Methodology for calculating the Product Carbon Footprint of Refractory Products

Author and owner:
World Refractory Association
Rue Belliard 12 – 1040 Brussels, Belgium

1 Document change control history and publication

1.1 Change history

Date	Authors	Version	Remarks
01.10.2024	World Refractory Association	1.0	Version distributed via website. Please refer to landing page indicated below, to retrieve the latest version of this document.
18.12.2024	World Refractory Association	1.1	Revision of cut-off criteria and Scope 2 and Scope 3 emission factors.

1.2 Location of the document

www.worldrefractories.org

World Refractories Association
Rue Belliard 12 – 1040 Brussels
Tel: +32 2 808 38 80 – *E-mail: secretariat@worldrefractories.org*

2 Introduction and purpose of the document

This document is meant as a technical guidance to help companies of the refractory industry to calculate cradle-to-gate Product Carbon Footprints (PCF) of refractory products, by setting common rules and minimum requirements. The intention is to ensure the comparability of PCF information provided by refractory companies to their customers.

Its scope of application covers all refractories and directly physically connected materials (e.g.: steel anchors) manufactured by companies of the refractory industry; it does not cover resale products.

Its geographic scope is worldwide.

CO_2 and other greenhouse gases (GHG) defined under the 1997 Kyoto Protocol are included within the scope of this document and reported as carbon dioxide equivalents (CO_{2e}).

This document is also intended to provide default GHG emission factors for raw materials used in the refractory industry, in case primary values or more accurate secondary values are not available.

This document can be used as a reference document against which companies can have their PCF third-party reviewed.

3 Normative reference

The methodology defined in this document is based on ISO14067:2018 *Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification*, which builds on the principles and requirements of the ISO standards 14040:2006 and 14044:2006 for life cycle assessment.

In case of doubt, the wording of the ISO14067 norm is binding.

4 Terms and definitions

4.1 Carbon Footprint and greenhouse gases

Carbon dioxide equivalent (CO_2e)

The CO_2e is a unit for comparing the radiative force of a GHG to the radiative force of carbon dioxide (ISO 14067:2018).

Greenhouse gas (GHG)

A GHG is a gaseous constituent of the atmosphere that can be of natural and anthropogenic origin. GHGs absorb and emit radiation at specific wavelengths within the spectrum of infrared emitted by the earth's surface, atmosphere and clouds (ISO 14067:2018). In this document we only consider the seven greenhouse gases listed by the 1997 Kyoto protocol and the Durban protocol (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3), whether they originate from fossil or biogenic sources.

Greenhouse gas emission factor (GHG emission factor)

A GHG emission factor is a coefficient that relates activity data with GHG emissions (ISO 14067:2018).

Activity data

Activity data is the quantity of inputs and outputs of the product system, as measured directly or collected from accounting and records.

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Product Carbon footprint (PCF)
This term describes the sum of all greenhouse gas emissions (GHG emissions) in a defined product system, expressed in CO_2 equivalents (CO_2e). The PCF is based on a (partial) life cycle assessment, using the single impact category climate change (ISO 14067:2018).

Product category
A product category describes a group of products that can fulfil equivalent functions (ISO 14067:2018).

Scope 1 direct CO_2e emissions
Scope 1 direct CO2e emissions result from production processes that are owned or controlled by the reporting company.

Scope 2 CO_2e indirect emissions
Scope 2 CO_2e emissions result from the generation of purchased energy such as electricity and steam.

Scope 3 upstream indirect CO_2e emissions
Scope 3 upstream CO_2e emissions include the CO_2e emissions from the following indirect sources:

- purchased goods and services
- capital goods
- fuel and energy related activities not included in scope 1 or scope 2
- upstream transportation and distribution
- waste generated in operations
- business travel
- employee commuting
- upstream leased assets

PCF study
A PCF study summarises all data (or link to data sources) assumptions, quality checks and calculation undertaken to report a PCF.

