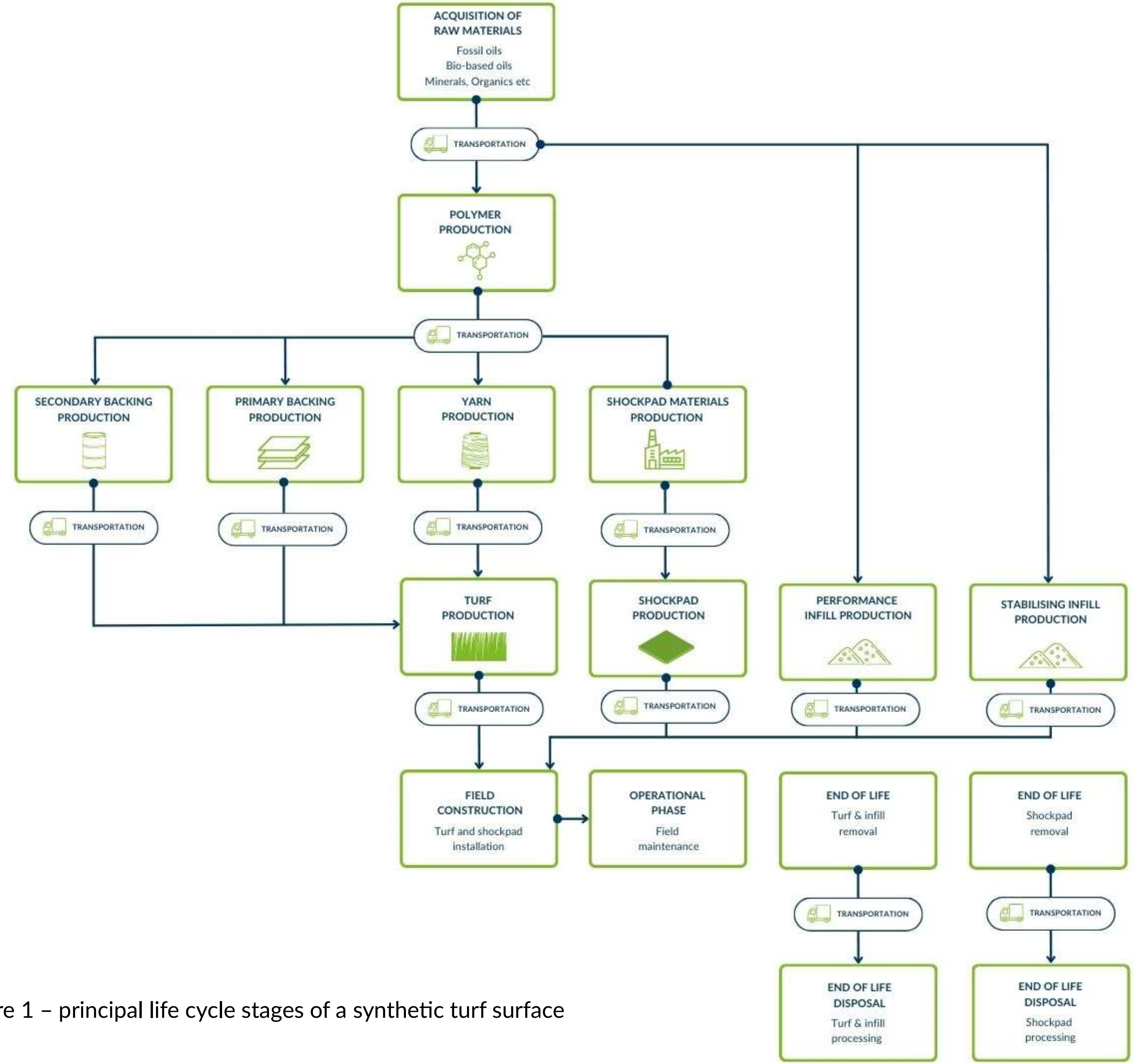

Figure 1 – principal life cycle stages of a synthetic turf surface

2	Report details			
2.1	**Product name:** (add hyperlink to product website)			
2.2	**Application** (describe intended landscape application(s))			
2.3	**Date of report:**			
2.4	**Company commissioning this PEF study:**			
2.5	**Geographical scope:** (default is EU+EFTA+UK)			
2.6	**Functional unit (FU):**	**Area**	1 m^2	
		Primary use (residential or recreational)		
		Service life (assuming correct levels of use and maintenance)	Eight years	
2.7	**Summary report prepared by:**	**Name**		
		Position		

2.8 Period of report validity

This report remains valid for a period of five years from the date of publication of the PEF Category Rules (June 2024), or until the Category Rules are next updated, whichever comes sooner.

2.9 Report verification

To comply with the requirements of the PEF CR for synthetic turf surfaces a PEF analysis needs to be independently verified; this is requirements of the European Commission. The verifiers is also required to confirm that this summary report accurately details the information generated by the PEF analysis.

