Financed by:

Iceland Liechtenstein Norway grants

Programme operator:

REPÚBLICA PORTUGUESA
AMBIENTE E AÇÃO CLIMÁTICA

Promotor:

SMART WASTE PORTUGAL
BUSINESS DEVELOPMENT NETWORK

CIRCULAR BUILDINGS

Demonstration Report

Partners:

3drivers engenharia inovação ambiente

U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Plataforma Tecnológica Portuguesa da Construção

[intentionally left blank]

TECHNICAL INFORMATION

Title

Circular Buildings – Demonstration Report

Promotor

Associação Smart Waste Portugal

Partners

3drivers – Engenharia, Inovação e Ambiente, Lda.

Faculdade de Engenharia da Universidade do Porto

Plataforma Tecnológica Portuguesa da Construção

Edition

Final Version – September 2021

Disclaimer: The content of this document is the responsibility of its authors, and the conclusions expressed may not necessarily coincide with the official position of EEA Grants.

[intentionally left blank]

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 SCOPE AND OBJECTIVES

The Circular Buildings project, funded by EEA grants under the Environment, Climate Change and Low Carbon Economy Programme, sought to increase the application of circular economy principles in the construction sector through the development of decision support tools directed at stakeholders in the value chain, which promote an increase in the reuse of materials and a reduction in the production of waste. Three guidelines were developed within the project, namely the "Guideline for improving efficiency indicators of circular buildings", the "Guideline for promoting circularity in Environmental Product Declarations" and the "Guideline for creating Circular Materials Passports". Additionally, a tool was developed to estimate the environmental and economic impacts associated with the end-of-life of materials and products from a construction project and the corresponding waste treatment.

A construction project of the remodelling and expansion of the elementary school *Dr. Flávio Gonçalves II* (Figure 1) in the municipality of Póvoa de Varzim was selected in order to demonstrate the tools developed in the Circular Buildings project. The construction project, which started early in 2021, and will be concluded in September, involves the requalification and modernization of the school buildings, as well as the requalification of exterior spaces.

Figure 1: Depiction of elementary school Dr. Flávio Gonçalves
Source: Municipality of Póvoa de Varzim, 2021

The demonstration part of the Circular Buildings project had the following objectives:

- To implement the calculation tool that assesses the environmental and economic impacts associated with the reuse and recovery of materials in the construction project and waste treatment.
- To characterize the environmental performance and the reuse and recovery potential of a construction product, through a Circular Material Passport and an EPD[1].

In order to carry out the demonstration activities, information about the waste management of the construction project was requested, namely, a map of quantities[2], the CDW management plan and CDW

[1] The "Guideline for improving efficiency indicators of circular buildings" was not applicable within the scope of the demonstration project given the time it would require a robust and reliable calculation of the efficiency indicators of the building.
[2] Map in which the construction works to be developed are defined and quantified.

production registration. Based on the provided information, the project team decided to study the ceramic tile product from CINCA, which is used for flooring in the school project, since it was the most adequate option for the study object of the demonstration of the Circular Material Passport and EPD tools.

2 DEMONSTRATION OF GUIDELINES

Two of the developed guidelines from the Circular Buildings project are meant to be applied at the product level: the “Guideline for creating Circular Materials Passports” and the “Guideline for promoting circularity in Environmental Product Declarations”. The use of these guidelines is, therefore, demonstrated through a case study selected from the set of new construction products to be installed in the school project, namely the ceramic tiles from the product line “Adamastor” from the Portuguese manufacturer Cinca, S.A. (Figure 2).

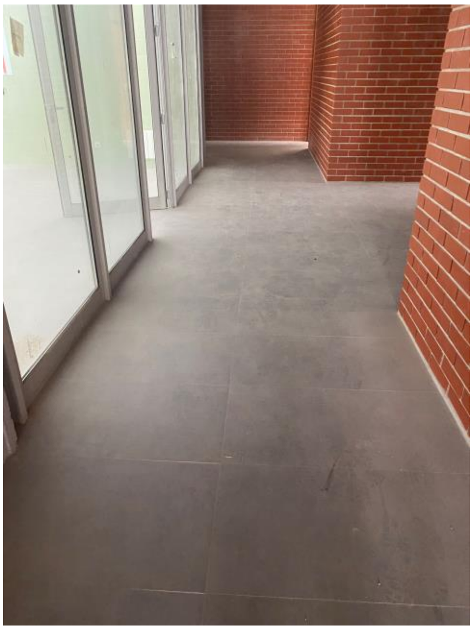


Figure 2: Adamastor ceramic tiles installed in the demonstration project of the school
Source: Taken by project team at site, 2021

It is important to note that the technical specifications of the tiles were provided by the company responsible for the school renovation and not by the producer. There was no environmental information available for the specific tile used in the project, therefore, it was necessary to resort to existing Environmental Product Declarations (EPD) from the Portuguese DAP Habitat programme for similar types of ceramic tiles as a data source. The following two existing EPDs were selected for this purpose:

- DAP 004:2019 for Porous body ceramic tiles from Pavigrés Cerâmicas, S.A.
- DAP 001:2021 for Porcelain stoneware (in Portuguese: *Grés Porcelânico*) from Grés Panaria Portugal, S.A.

2.1 DEMONSTRATION OF GUIDELINE FOR CREATING CIRCULAR MATERIALS PASSPORTS

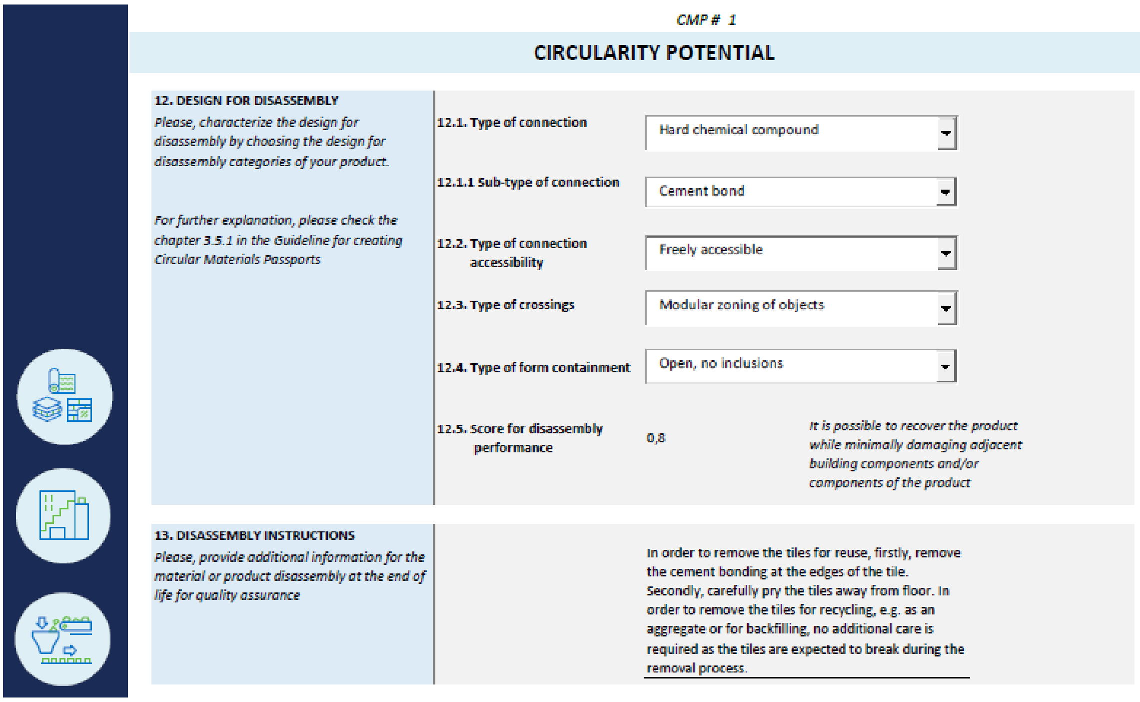
Given the significant environmental impacts of the construction sector, especially from raw materials extraction, it is essential to increase resource efficiency, minimise construction and demolition waste (CDW) production and promote the transition to a Circular Economy. In order to achieve these objectives, it is important to resort to reliable and standardised information on the material composition of the building stock and related products. This information can be obtained through digital tools, such as material passports. Material passports were identified by several entities, at the EU and national level, as a valuable tool to increase circularity in the construction sector.

In the Circular Buildings project, a guideline for creating Circular Materials Passports (CMP) was developed which aims to define the structure of a circular material passport and to provide a robust methodology for characterizing the circularity of construction products, thereby promoting this tool among the stakeholders in the construction sector. The guideline, therefore, intends to address the need for clear and standardized orientations for the creation and implementation of materials passports.