4.2 Product systems, products, and processes

Product system
A product system describes a collection of unit processes with elementary and product flows. A product system performs one or more defined functions and models the life cycle of a product (ISO 14067:2018).

System boundary
The system boundary is based on a set of criteria that define which unit processes are part of the system under study (ISO 14067:2018).

Process
A Process is a set of interrelated or interacting activities that transform inputs into outputs (ISO 14067:2018).

Unit process
A unit process represents the smallest element considered in the life cycle analysis for which input, and output data are collected and quantified (ISO 14067:2018).

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Reference year
The reference year describes the valid reference period of the activity data, GHG emission factors and PCF calculations.

Declared unit
The declared unit represent the quantity of a product for use as a reference unit in the quantification of a PCF (ISO 14067:2018).

Elementary flow
An elementary flow is a material or energy entering/leaving the studied system that has been drawn from the environment without previous human transformation/which is released to the environment without subsequent human transformation (ISO 14067:2018).

Product Group
A product Group is a group of products, which share comparable production processes and raw material compositions and have a product carbon footprint within defined tolerances.

Representative Product
A Representative Product is a virtual product which can be defined within a Product Group, by determining the weighted average properties (raw materials composition and process parameters) of all products of the Product Group on single site or on multiple site level.

4.3 Materials

Input materials
Material entering the product system, including primary raw material, secondary raw materials, additives, packing material.

Primary (juvenile/virgin) raw material
Raw material that has been extracted directly from nature, and potentially subsequently processed, and is used as an input into the product system.

Secondary raw material (circular/recycled material)
Material that has been reclaimed and potentially reprocessed after it was used by a third party and is used as an input into the product system.

Additives
Material, mostly non ceramic, used to adjust properties of final products.

Packing material
Plastic, cardboard, wood and the like to cover and protect goods.

Scrap
Material that is generated within the production process and is removed from the production process at any stage because specifications are not met or residual material from the production process (e.g.: filter dust).
Scrap can be divided into three categories: recycled scrap, by-product, waste.

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Recycled Scrap
Scrap which is reused within the boundaries of the product system in lieu of primary raw material, possibly following some processing.

By-product
Scrap that will be sent outside the system boundaries of the reporting company for usage by a third party as a secondary material, possibly following some processing.

Waste
Scrap that will be sent outside the boundaries of the reporting company for disposal. Waste can be disposed of either by landfilling or further processing (eg: incineration)

Table 1 Material flow terms

Movement	Upstream	In the system boundary	Downstream
From supplier to system boundary	Primary raw material, Secondary raw material, additives from suppliers	To be used as input material	
Remains in the system boundary		Scrap, internal used: Recycled Scrap	
From system boundary to downstream application		Scrap, sent out for alternative use	by-product
		Scrap, sent outside for disposal	waste

4.4 Data

Primary data
Primary data describes process or activity data which is obtained from direct measurement, or a calculation based on direct measurements (ISO 14067:2018).
Primary data shall not necessarily originate from the studied product system, because it might relate to a different but comparable product system.

Site-specific data
Site specific data describes primary data which is obtained within the product system (ISO 14067:2018).

Secondary data
Secondary data describes data sources which do not fulfil the requirements for primary data. This can include data from databases and/or published literature, default GHG emission factors from national inventories, calculated data, estimates or other representative validated data (ISO 14067:2018).

Cut-off criteria
The cut-off criteria represent the amount of material or energy flow or the level of significance of GHG emissions associated with unit processes or the product system to be excluded from a PCF study (ISO 14067:2018).

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Rue Belliard 12 – 1040 Brussels
Tel: +32 2 808 38 80 – *E-mail: secretariat@worldrefractories.org*

5 Methodological principles, scope and requirements

5.1 Principles

When preparing a PCF, companies shall adopt the following principles, in accordance with ISO 14067:2018.