Verification company	
Verifier’s name	
Verification report number / hyperlink	

3 Summary of results per functional unit

	EF category	Unit	Result
3.1	Overall weighted PEF results as a single score	x10^{-3} Pts	
3.2	Acidification	mol H+ eq	
3.3	Climate change[2]	kg CO^2 eq	
3.4	Particulate matter	Disease inc.	
3.5	Resources used (fossil fuels)	MJ	
3.6	Resources used (minerals & metals)	kg Sb eq	
3.7	Water use	m^3 depriv.	
3.8	Potential microplastic loss to the environment – mandatory additional information		
3.8.1	Estimated potential fibre debris loss to the environment	kg/Functional Unit	
3.8.2	Estimated potential polymeric infill loss to the environment	kg/ Functional Unit	

[2] Note: the sub-indicators 'Climate change – biogenic' and 'Climate change - land use and land transformation' are not reported separately as their contribution to the total climate change impact, based on the PEF CR benchmark results, were less than 5% each."

4	Synthetic turf product declaration[3]				
4.1	Synthetic turf system name				
4.2	System supplier				
4.3	Synthetic turf carpet product name / code				
4.4	Shockpad product name (if applicable) and supplier				
4.5	Stabilising infill product name (if applicable) and supplier				
4.6	**Synthetic turf carpet**				
4.6.1	Method of manufacturing				
4.6.2	Manufacturing location(s)				
4.6.3	Percentage of production for each manufacturing location				
4.6.4	Pile height (mm)				
4.6.5	Total carpet weight (g/m^2)				
4.6.6	Tufts/m^2				
4.6.7	Filaments/m^2				
4.6.7	Pile weight (g/m^2)				

[3] If multiple single components are used in the synthetic turf surface or the PEF analysis is based on components manufactured in more than one location, details of each must be listed.

4.7	**Synthetic turf pile yarns**				
4.7.1	Manufacturing location(s)				
4.7.2	Percentage of production for each manufacturing location				
4.7.3	Pile yarn polymer				
4.7.54	Pile profile / shape				
4.7.5	Pile yarn dtex				
4.7.6	Pile thickness (Ꙡm)				
4.8	**Primary backing**				
4.8.1	Product name				
4.8.2	Manufacturing location(s)				
4.8.3	Percentage of production for each manufacturing location				
4.8.4	Primary backing weight (g/m^2)				
4.9	**Secondary backing**				
4.9.1	Product type				
4.9.2	Manufacturing location(s)				
4.9.3	Percentage of production for each manufacturing location				
4.9.4	Wet application weight (g/m^2)				

4.10	**Performance infill (if used)** [4]				
4.10.1	Product type				
4.10.2	Production location				
4.10.3	Application rate (kg/m^2)				
4.11	**Stabilising infill (if used)** [3]				
4.11.1	Product type				
4.11.2	Production location				
4.11.3	Application rate (kg/m^2)				
4.12	**Shockpad (if used)** [3]				
4.12.1	Product name				
4.12.2	Product description				
4.12.3	Manufacturing location(s)				
4.12.4	Percentage of production for each manufacturing location				
4.12.5	Shockpad thickness (mm)				

[4] Most synthetic turf landscaping turfs do not contain performance infill, and many do not use stabilising infills or shockpads

5 Characterized results per impact category and life cycle stage per functional unit

	Impact category	Unit	Complete life cycle	LCS 1.1	LCS 1.2	LCS 1.3	LCS 1.4	LCS 1.5	LCS 1.6	LCS 2.1	LCS 2.2	LCS 2.3
				Yarn production	Primary backing production	Secondary backing production	RMA & PP [5] for perform. infill	Sand acquisition	RMA & PP for shockpad	Turf carpet production	Perform. Infill production	Shockpad production
5.1	Acidification	mol H+ eq										
5.2	Climate change	kg CO^2 eq										
5.3	Ecotoxicity, freshwater	CTUe										
5.4	Particulate matter	Disease in.										
5.5	Eutrophication, marine	kg N eq										
5.6	Eutrophication, freshwater	kg P eq										
5.7	Eutrophication, terrestrial	mol N eq										
5.8	Human toxicity, cancer	CTUh										
5.9	Human toxicity, non-cancer	CTUh										
5.10	Ionising radiation	kBq U-235 eq										
5.11	Land use	Pt										
5.12	Ozone depletion	kg CFC11 eq										
5.13	Photochemical ozone formation	kg NMVOC eq										
5.14	Resource use, fossils	MJ										
5.15	Resource use, minerals, and metals	kg Sb eq										
5.16	Water use	m3 depriv.										

[5] RMA = raw material acquisition PP = pre-production

	Impact category	Unit	LSC 3.1	LCS 3.2	LCS3.3	LCS3.4	LCS 4.1	LCS 4.2	LCS 5.1	LCS 5.2	LCS 5.3	LCS 5.4
			S&D[6] of Turf carpet	S&D of performance infill	S&D of stabilising infill	S&D of shockpad	Installation	Operation (Use)	EOL of turf carpet	EOL of performance infill	EOL of stabilising infill	EOL of shockpad
5.17	Acidification	mol H+ eq										
5.18	Climate change	kg CO2 eq										
5.19	Ecotoxicity, freshwater	CTUe										
5.20	Particulate matter	CTUh										
5.21	Eutrophication, marine	kg N eq										
5.22	Eutrophication, freshwater	kg P eq										
5.23	Eutrophication, terrestrial	mol N eq										
5.24	Human toxicity, cancer	CTUh										
5.25	Human toxicity, non-cancer	CTUh										
5.26	Ionising radiation	kBq U-235 eq										
5.27	Land use	Pt										
5.28	Ozone depletion	kg CFC11 eq										

[6] S & D = storage and distribution

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