The proposed structured of the CMP that is presented in the respective guideline, was also implemented in an MS Excel template, which is publicly available on the project's website. In order to demonstrate the CMP's proposal, a mock CMP of the "Adamastor" ceramic tiles from the Portuguese manufacturer Cinca, S.A. was generated, using the aforementioned template. The resulting CMP provides information about the circularity potential of the ceramic tiles used in the construction project of the elementary school, based on average market data.

When analysing the mock CMP (Annex I), the user can understand how the circularity potential was assessed for that specific product, namely when it comes to its design for disassembly (Figure 3).

The objective of this demonstration is to provide the reader with a complete example of the CMP, as defined within the Circular Buildings project, and to exemplify how the fields should be filled out. Again, it must be stressed that this is a mock CMP and the information included should not be taken as representative.



CMP # 1

CIRCULARITY POTENTIAL

12. DESIGN FOR DISASSEMBLY
Please, characterize the design for disassembly by choosing the design for disassembly categories of your product.

For further explanation, please check the chapter 3.5.1 in the Guideline for creating Circular Materials Passports

12.1. Type of connection	Hard chemical compound
12.1.1 Sub-type of connection	Cement bond
12.2. Type of connection accessibility	Freely accessible
12.3. Type of crossings	Modular zoning of objects
12.4. Type of form containment	Open, no inclusions
12.5. Score for disassembly performance	0,8 — *It is possible to recover the product while minimally damaging adjacent building components and/or components of the product*

13. DISASSEMBLY INSTRUCTIONS
Please, provide additional information for the material or product disassembly at the end of life for quality assurance

In order to remove the tiles for reuse, firstly, remove the cement bonding at the edges of the tile. Secondly, carefully pry the tiles away from floor. In order to remove the tiles for recycling, e.g. as an aggregate or for backfilling, no additional care is required as the tiles are expected to break during the removal process.

Figure 3: Excerpt from the Circularity Potential section of the mock CMP (in Annex I)

2.2 DEMONSTRATION OF GUIDELINE FOR PROMOTING CIRCULARITY IN ENVIRONMENTAL PRODUCT DECLARATIONS

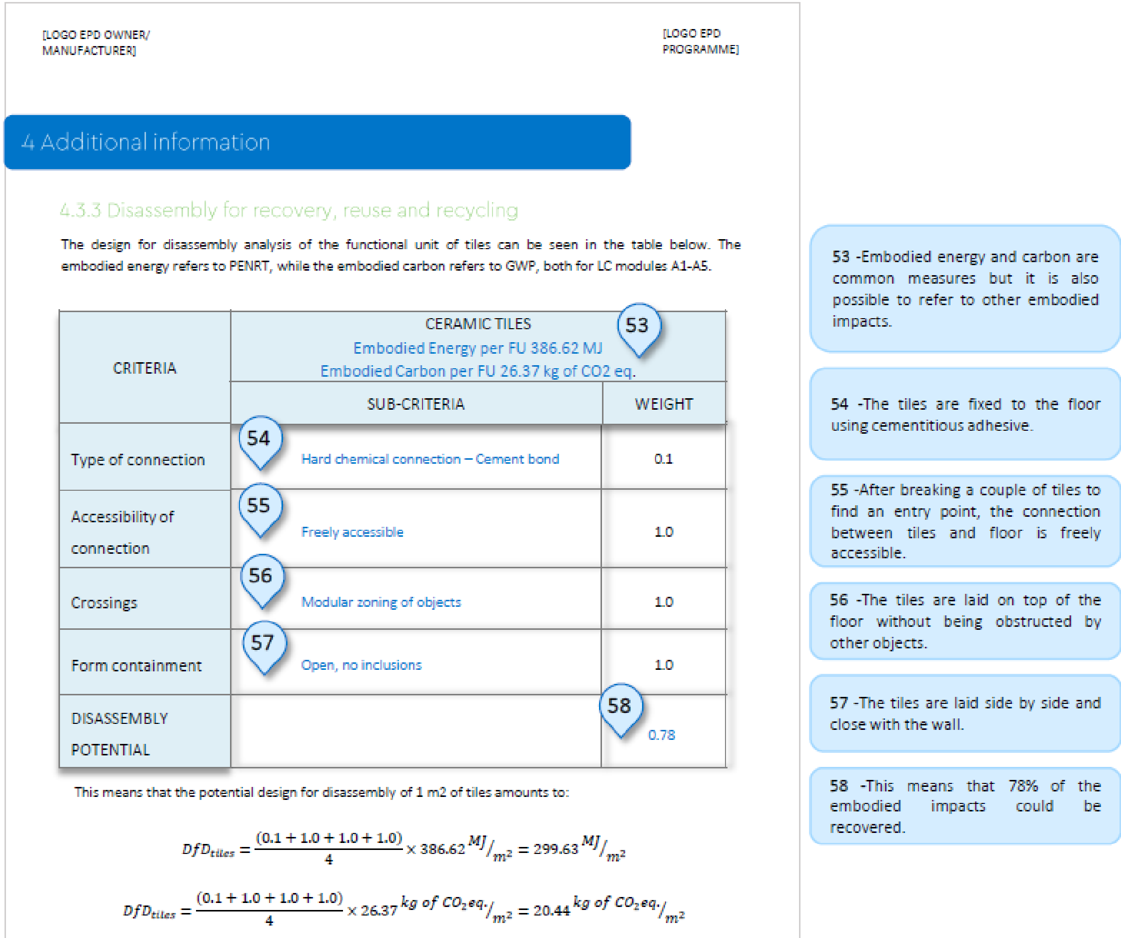
Standardized documents such as Environmental Product Declarations (EPD) are important to analyse and compare the environmental performance of products in a transparent manner. EPD allow to include information concerning products' end-of-life in modules C and D, however, the information is currently not mandatory. When it comes to construction products specifically, there are very few cases which include this information.

In the Circular Buildings project, a guideline for promoting circularity in Environmental Product Declarations was developed to provide an overview of the aim and scope of EPD for construction products, as well as providing recommendations for integrating circularity measures in EPD to enhance the recovery, reuse and recycling of construction products, thereby reducing the associated environmental impacts.

The guideline aims to promote circular construction through an improved understanding of EPD and their integral opportunities to quantify and qualify circularity measures together with manufacturers of building products and their consumers and to LCA practitioners.

The guideline was demonstrated in a practical example to help achieve its objectives. A mock EPD was developed for ceramic tiles to provide further information on how to prepare a product EPD, and to illustrate the recommendations from the EPD guideline. The mock EPD does not have any validity, nor is it registered under an EPD programme. The resulting document shows the mock EPD, page by page, with additional annotations in light blue bubbles on the right side. The objective of this demonstration is to have a straight-forward and easy-to-understand guiding document that leads the reader through the different sections of an EPD, based on the requirements from the relevant Product Category Rules (Dias *et al.* 2020).

The user can then analyse the EPD, presented in Annex II, by following the annotations in blue, which further explain the sections of the EPD (Figure 4). Special attention should be paid to the Additional Information section in which information about the ceramic tiles' end-of-life scenarios and circularity indicator is detailed.



[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

4 Additional information

4.3.3 Disassembly for recovery, reuse and recycling

The design for disassembly analysis of the functional unit of tiles can be seen in the table below. The embodied energy refers to PENRT, while the embodied carbon refers to GWP, both for LC modules A1-A5.

CRITERIA	CERAMIC TILES Embodied Energy per FU 386.62 MJ Embodied Carbon per FU 26.37 kg of CO2 eq. (53)	
	SUB-CRITERIA	WEIGHT
Type of connection	(54) Hard chemical connection – Cement bond	0.1
Accessibility of connection	(55) Freely accessible	1.0
Crossings	(56) Modular zoning of objects	1.0
Form containment	(57) Open, no inclusions	1.0
DISASSEMBLY POTENTIAL		(58) 0.78

This means that the potential design for disassembly of 1 m2 of tiles amounts to:

$$DfD_{tiles} = \frac{(0.1 + 1.0 + 1.0 + 1.0)}{4} \times 386.62\,{}^{MJ}/_{m^2} = 299.63\,{}^{MJ}/_{m^2}$$

$$DfD_{tiles} = \frac{(0.1 + 1.0 + 1.0 + 1.0)}{4} \times 26.37\,{}^{kg\ of\ CO_2eq.}/_{m^2} = 20.44\,{}^{kg\ of\ CO_2eq.}/_{m^2}$$

53 -Embodied energy and carbon are common measures but it is also possible to refer to other embodied impacts.

54 -The tiles are fixed to the floor using cementitious adhesive.