- Life cycle perspective
- Relative approach and functional and declared unit
- Relevance
- Completeness
- Consistency
- Coherence
- Accuracy
- Transparency
- Priority of scientific approach

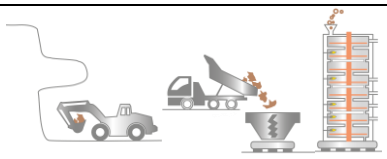
5.2 Declared unit definition

The declared unit for which the PCF of a product system is calculated shall be kg (or tonne, or any multiple of kg) finished product, at factory gate. If the finished product includes some non-refractory components, these shall be included. The declared unit is independent on the production characteristics in terms of geometrical characteristics.
Alternatively, or additionally, the declared unit for which the PCF of a product system is calculated may be the commercial unit of measure (e. g. piece or volume of product).

The PCF shall be calculated as kg CO2e per declared unit.

5.3 System and boundaries

The cradle-to-gate PCF shall include the GHG emissions, expressed as CO2e, from the extraction of the input raw material up to production of the final product, at factory gate. It shall include all product related direct GHG emissions, from Scopes 1, 2 and 3 upstream.
In consequence, the GHG emissions from the following activities shall be included, as described in Table 2.
Table 2 Activities included in this methodology

Activity	Memo	Scope	For illustration
Input materials	From Ore extraction to final treatment (all input materials to the final article, including e.g. steel)	Scope 3, upstream	
Upstream transportation	Complete transport chain of raw materials from mine to refractory producer	Scope 3, upstream	

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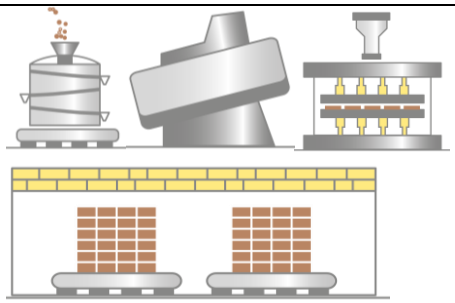
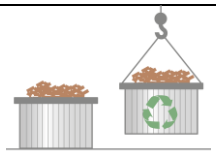
	via processing or indirect suppliers		
Manufacturing	Mechanical and/or thermal treatment	Scope 1 or 2	
Site-to-site transportation	Transport within the reporting company	Scope 1	
Fuel and energy related activities	Emissions related to production of energy carriers	Scope 3	
Waste disposal / treatment	All kind of process or manufacturing related solid or liquid waste	Scope 3	
Treatment of Secondary raw material (recycled material)	Any kind of emissions related to ensure suitability of recycled raw materials	Scope 3	

5.4 Exclusions

All other scope 3 streams from GHG protocol / ISO 14067, not mentioned above, may be excluded (e.g. Capital goods / infrastructure, Employee commuting / business travel)

The GHG emissions related to packing of input materials and finished products may be excluded.

5.5 Carbon removals

If carbon capture and storage technologies are used within the system boundaries, only the remaining greenhouse gas emissions to the atmosphere are included in the PCF calculations.

Carbon credits and offsets cannot be considered in the PCF calculations.

6 Data requirements

6.1 General principles applying to activity data and emission factors

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Table 3 general requirements applicable to data

Geographical representativeness	Activity data and GHG emission factors shall be representative for all sites relevant for the product under study.
Technological representativeness	Specific (actual) technology from the production plants for product under study shall be selected.
Temporal representativeness	The activity data considered should cover at least 12 calendar months to avoid seasonal changes and not be older than 3 years, GHG emission factors shall be taken from the most recent sources and checked for updates at maximum every 3 years.
Consistency	Activity data: A minimum of consistency and justification will have to be ensured by checking for 15% deviation from the previous year's activity data. In case of a greater deviation, a justifying comment shall be provided.
Completeness	See cut-off criteria (chapter Cut-off criteria7).
Reliability	Activity data shall be based on measurements of actual and site-specific data.
Precision	Activity data, GHG emission factors and calculations shall be internally verified for plausibility.