55 -After breaking a couple of tiles to find an entry point, the connection between tiles and floor is freely accessible.

56 -The tiles are laid on top of the floor without being obstructed by other objects.

57 -The tiles are laid side by side and close with the wall.

58 -This means that 78% of the embodied impacts could be recovered.

Figure 4: Excerpt from the Disassembly for recovery, reuse and recycling section of the mock EPD (in Annex II)

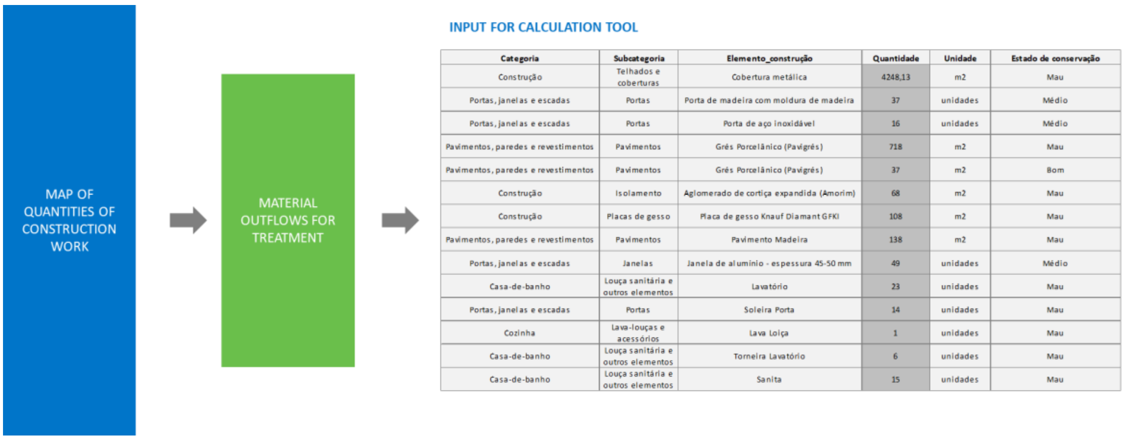
3 DEMONSTRATION OF CALCULATION TOOL

The monitoring of the construction work in the school was carried out to demonstrate the calculation tool[3]. This was done mainly through document control and site visits, to quantify the removed materials and produced waste, as well as to characterize their final treatment.

An analysis of the map of quantities, as well as the electronic waste declaration forms (e-GAR in Portuguese) was carried out to develop a material flow analysis of the removed materials, the results of which were introduced in the calculation tool as input.

3.1 MATERIAL OUTFLOWS

The analysis of the provided data in the map of quantities resulted in the characterization of the main material flows that were removed from the school to be either reused, recycled, or landfilled (Figure 5). This analysis aimed to ensure the representativeness of the material flows from the remodelling and expansion of the school, however, the analysis only considered the materials which were properly quantified in the map of quantities (includes information at product level).



Categoria	Subcategoria	Elemento_construção	Quantidade	Unidade	Estado de conservação
Construção	Telhados e coberturas	Cobertura metálica	4248,13	m2	Mau
Portas, janelas e escadas	Portas	Porta de madeira com moldura de madeira	37	unidades	Médio
Portas, janelas e escadas	Portas	Porta de aço inoxidável	16	unidades	Médio
Pavimentos, paredes e revestimentos	Pavimentos	Grés Porcelânico (Pavigrés)	718	m2	Mau
Pavimentos, paredes e revestimentos	Pavimentos	Grés Porcelânico (Pavigrés)	37	m2	Bom
Construção	Isolamento	Aglomerado de cortiça expandida (Amorim)	68	m2	Mau
Construção	Placas de gesso	Placa de gesso Knauf Diamant GFKI	108	m2	Mau
Pavimentos, paredes e revestimentos	Pavimentos	Pavimento Madeira	138	m2	Mau
Portas, janelas e escadas	Janelas	Janela de aluminio - espessura 45-50 mm	49	unidades	Médio
Casa-de-banho	Louça sanitária e outros elementos	Lavatório	23	unidades	Mau
Portas, janelas e escadas	Portas	Soleira Porta	14	unidades	Mau
Cozinha	Lava-louças e acessórios	Lava Loiça	1	unidades	Mau
Casa-de-banho	Louça sanitária e outros elementos	Torneira Lavatório	6	unidades	Mau
Casa-de-banho	Louça sanitária e outros elementos	Sanita	15	unidades	Mau

Figure 5: Data treatment process from construction project

The consolidated data was then introduced in the calculation tool as input values, resorting to the database of construction products (Table 1). This database contains the information regarding the unit weight of the products, their material composition, and the environmental and economic impacts which are associated to their possible end-of-life destinations, namely, reuse, recycling, and landfill[4].

[3] Calculation tool is in Portuguese. English version will be made available.
[4] The methodology for the calculation of these impacts is further explained in the Calculation Tool's Methodology Note, available at the project's website

Table 1: Main material outflows of demonstration project

Construction product	Quantity	Unit	Destination
Metal cover	4 248	m^2	Landfill
Wooden doors	37	units	Landfill
Metal doors	16	units	Landfill
Ceramic tiles	718	m^2	Landfill
Ceramic tiles	37	m^2	Reuse
Agglomerate of expanded cork	68	m^2	Landfill
Plasterboard	108	m^2	Landfill
Wooden pavement	138	m^2	Landfill
Aluminium windows	49	units	Landfill
Bathroom sinks	23	units	Landfill
Bottom door brushes	14	units	Landfill
Kitchen sinks	1	units	Landfill
Faucets	6	units	Landfill
Toilets	15	units	Landfill

For instance, according to Table 1, one of the most significant waste flows was the metal sheet for the covering of pavilions and exterior corridors in the school. Figure 6 shows the shipment of waste metal sheet to landfill in the construction site of the school. According to the construction company, these materials were unsuitable for recycling.

Figure 6. Waste metal sheet sorted in the construction site of the school
Source: Taken by project team on site, 2021

The input values and the database information allowed to estimate that approximately 86 tonnes of materials from the construction project were sent for treatment. The material composition of these material flows is depicted in Figure 7, which shows that metal waste is the most representative waste stream in the project (58%). According to the contractor, all waste streams were sent to landfill, except for a small percentage of ceramic tiles which was reused on-site (Figure 8). The assertion that all CDW is sent for landfill might not fully translate what takes place outside the construction site, since contractors are not usually privy to what takes place at the waste management facility. However, for the purpose of the demonstration of the calculation tool, these potential deviations are not significant.

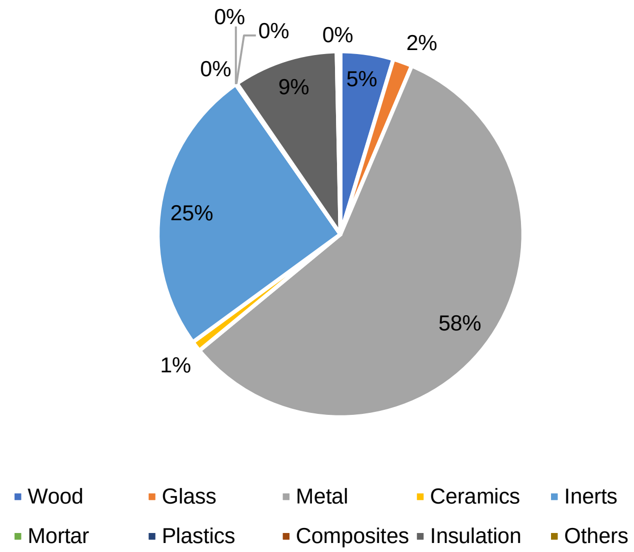


Figure 7: Estimated material composition of the material outflows of the demonstration project

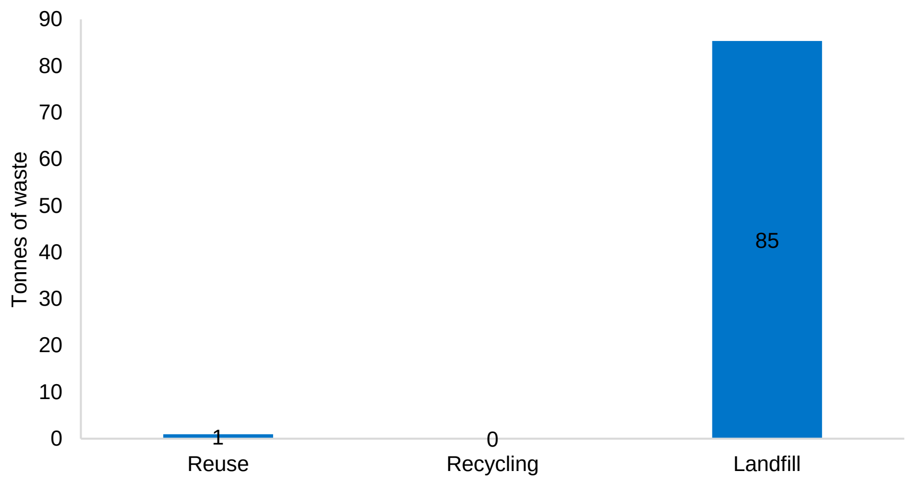


Figure 8: Destinations of the material outflows of the demonstration project

3.2 CRITICAL ANALYSIS OF MATERIAL FLOWS ESTIMATE

The obtained results were cross-checked with the waste production data provided by the construction company. According to the provided data, circa 56 tonnes of CDW were produced during the construction project (Figure 9), until the first week of August, of which 47% corresponds to waste metals (Figure 10). It is important to note that the construction project is still ongoing until September, which means that a certain quantity of waste was yet to be reported under the scope of the demonstration project.

Additionally, according to the project's Prevention Plan for CDW management, 700 m^3 of bricks, tiles and concrete and 280 m^3 of non-contaminated soils and stones were reused on site. In conclusion, it is not possible at this point to compare the estimations of 86 tonnes, which are based on the building element quantities (*mapas de quantidades*), with the 56 tonnes calculated from waste declarations. The completeness or robustness of the estimations can be reassessed after the conclusion of the construction project.

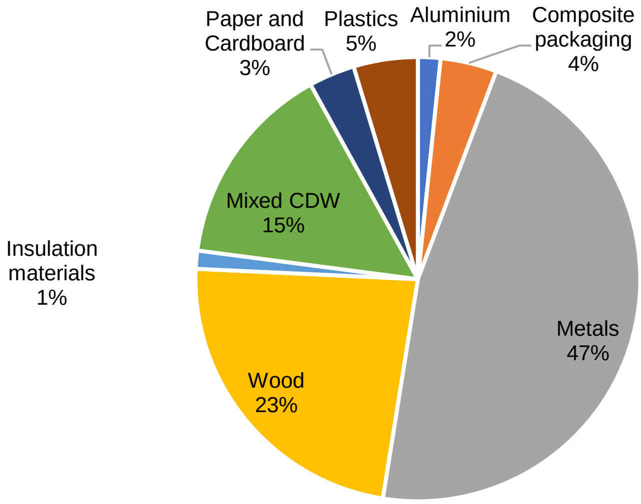


Figure 9: Reported waste composition of the project from its beginning until the first week of August
Source: Data provided by construction company

Figure 10. Sorting of metal waste in construction site
Source: Taken by project team at site, 2021

When it comes to the actual treatment destinations for these waste materials, Figure 11 shows almost 90% of the produced waste is sent for preparation for recovery or recycling, whereas only 42% of the waste wood produced was sent to recycling. This is the result of an established practice in the construction and waste management sectors, in which waste declarations are filled with the R12 or R13, which stand for temporary storage or preparation for recycling, despite most of it ending as landfilled. This information ultimately is at odds with the information provided by the contractor, which was considered to be more reliable than the waste declaration forms (*e-gar*).

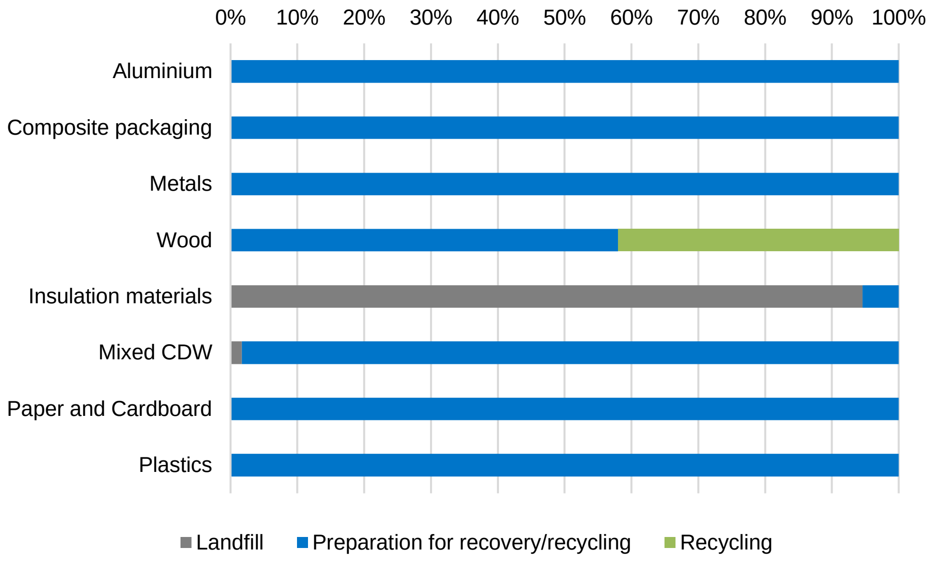


Figure 11: Reported waste treatment during construction project
Source: Data provided by construction company

In conclusion, the figures obtained from the calculation tool are within the same order of magnitude of the measured outputs from waste declaration forms, but it will be necessary post-project to determine the possible deviations and conclude on the robustness of the estimation.

3.3 IMPACT ASSESSMENT

Based on the data described in section 3.1, the tool estimated the environmental and economic impacts associated with the treatment applied to the defined waste material outflows. The methodology for the estimation of these impacts for each of the products included in the database is further explained in the Calculation Tool's Methodology Note (available on the project's website).

Environmental impacts (GHG emissions)

The treatment of the considered material inputs resulted in total Greenhouse Gas (GHG) emissions of 363 tonnes of CO_2 eq. As expected, these impacts are mostly associated with landfilling of the materials, namely organic matter, such as wood. The reuse of part of the ceramic pavement resulted in the avoidance of 14 tonnes of CO_2 eq (Figure 12).

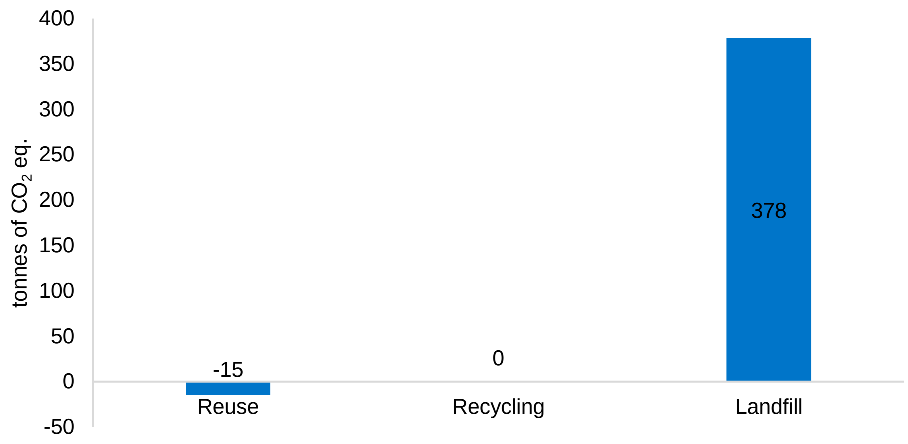


Figure 12: GHG emissions results from calculation tool

Economic impacts

The treatment of the considered material inputs resulted in a total cost of approximately 73 thousand euros, mostly associated with landfilling (Figure 13), which can be considered direct costs. The avoided costs of reusing part of the ceramic tiles amounted to 17 thousand euros, which intuitively suggests that the most important economic effects are the result not of direct costs of landfilling, but instead of the materials that are not reused or recycled. This is further explored in the next section.

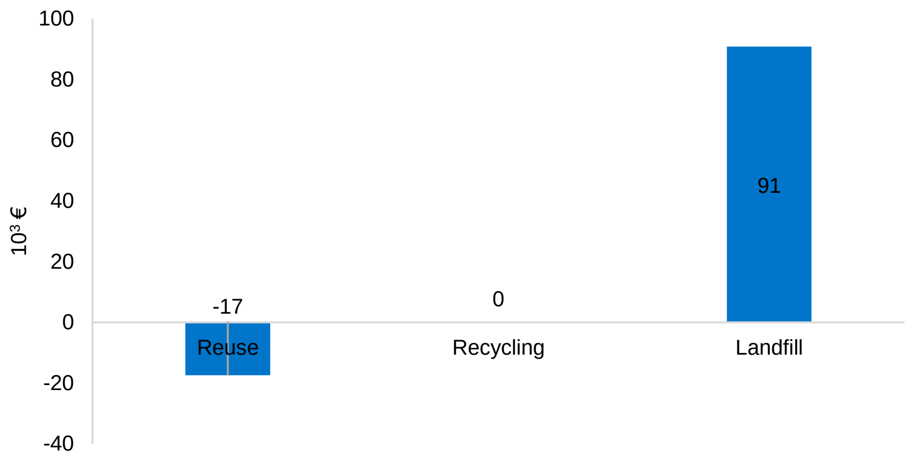


Figure 13: Economic impact results from calculation tool

3.4 SCENARIO ANALYSIS – POTENTIAL FOR REUSE AND RECYCLING

According to the construction company, the construction methods applied aimed to minimize waste production and maximize resource use in the construction site. This is due to an economic imperative, as moving in and out soil and other materials has supply and logistic costs. Also, in public construction works, companies are subjected to significant constraints from tenders, namely concerning costs, which might contribute to increase the reuse of soils and other low-value materials, but simultaneously hinder reuse and recycling of CDW, particularly with materials that require careful disassembly, with landfill still being the main waste treatment destination.