6.2 Activity data quality requirements

Collect primary (company-specific) activity data via a bottom-up approach and for each manufacturing site.

6.3 Scope 1 GHG emission factors

High quality GHG emission factors shall be used.

6.3.1 Handling of biogenic materials

The balance of emissions and removals (from the atmosphere by photosynthesis) shall be used as a conversion factor in the PCF calculation. The gross amount of emissions and removals from biogenic sources shall be included in the PCF study.

6.4 Scope 2 GHG emission factors data quality requirements

If supplier-specific data for Scope 2 GHG emission factors of external energy supply (also referred to as market-based GHG emission factors) for the reference period is available, it should be used. If supplier-specific data is not available, country electricity grid emission factors (also referred to as location-based factors) should be used. Country electricity grid emission factors are published annually by the International Energy Agency

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Rue Belliard 12 – 1040 Brussels
Tel: +32 2 808 38 80 – *E-mail: secretariat@worldrefractories.org*

6.5 Scope 3 data quality requirements

6.5.1 Input materials

GHG emission factors, Hierarchy of sources

If 3rd party verified supplier specific GHG emission factors are available, they shall be used. If not, 3rd party verified, the supplier specific GHG emission factors shall be assessed for plausibility versus WRA emission factors in particular.

If supplier specific GHG emission factors are not available or are deemed unreliable then the default figures provided by the World Refractory Association can be used, or alternative figures if they originated from reputable sources and they are assessed to be more accurate.

Similar range GHG emission factors (simplification of emission factors)

If it can be demonstrated that various raw materials have similar range of emission factors, an average PCF value can be used.

If a raw material is supplied from multiple sources, a weighted average PCF can be calculated from the PCF of the different sources based on the tonnage consumed from each source.

6.5.2 Upstream transportation

Activity data

Actual transport mode (lorry, train, barge, sea freight etc) and actual transport distances should be used. If, however, the effort to collect such information is excessive, individual and average transport distances and mode should be estimated.

GHG emission factors, hierarchy of sources

If supplier-specific transport GHG emission factors are available, it should be used.

If supplier-specific GHG emission factors are not or only partially available, GHG emission factors from specialist or official sources (e.g., EcoTransIT, Sphera/GaBi, Ecoinvent) shall be used.

Average transport GHG emission factor (simplification of transport emissions)

If specific data is not available or its use is impractical, the average GHG emission factor from upstream transportation (total GHG emissions from upstream transportation divided by the total tonnage of raw materials) shall be calculated.

6.5.3 Indirect emissions of fuels

Indirect emissions of fuels (classified as “fuel and energy related activities” in the GHG Protocol) must be included in the PCF calculations.

7 Cut-off criteria

The PCF activity data collection shall aim for completeness – a closed mass and energy balance – and avoid cut-offs altogether. However, no undue effort should be spent on

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Rue Belliard 12 – 1040 Brussels
Tel: +32 2 808 38 80 – *E-mail: secretariat@worldrefractories.org*

developing data of negligible significance concerning GHG Cut-offs may become useful in cases where no data are available, where elementary flows are very small, or where the level of effort required to close data gaps and to achieve an acceptable result becomes prohibitive.

1. Include all material inputs that have:
    a. a cumulative total of at least 95% of the total mass inputs to the unit process, leaving out only small volume additives (less than 1% each in weight).
    b. or contributing to a minimum of 95% of the declared PCF impact leaving out only materials with an impact of less than 1% each on the total material PCF (not including processes that are explicitly outside the system boundary).
2. Include all energy inputs that have a:
    a. Cumulative total of at least 95% of total energy inputs to the unit process
    b. or contributing to a minimum of 95% of the declared GHG emissions impact (not including processes that are explicitly outside the system boundary).