Under the demonstration project, it is important to assess an alternative scenario with increased reuse and recycling of CDW, in order to analyse the difference in environmental as well as economic impacts. The characterization of the baseline scenario (real situation) with the alternative scenario is presented in Table 2. The latter was defined after an assessment of the material flows.

Table 2. Characterization of waste treatment scenarios of the demonstration project

Construction product	Baseline			Alternative Scenario		
	Reuse	Recycling	Landfill	Reuse	Recycling	Landfill
Metal cover	0%	0%	100%	0%	80%	20%
Wooden doors	0%	0%	100%	70%	30%	0%
Metal doors	0%	0%	100%	70%	30%	0%
Ceramic tiles	5%	0%	95%	5%	95%	0%
Agglomerate of expanded cork	0%	0%	100%	0%	100%	0%
Plasterboard	0%	0%	100%	0%	100%	0%
Wooden pavement	0%	0%	100%	0%	100%	0%
Aluminium windows	0%	0%	100%	70%	30%	0%
Bathroom sinks	0%	0%	100%	0%	100%	0%
Bottom door brushes	0%	0%	100%	0%	100%	0%
Kitchen sinks	0%	0%	100%	0%	100%	0%
Faucets	0%	0%	100%	100%	0%	0%
Toilets	0%	0%	100%	0%	100%	0%

The alternative scenario results in the reduction of landfilling to approximately 11%, compared to the landfilling of almost 99% of the considered materials in the baseline scenario (Figure 14).

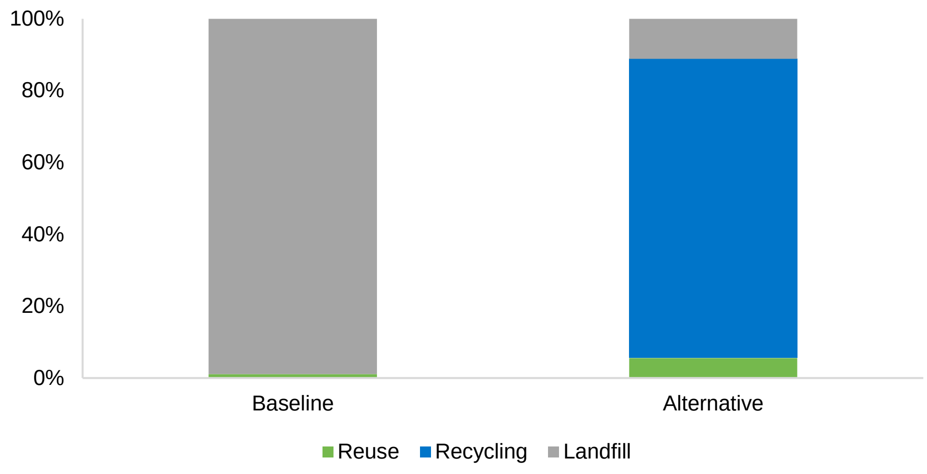


Figure 14: Comparison of end-of-life destinations between scenarios

Environmental impacts (GHG emissions)

The increase of reuse and recycling in the alternative scenarios results in a benefit of approximately 3.8 thousand tonnes of CO_2 eq. (Figure 15). These benefits are mostly associated with the avoided production of construction materials, which have embedded emissions. While there is uncertainty surrounding these results, the sheer difference between the two scenarios suggest that a reuse and recycling strategy should be pursued by developers and contractors.

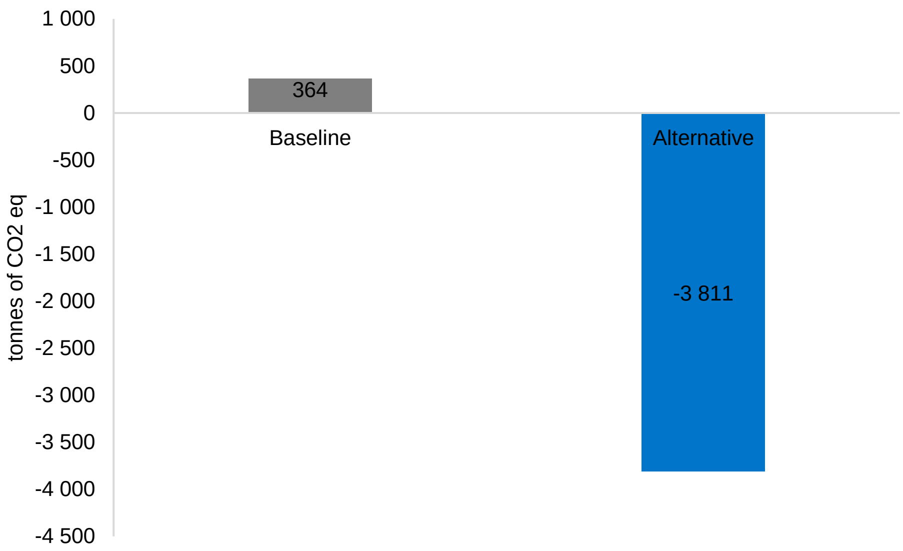


Figure 15: Comparison of GHG emissions results from calculation tool between scenarios

Economic impacts

The increase of reuse and recycling in the alternative scenarios results in an economic benefit of approximately 554’000 Euros (Figure 16). These results follow the same pattern as the environmental assessment but should be framed as an economic benefit for the developer. It must be stated that this benefit does not account the potential revenue loss for the supply chain (negative economic effect) or the increased labour costs (positive economic effect). The increased labour costs are borne by the contractor, which ultimately might explain the small weight of reuse and recycling, despite offering potential benefits to the developer. In conclusion, it should fall on the developer to pursue a reuse and recycling strategy for its demolition or renovation project.

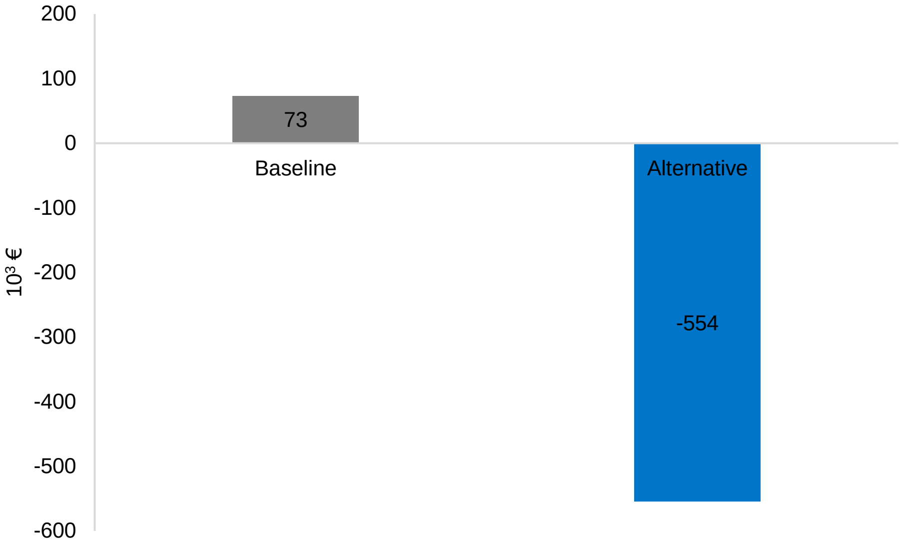


Figure 16: Comparison of economic impact results from calculation tool between scenarios

4 CONCLUDING REMARKS

The aim of the demonstration project was to test and demonstrate the use of the tools developed under the Circular Buildings project in a production environment. As a general conclusion, the proposed tools are ready to be used by practitioners

The demonstration of the Guidelines focused on how these tools can be used in specific products. Practitioners can use as examples and therefore easily translate the recommendations and calculation methods into their specific objects of study. In the case of the circular material passport, the demonstration can also be used as a template to help reduce the workload.

Regarding the demonstration of the calculation tool, the results allowed to better understand the economic and environmental benefits of increasing reuse and recycling, using the described project as a case-study. Practitioners can use the calculation tool with a minimum set of information, namely the estimated number of products used in the project, but for more in-depth analysis the practitioner can adapt or add new entries to the product database. The tool can therefore grow with practice and improve the underlying assumptions base on the scientific and professional community feedback.

The results that were obtained for the demolition project show that there are significant environmental and economic benefits from a reuse and recycling strategy. Despite the uncertainty associated with these calculation tools, the difference between the ‘landfill’ and ‘reuse and recycling’ strategies are large enough to support this finding. Also, it is important to stress that the calculated economic benefits are from the developer perspective, but not on the contractor or supplier of construction products. It can then be stated that it is in the developer’s best interest to focus on a reuse and recycling strategy.

The limitations that are mentioned in the report are strongly related to time restrictions, i.e. the project duration. However, the outcomes of the Edifícios Circulares project laid a strong foundation to grow and improve the proposed tools, ultimately contributing to the adoption of tools such as material passports, efficiency indicators and EPD, and a better understanding of environmental and economic impacts of construction projects. The consortium will continue to work these products within research, innovation and commercial scopes.

ANNEX I – MOCK CIRCULAR MATERIALS PASSPORT

CIRCULAR Buildings

CIRCULAR MATERIAL PASSPORT

Financed by:

Iceland Liechtenstein Norway grants

Programme operator:

REPÚBLICA PORTUGUESA AMBIENTE E AÇÃO CLIMÁTICA

Promotor:

SMART WASTE PORTUGAL BUSINESS DEVELOPMENT NETWORK

Partners:

3drivers engenharia inovação ambiente

U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Plataforma Tecnológica Portuguesa da Construção

PASSPORT NUMBER *CMP # 1*

GENERAL DATA

1. PRODUCT NAME		Adamastor porcelain stoneware
2. PRODUCT CATEGORY *Please, classify the product into a particular category of building products by selecting the best option for each Tier*	**2.1. Tier 1**	Core
	2.2. Tier 2	Fittings and furnishings
	2.3. Tier 3	Floor coverings and finishes
3. FUNCTION *Please, describe the function of your product or the components of your product (e.g., product or component of HVAC system in the building project)*		The tiles can be used as interior floor covering, in residential and public areas.

CMP # 1

4. MANUFACTURER		CINCA, S.A.
5. DATA SOURCE *If you have another data source, please write it down in the open fields below*		☑ Manufacturer's specifications ☑ Other Data Source *1.* DAP 004:2019 for Porous body ceramic tiles from Pavigrés Cerâmicas, S.A. *2.* DAP 001:2021 for Grés Porcelânico from Grés Panaria Portugal, S.A. *3.*

USE AND LOCATION

6. BUILDING IDENTIFICATION	**6.1. Name/Building number**	Escola Básica Dr. Flávio Gonçalves
	6.2. Address	R. de José Régio 323, 4490-648 Póvoa de Varzim
	6.3. Building type	Renovated building
7. INSTALLATION DATE	**7.1. Year**	2021

8. LOCATION *Please, provide the specific location of the product within the building (e.g., which floor, side of the building, etc.)*	The tiles are used in different parts of the school, namely: 4.5 m2 in Pavilhão A, 203.7 m2 in Pavilhão C, 755.9 m2 in Pavilhão D, 840.07 m2 in Pavilhão G, 6.25 m2 in other areas
9. EXPECTED SERVICE LIFESPAN *Please provide the expected lifespan of your product, if you don't have a specific value, please check the Typical Service Lifespan box and the value of your product service lifespan will be generated*	**9.1. Expected lifespan (years)** 50 ☐ **9.2. Typical Service Lifespan (years)**
10. MAINTENANCE *Please, provide the best maintenance practices for the product with the aim to extend its service lifetime*	Use 0.2 ml of detergent and 0.1 l of water to wash 1 m2 of floor tiles.
11. EXPECTED END-OF-LIFE *Please, provide the expected end-of-life of your product in order to estimate the year of your product replacement*	2071

CIRCULARITY POTENTIAL

12. DESIGN FOR DISASSEMBLY

Please, characterize the design for disassembly by choosing the design for disassembly categories of your product.

For further explanation, please check the chapter 3.5.1 in the Guideline for creating Circular Materials Passports

12.1. Type of connection	Hard chemical compound
12.1.1 Sub-type of connection	Cement bond
12.2. Type of connection accessibility	Freely accessible
12.3. Type of crossings	Modular zoning of objects
12.4. Type of form containment	Open, no inclusions
12.5. Score for disassembly performance	0,8 — *It is possible to recover the product while minimally damaging adjacent building components and/or components of the product*

13. DISASSEMBLY INSTRUCTIONS

Please, provide additional information for the material or product disassembly at the end of life for quality assurance

In order to remove the tiles for reuse, firstly, remove the cement bonding at the edges of the tile. Secondly, carefully pry the tiles away from floor. In order to remove the tiles for recycling, e.g. as an aggregate or for backfilling, no additional care is required as the tiles are expected to break during the removal process.

CMP # 1

14. QUANTITY

Please, fill the fields that turned into dark grey with the quantity estimation

Note 1: The dark grey fields are linked to the score for disassembly performance.

	Product	Components				
		Component 1	*Component 2*	*Component 3*	*Component 4*	*Component 5*
14.1. Weight (kg)	23,60					

15. MATERIAL COMPOSITION

To estimate the % of the material composition, please, fill the fields that turned into dark grey.

Note 1: The dark grey fields are linked to the score for disassembly performance. If your product has less than 1 point, it is unlikely to know the component's material composition. In this case, it is important only to estimate the product composition (materials). But if your product has more than 2 points, it is easier to estimate the materials components composition.

In case of your product is composed with another material type, please indicate and estimates in the dark grey fields

	Product	Components				
		Component 1	*Component 2*	*Component 3*	*Component 4*	*Component 5*
15.1. Concrete, brick (stone), tiles and ceramics	100,0%					
15.2. Structural wood or other bio-based						
15.3. Glass						
15.4. Plastic						
15.5 Bituminous mixtures						
15.6. Metal						
15.7. Insulation materials						
15.8. Gypsum						
15.9. Mixture						
15.10.						
15.11.						
15.12.						
15.13.						
15.14.						
15.15. Total	**100,0%**					
	OK					

CMP # *1*

16. MATERIAL INPUT SOURCES

(Optional field)

Please, estimate the % of the following type of sources for your product or of its components (fill the fields that turned into dark grey).

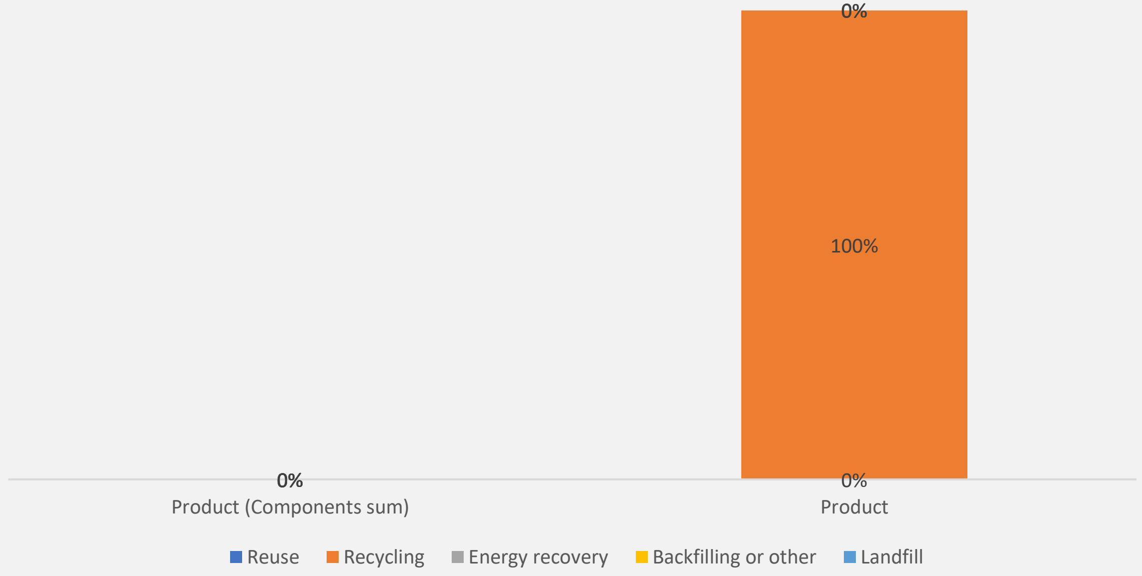
	Reused	Recycled	Biomass	Virgin	Total	
16.1. Product				100%	**100%**	**OK**
16.2. Component 1						
16.3. Component 2						
16.4. Component 3						
16.5. Component 4						
16.6. Component 5						
16.7.Total				**100%**	**-**	