The World Refractory Association's list of default GHG emission factors can be used to evaluate contributions to the CO2 impacts and determine cut off limits.

8 Allocation rules

8.1 General principle

Except for the application of cut-off criteria, allocation methods employed must ensure that all GHG emissions from the inputs into the product system are assigned to the finished goods (product system's outputs).

8.2 Raw material and energy inputs

The following stepwise procedure shall be applied for multifunctional products and multiproduct processes:

1. Allocations shall be avoided, if possible, by dividing the unit process into two or more sub-processes and collecting the data related to these sub-processes.
2. If allocation cannot be avoided, the inputs and outputs of the system shall be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them (e.g. weight). This means that they should reflect the way in which the inputs and outputs are changed by quantitative changes in the products or functions delivered by the system.
3. Where physical relationships alone cannot be established or used as the basis for allocation (or they are too time consuming), the most suitable allocation procedure shall be used and documented. Unless a more appropriate allocation procedure is justified, an allocation procedure based on mass shall be applied.

8.3 GHG emission factors - Secondary raw material

Secondary raw materials entering the product system are considered to have a GHG emission factor of 0.

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The emissions associated with the transportation and re-processing of secondary raw materials shall be included.

8.4 Waste

No emissions shall be allocated to waste (ceramic and non-ceramic) generated in the process and leaving the system boundaries.

CO2 emissions from any process before landfilling (e.g. incineration) shall be allocated to the products according to their mass.

CO2 emissions from the transportation of waste may be ignored.

8.5 By-product

No emissions shall be allocated to by-products generated in the process and leaving the system boundaries.

CO2 emissions from the transportation of by-products may be ignored.

8.6 Recycled scrap

Two options are available for the allocation of GHG emissions to recycled scrap.

1) allocate GHG emissions using the cut-off method:
   - All emissions are allocated to the finished product coming out of the product system
   - No emissions are allocated to the scrap generated in the product system, and
   - A GHG emission factor of zero is applied to recycled scrap used in products.

2) Allocate GHG emissions using the mass allocation method:
   - Emissions are allocated between the main product and the scrap to be recycled based on their mass share in the total output over a period of at least one year (no emissions allocated to scrap that is not recycled)
   - Recycled scrap used in products will be assigned the GHG emission factor coming out of the above calculation.

Companies may choose the most practical option.

9 Product Carbon Footprint calculations

9.1 Input material quantity calculation

The quantity of input materials to be considered in the PCF can be determined either through direct measurement, via a mass balance calculation or from the product's bill of materials. The most accurate method practically available should be preferred.

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9.2 PCF calculation within a Product Group

Preferably, specific PCF calculations should be carried out for each product within a Product Group, using product-specific input and output data.

Alternatively, a Representative Product can be defined for the Product Group, and its Product Carbon Footprint can be calculated. If following a sensitivity analysis, all products within the Product Group are found to have a PCF within 15% of the PCF or the representative product, all products within the Product Group can be assigned the same PCF. The following conditions must be met:

- All products within the Product Group must undergo very similar energy intensive manufacturing processes.
- The recipe of the representative product shall be the weighted average of the recipes of all products included in the Product Group. It may be an existing product or a virtual one.
- The sensitivity analysis shall contain:
    - a) the PCF calculation of the representative product and
    - b) demonstration of the compliance with the 15% threshold, via the PCF calculation of the two existing products within the Product Group:
        - with the lowest and highest content of the raw materials with the highest raw materials emission factor
        - or with the highest and lowest PCF.

9.3 PCF calculation for a product manufactured in multiple sites

If a product is manufactured in multiple sites, a single PCF covering a) single, b) all sites in a geographic area or c) worldwide can be calculated.
The PCF of a multi-site product shall be calculated either as the weighted average of the PCF of products manufactured in each site or using the weighted averages of inputs and outputs of each site.

Alternatively, a Reference Site can be defined for any product. The Refence Site shall be the one with the Product's highest annual output or its choice shall be justified. If following a sensitivity analysis, all products manufactured in multiple locations are found to have a PCF within 15% of the PCF or the Reference Site, all products can be assigned the same PCF. The following conditions must be met:

- All sites must have comparable manufacturing processes.
- The sensitivity analysis shall contain
    - a) the PCF calculation of the reference site and
    - b) PCF calculations demonstrating the compliance with the 15% threshold of all other participating sites.

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9.4 PCF calculation for a product group manufactured in multiple sites

If a product group is manufactured in multiple sites, a single PCF covering all selected sites and products can be calculated.

The rules defined in paragraphs 9.2 and 9.3 can be combined. The sensitivity analysis requirements of paragraphs 9.2 and 9.3 will be applicable to each product within the multi-site product group.

10 PCF documentation

The PCF study or general documentation will include at least following information:

- Declared unit.
- Total GHG emissions (of fossil and biogenic sources). The quantity of biogenic emissions may be included as a comment.
- Main process steps in which GHG emissions occur, and their absolute and relative contribution to the total.
- The selected cut-off criteria and cut-offs, and relevant calculation to justify their applicability.
- The selected allocation methods.
- Description of data and data quality (especially for secondary data).
- Market-based or location-based approach for electricity related GHG emissions
- Reference year, time period for which the PCF is representative.

11 Certification

It is recommended that companies seek external certification against this document for at least one product, to ascertain that the applied methodology meets the requirements of this document.

The study shall include:

- All GHG emission factors used,
- the results of the consistency analysis and comments in case of deviation
- at least a summary of a test report stating the scope of the test and the result.

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Rue Belliard 12 – 1040 Brussels
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12 Appendix: World Refractories Association list of default GHG emission factors.

12.1 Change History

Date	Authors	Version	Remarks
01.11.2024	World Refractory Association	1.0	Version distributed via website. Please refer to landing page indicated below, to retrieve the latest version of this document.

12.2 Objective and Determination of the Factors

The raw material-specific GHG emission factors provided in this document are based on the values determined to date by the companies involved in the document “Methology for Calculating the Product Carbon Footprint of Refractory Products”.

The GHG emission factors shall be used to calculate the Product Carbon Footprint of refractory products. These values are considered to be “fall back values” meaning that the given values were viewed conservatively. If one or more raw materials have their own GHG emission factor verified by the manufacturer and/or supplier, these should be used in the calculation of the refractory product carbon footprint.

12.3 Quality classification

In the case of poor data quality but the perceived need to provide a value, the addition “More data required” is assigned.

Disclaimer

These values have been compiled and checked to the best of our knowledge using external and internal sources. However, no guarantee is given for their accuracy.

12.4 GHG Emissions Factors for Transportation

The publicly available compilation of the non-profit organization NTM (Network for Transport Measures) can be used to estimate the GHG emissions caused by the transport of raw materials.

GHG emission factors can be accessed at:
https://www.transportmeasures.org/en/wiki/evaluation-transport-suppliers/

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12.5 Indirect Fuel Emissions

Besides the direct emissions when burning any kind of fuel (Scope 1), indirect emissions are being created when producing and transporting these fuels (Scope 3), so called WTT emissions ("well to tank"). The overall CO_{2e} emissions for any kind of fuel are calculated via:

e.g.: Natural Gas: $PCF(\text{Natural Gas})_{total} = PCF(\text{Natural Gas})_{Scope\ 1} + PCF(\text{Natural Gas})_{Scope\ 3}$

Fall back values of these Scope 1 and 3 emissions of commonly used fuels are given here:

ghg-conversion-factors-2024-full_set__for_advanced_users__v1_1.xlsx

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Rue Belliard 12 – 1040 Brussels
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12.6 GHG Emission Factors