CMP # 1

17. WASTE SCENARIOS

Please, choose the most likely waste scenario for your product or its components (choose the boxes that turned into dark grey)

17.1. Product	Recycling
17.2. Component 1	
17.3. Component 2	
17.4. Component 3	
17.5. Component 4	
17.6. Component 5	



CMP # 1

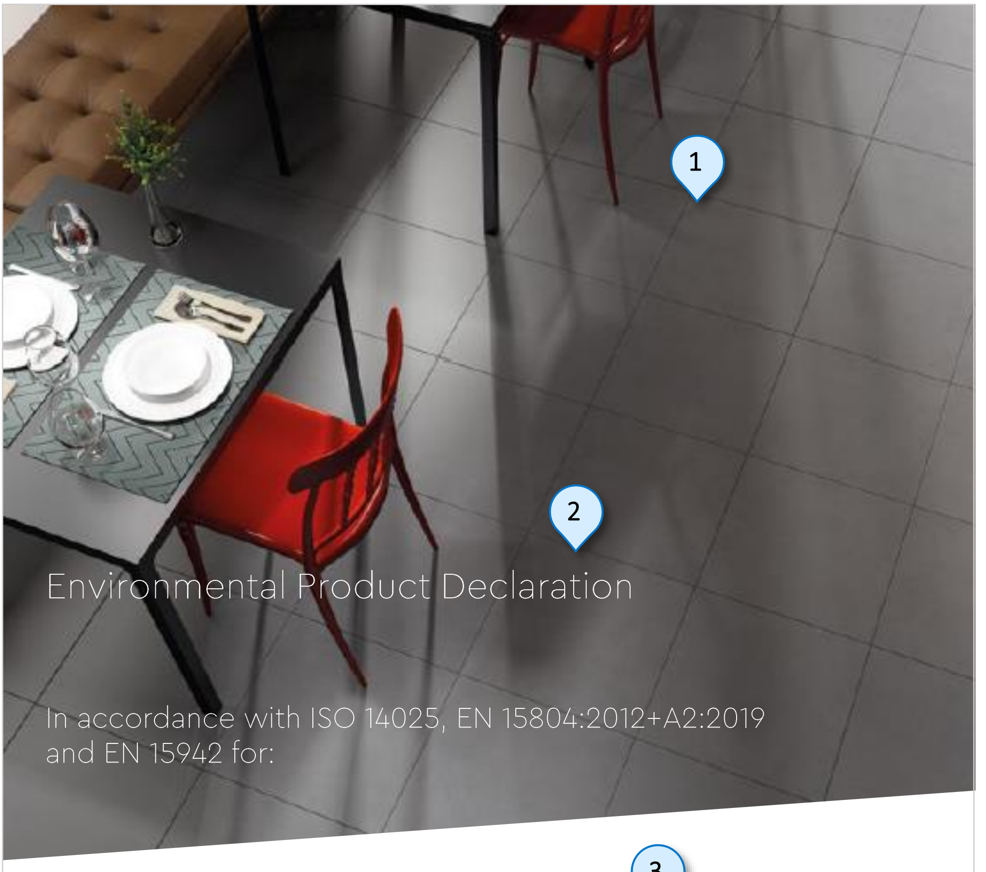
17. WASTE SCENARIOS

The following table will show the weight of your product per waste scenario

Weight (kg)	**Reuse**	**Recycling**	**Energy recovery**	**Backfilling or other**	**Landfill**
Product		23,60			

ANNEX II - MOCK EPD

FRONT PAGE



Environmental Product Declaration

In accordance with ISO 14025, EN 15804:2012+A2:2019 and EN 15942 for:

Adamastor – Body porcelain stoneware

From: [LOGO EPD OWNER/ MANUFACTURER]

Programme:	Sistema DAP Habitat
Programme operator:	Associação Plataforma para a Construção Sustentável
EPD registration number:	DAP AAA-AAAA
Publication date:	202X-XX-YY
Valid until:	202X-XX-YY

[Logo EPD programme operator]

[Logo EPD ECO platform]

1 - It is common for the EPD front page to include an illustrative image of the product.

2 - This document is a mock EPD for the Adamastor ceramic tile from CINCA, S.A.
Therefore, it refers to the most common EPD type (covering one product from one manufacturer). However, it is also possible to produce an EPD for a manufacturer's product range as long as the different products have similar characteristics, or for one type of product from different manufacturers.
The EPD type should be chosen based on the needs and budget.

3 - The front page of an EPD is not standardized but should include the following information:

- Title
- Respected standards
- Name of the product
- Logos of the EPD programme and EPD owner
- Registration number and validity

4 - In a registered EPD, these fields include a unique registration number and information regarding the validity of the EPD

[intentionally left blank]

CONTENTS

[LOGO EPD OWNER/
MANUFACTURER]

[LOGO EPD
PROGRAMME]

5

Contents

5 - An EPD should always include a table of contents for orientation. The structure and content of chapters slightly vary between EPD programmes. The required components of an EPD are detailed in the relevant Product Category Rules (PCR), in this case, for a construction product in Portugal, this can be found in: Dias, A.C., A. Baio Dias, C. Rocha, F. Freire, H. Gervasio, J.D. Silvestre, and M. Almeida. 2020b. Product category rules (PCR) - Basic module: Construction products and services according to the EN 15804:2012 + A1:2013.

[intentionally left blank]

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

6

1. General Information

7

1.1 The DAP Habitat System

8

Programme operator:	Sustainable Construction Platform www.centrohabitat.net centrohabitat@centrohabitat.net
Address:	Departamento Engenharia Civil Universidade de Aveiro 3810-193 Aveiro, Portugal
Email address:	deptecnico@centrohabitat.net
Telephone number:	(+351) 234 401 576
Website:	www.daphabitat.pt
Logo:	[LOGO EPD PROGRAMME]

9

1.2 EPD owner

Name of the owner:	CINCA - Companhia Industrial Cerâmica, SA.
Production site:	Rue 1º de Maio 1 Argoncilhe, Portugal
Address (headquarters):	Rua Principal, nº 39 4505-374 Fiães
Email address:	cinca@cinca.pt
Telephone number:	(+351) 227 476 400
Website:	www.cinca.pt
Logo:	[LOGO EPD OWNER]
Information concerning the applicable management systems:	ISO 9001:2015 – Quality Management Systems ISO 14001:2015 – Environmental Management Systems

6 - The first chapter in an EPD should include background information about:
- under which programme the EPD is registered;
- who owns the EPD, meaning who is responsible for the content;
- authors;
- validity;
- verification through an external reviewer;
- relevant PCRs;
- a brief description of the product.

7 - In this section information about the EPD programme is presented. DAP Habitat is the Portuguese EPD system.

8 - A program operator can be a company or a group of companies, industrial sector or trade association, public authorities or agencies, or an independent scientific body or other organisation.

9 - Motivation for a manufacturer to make a EPD for their product can be:
- Make it part of their corporate sustainability strategy;
- Create transparency for clients and building designers to choose low environmental impacts products
- Comply with environmental standards, which can be expected to become stricter in the near future
- Often green building certification schemes like BREEAM require the use of EPDs, meaning that products with an EPD have a market advantage

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

1. General Information

10

Specific aspects regarding the production:	$CAE_{Rev.3}$ n.º 23312 – Manufacture of ceramic tiles, mosaic, and plates (Fabricação de ladrilhos, mosaicos e placas de cerâmica)
11 Organization's environmental policy:	The manufacturing of CINCA's wall and floor tiles is based on BAT – Best Available Techniques in the industry, with the aim of reducing natural resources and energy to a minimum. 100% Of manufacturing recyclable residues are reutilized in the manufacturing. Production lines reutilize closed water circuits that are adequately treated resulting in a 0% discharge of residual waters into the environment. Gas emissions levels are analysed periodically to confirm its conformity with local and European rules and regulations. Whenever necessary appropriate treatment systems are in place. 100% of non-reusable cardboard boxes and wooden pallets are sent to the respective recycling centres. Permanent monitorization of all processes and systems allow for improved quality, minimizing waste and resources to reduce any environmental impact to a minimum. CINCA has strict environmental control systems implemented, which in many aspects, are beyond that required by European Union regulations. CINCA's Integrated Management System is submitted periodically to third party evaluation that monitor CINCA's capacity to comply with legal regulations, as well as the achievement of targets set out by the company itself. Under normal conditions of use, life span of ceramic wall and floor tiles is higher than any other product conceived for the same use. Ceramic products are considered inert and no particular care is required in its treatment as a residue. In the event of replacement, ceramic tiles are easy to recycle and may be used as raw materials for other industries. All packaging materials (boxes, plastic and wooden pallets) are totally recyclable and easily reutilized.
12 Information about the organization:	CINCA - Companhia Industrial Ceramica, SA, company with the headquarters in Fiães, county of Santa Maria da Feira, started its business with the production of porcelain mosaics with measures of 2.5 x 2.5 cm in response to the needs of architects, builders and consumers in Portugal. More than 50 years of knowledge and experience passed through generations, from the pioneers to a young and dynamic technical team allow Cinca an incomparable control of techniques and ceramic solutions. For many years CINCA has been maintaining an ongoing presence in the main markets of ceramic products throughout the world, understanding each market's requirements and always offering adequate answers to their needs. CINCA is present in more than 70 countries of the 5 continents. Due to the significantly greater level of competition on a world-wide scale, the demands of today's market share of a far higher level than in the past. Therefore Cinca aims for quality in every aspect of our product; usability, practicality, price, after sales service, environment issues and human resources.