Category	Group	Subgroup	PCF in kg CO2e/kg product	Comment
Alumina	**High alumina (>90%)**	Tabular	**1.5**	
		Brown fused	**2.0**	
		White fused	**3.0**	
		Hydrate	**0.6**	
		Calcined	**1.3**	
		Reactive	**1.9**	
	Medium alumina (70-90%)	Bauxite rotary calcined	**0.8**	More Data Required
		Bauxite shaft calcined	**0.7**	
		High alumina chamotte	**0.7**	More Data Required
	Alumina compound	Spinel sintered	**1.3**	
		Spinel fused	**3.0**	
		Zirconia alumina	**5.8**	More Data Required
		Zircon mullite	**1.7**	More Data Required
	Alumina silicate not calcined	Andalusite	**0.5**	
		Kyanite	**0.5**	
		Sillimanite	**0.1**	
		Pyrophyllite	**0.1**	
		Mica	**0.1**	
		Bentonite	**0.2**	
		Clay	**0.2**	
	Alumina silicate calcined	Sintermullit, Chamotte (55 to 69%)	**1.2**	
		Chamotte (40 to 54%)	**0.7**	

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Magnesia	**Fused Magnesia (>96%)**	FM	**4.0**	
	DBM (Dead Burn Magnesia, >89%)	DBM shaft kiln	**2.5**	
		DBM < 95 % MgO	**1.8**	
		DBM > 95 % MgO	**2.5**	
		DBM sea water (> 98 % MgO)	**2.5**	
	Magnesia compounds	Magnesia Chrome oxyde, fused	**2.5**	More Data Required
	CCM (Caustic Calcined Magnesia)		**1.6**	
	Hydrate		**0.5**	More Data Required
	Magnesium silicate	Olivine Fosterite Periclase Talc Cordierite Sepiolite Basalt	**0.1**	
		Olivine fired	**0.6**	More Data Required
	Magnesium calcium (Dolomite)	Raw dolomite	**0.1**	
		Dead Burnt dolomite	**2.0**	
Zirconia	**Zirconium silicate**		**0.1**	More Data Required
		Monoclinic	**10.3**	
		Calcia stabilized	**14.3**	
	Zirconia compounds	Zirconia alumina fused	**12.7**	
		Zirconia mullite fused	**2.0**	
Solvents	**Alcohol**	Ethanol, Methanol, IPA (Isopropyle alcohol), Glycerol	**0.7**	
	Aldehyde	Furfuraldehyde	**0.6**	
	Esters	Dibasics esters	**2.4**	
	Aromatic Hydrocarbon	Aromatic Hydrocarbon Solvent, Other aromatics - NES*	**1.0**	More Data Required
	Aliphatic hydrocarbon solvent	Hexane, Heptane, white spirit, Other aliphatics - NES*	**1.0**	More Data Required

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	Ether	Ethylene glycol phenyl ether	**1.0**	More Data Required
Metals	**Aluminum**	Aluminum virgin powder and granules	**21.6**	
		Aluminum recycled	**0.8**	
	Silicium	Powder	**15.9**	More Data Required
	Ferrosilicon	Powder	**5.0**	More Data Required
	Ferro-alloys (excluding ferrosilicon)	Powder	**5.0**	More Data Required
	Platinum & Rhodium	Wire	**80000**	
Resin	**Phenolic Resin**		**4.5**	
	Non Phenolic Resin		**4.5**	
	Natural Resin		**0.1**	
Fibers	**Metallic fibers**	Stainless steel	**5.2**	
		Carbon steel	**2.0**	
		Aluminum	**21.6**	
	Polymer	Polypropylene, PET, Polyester, PVA, and others	**3.6**	
	Shaped Ceramics	Dense Alumina	**3.0**	
		Alumina silicate	**1.7**	
		Silica magnesia	**1.6**	
		Glass	**1.4**	
		Calcium silicate	**1.0**	
		Ceramic paper	**2.5**	
	Natural (wood or plant based excl. paper)	Wood, cellulose	**0.3**	
	Carbon		**2.3**	

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	Paper recycling based		**0.3**	
Silica	**Quartz**	Sand	**0.1**	
	Fused		**1.4**	
	Silica fume (low purity/by-product)		**0.1**	
	Silica fume (high purity/processed product)		**3.9**	
	Colloidal silica	water glass	**0.9**	
Sodium, Potassium compounds			**5.0**	More Data Required
Graphite	**Graphite solutions**	Graphite colloidal	**0.4**	
	Graphite flake	Graphite flake natural	**0.4**	
		Graphite flake synthetic	**3.1**	
	Other Graphites natural		**0.4**	
	Other graphite synthetic		**3.1**	
Carbon	**Carbon Powder**	Carbon Black	**2.3**	
		Coke	**2.6**	
		Coal	**0.5**	
		Charcoal	**2.8**	
		Petroleum Coke	**0.7**	
	Tar & Pitch	Coal pitch	**0.7**	
		Synthetic pitch	**0.7**	
		Petroleum pitch	**0.7**	
Lightweight fillers (except alumina and silica bubbles/spheres)	**Fly Ash derivatives**	Fly ash/ Floaters	**0.1**	
		Cenosphere	**3.0**	
	Rice Husk		**0.1**	
	Perlite, expanded		**0.7**	

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	Diatomaceous Earth - Diatomite - Kieselguhr		**0.4**	
	Vermiculite		**0.4**	
	Alag (Alumina + Calcia)		**0.7**	
	EFG (Slica + Alumina)		**0.7**	
	Nutshell powder		**0.1**	
Silicon compounds (excluding silica)	**Carbide >85%**		**7.3**	
	Ferrosilicon nitride		**7**	More Data Required
Foam	**Polyester Polyol**		**3.6**	
Mineral Oils	**Liquid, paste or solid (at room temp)**	light fuel oil	**1**	
Cement		Rotary kiln clinker	**1.5**	
		Cement with additives	**1.1**	
		Cement portland	**0.9**	
	Spinel cement		**1.5**	
Glass/Glaze Powders	**Frit**		**1.4**	
Zircon			**1.1**	
Iron compounds	**Iron Oxide**		**0.1**	
	Iron Sillicate		**0.1**	
Mica	**Dry**		**0.1**	
	Wet		**0.5**	
Cellulose products & Lignosulphonates	**Lignosulphonate, Cellulose (Sodium carboxy methyl, Methyl, Hydroxy Propyl) - Powders**		**0.4**	
	Wheat Flour		**0.1**	

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Chrome compounds	**Chrome sand**	**0.1**	
	Chromium oxide	**6**	
Inorganic chemicals (Acetate, Nitrate, Fluoride, Stearate, Sulphate, Sulfur, Chloride, Carbonate, Phosphate, oxyde (not listed alsewhere)		**1.0**	More Data Required
Surfactants, Foaming agents, Antifoaming agents, Dispersants		**1.0**	More Data Required
Polymers and Plastics (Vinyl, Acrylic and others polymers)		**3.6**	More Data Required
Sugars and starches		**1**	
Boron compounds	**Borax**	**2**	
Feldspar	**Feldspar**	**0.1**	
Silicates, Not Clay	**Wollastonite**	**0.7**	
	Olivine	**0.1**	
	Olivine Fired	**0.7**	
	Pumice	**0.1**	
Acids	**Inorganic**	**0.1**	
	Organic	**10**	More Data Required
Biocides		**10**	
Organic Pigments		**10**	
Wax	**Bee Waxes**	**0.1**	
	Paraffin Wax	**0.7**	
Other organic chemicals		**10**	

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12.7 Remarks

If you are aware of more precise raw material GHG emission factors, please contact the WRA so that these can be included in the next version of this document.

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