Please note that the EPD owner has the sole ownership, liability, and responsibility for the EPD.

10 - CAERev.3 stands for the Portuguese Classification of Economic Activities, Revision 3, prepared by the Instituto Nacional de Estatística (INE)

11 - This text should reflect the organization's mission, policy and possibly its concrete targets for environmental sustainability.

12 - This section can be written freely. It can include, for example, an organisation chart or photos of the production line.

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

1. General Information

1.3 Information about the EPD

Authors:	1. CINCA, S.A. (13) 2. Centro Tecnológico da Cerâmica e do Vidro (CTCV)
Contact of the authors:	1. Rua Principal, nº 39 - 4505-374 Fiães – Portugal (+351) 227 476 400; cinca@cinca.pt 2. CTCV materials: habitat | iParque – Parque Tecnológico de Coimbra - Lote 6 | 3040-540 Antanhol- Portugal (+351) 239 499 200
Emission date:	XXXX-XX-XX
Registration date:	YYYY-YY-YY (14)
Registration number:	DAP AAA-AAAA
Valid until:	ZZZZ-ZZ-ZZ (15)
Representativeness of the EPD (location, manufacturer, group of manufacturers):	(16) EPD of one (1) product class, produced in one (1) industrial plant belonging to one (1) sole producer (CINCA, S.A.).
Where to consult explanatory material:	www.cinca.pt (17)
Type of EPD:	Cradle-to-grave (A1-D)

(18)

1.4 Proof of verification

Independent external verification according to the standards ISO 14025, EN 15804:2012+A2:2019 and EN 15942:

On behalf of the certifying entity	Verifier
[SIGNATURE]	[SIGNATURE]
[NAME OF THE ENTITY]	[NAME OF THE VERIFIER]

13 - The listed authors here include, besides the manufacturer, the representative entity of ceramics in Portugal. This is a suggestion based on similar EPDs for ceramic tiles. Collaborating with CTCV on such an EPD is helpful as they have laboratories for testing and expertise of the technical properties of ceramic tiles.

14 - This date is also sometimes calls the "publication date" or the "issue date". It refers to the date when the EPD owner, in this case the tile manufacturer, submits the EPD registration. Note that this date remains unchanged even if later updates of the EPD are published.

15 - The standard validity of an EPD is five years. The date is set during the verification

16 - To clarify the representativeness of the data used for the analysis in this EPD

17 - The most common types are:
- Cradle-to-gate (A1-A3)
- Cradle-to-gate with options (A1-A3 and additional LC modules)
- Cradle-to-grave (A1-A5, B1-B7, C1-C4, D)

Please note that although some modules are reported they might be set to non relevant as their impacts are negligible.

18 - The verification by an independent third-party confirms that specified requirements have been fulfilled. The verification process is based on objective evidence and considers accuracy, reliability and consistency

1. General Information

19

1.5 EPD Registration

On behalf of the Plataforma para a Construção Sustentável
[SIGNATURE OF THE PROGRAM OPERATOR]

19 - Registering the EPD is the final step, after successful external verification. The EPD programme operator is responsible for the registration. They will also publish the EPD publicly on their website.

20

1.6 Product category rules (PCR)

PCR name	Emission date	Registration number in the database	Version	Valid until
EN 15804: 2012 + A2:2019 - Core rules for the product category of construction products (CEN/TC 350 2019)	30.10.2019	--	--	--
PCR: Basic module for construction products and services (Dias *et al.* 2020b)	19.01.2016	RCP-MB001	Version 2.1 Edition 11/2020	31.01.2022
PCR: Floor coverings (Dias *et al.* 2020a)	10.02.2014	RCP001:2014	Version 1.1 Edition 11/2020	31.01.2022
EN 17160 - Product category rules for ceramic tiles (CEN/TC 67 2019)	13.11.2019	--	--	--

20 - PCRs are rules that define how to develop an EPD for a specific product category, which is defined by the programme operator. Their objective is to safeguard the application of similar rules for similar products. This then allows comparison between EPDs of similar products.

21

1.7 Product information

PRODUCT NAME
Adamastor porcelain stoneware

PRODUCT IDENTIFICATION
CINCA number 8620

PRODUCT DESCRIPTION
The analysed tiles in this EPD refer to the Adamastor beige tiles with a size of 49 cm x 49 cm x 0.97 cm. However, the Adamastor line includes a range of different colours and sizes. Since the production process is the same, regardless of the thickness or shape of the products, it is possible to convert the results presented in this EPD to other units.

The tiles have a density of 2145 kg/m^3. The referred tiles are packed in sets of four tiles (0.96 m^2 of tiles) per box. One pallet carries 48 boxes (46.08 m^2 of tiles). One pallet weighs 1094 kg (gross weight) and measures 120 x 100 x 64 cm.

The tiles are primarily made of naturally occurring major raw materials such as clay, pegmatite, and albite, but they may also include other minor raw materials such as feldspar, zinc, zircon and kaolin.

21 - This section should clearly identify the product, as well as describe the most important characteristics of the product, including function, material composition and design, and technical parameters.

1. General Information

ILLUSTRATION OF THE PRODUCT

MAIN TECHNICAL CHARACTERISTICS OF THE PRODUCT

22

Standard required by the norm	Mean value of tolerances	Norm
Dimensional characteristics	Deviation from work size: ± 0,3% Thickness: ± 5% Straightness of edges: ± 0.5% Rectangularity: ± 0.5%	EN ISO 10545-2
Water absorption	Eb ≤ 0,2%	EN ISO 10545-3
Breaking strength in N	≥ 1430	EN ISO 10545-4
Rupture modulus N / mm2	≥ 38N/mm2	EN ISO 10545-4
Linear thermal dilatation ($x10^{-6}$ k^{-1})	6,0 - 7,0	EN ISO 10545-8

APPLICATION OF THE PRODUCT

The coloured body porcelain stoneware tiles can be used for interior floor coverings in the following types of buildings:

- Residential
- Commercial
- Public
- Health institutions such as hospitals

22 - More technical characteristics could be added here

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

2. Life cycle assessment (LCA) information

2.1 Calculation rules of the LCA

23

FUNCTIONAL UNIT

1 m^2 of tiles including packaging during one life cycle (equal to the reference service life)

24

REFERENCE SERVICE LIFE

50 years

25

TEMPORAL AND GEOGRAPHICAL SCOPE

2021 , Portugal

26

DATABASE(S) AND LCA SOFTWARE USED

For processes over which producers have no influence or specific information, such as the extraction of raw materials, generic data from the Ecoinvent v3.3 databases (Ecoinvent 2021) were used. Generic data from Ecoinvent v3.3 databases meets the quality criteria (age, geographical and technological coverage, plausibility, etc.) of generic data. The LCA software SimaPro (PRé Consultants 2021) was used.

27

DESCRIPTION OF SYSTEM BOUNDARIES

Cradle to grave and module D (benefits and loads beyond the system boundary)

28

CUT-OFF CRITERIA

According to paragraph 6.3.5 of EN 15804 (CEN/TC 350 2019), the exclusion criterion for unitary processes is 1% of the total energy consumed and 1% of the total mass of the inputs. Particular
attention should be paid not to exceed a total of 5% of energy and mass flows excluded in the product step.
The following cases were not considered in this study, as they fall under the exclusion criteria:

- Environmental loads associated with the construction of industrial infrastructures and the manufacture of machinery and equipment;
- Environmental loads relating to infrastructure (vehicle and road production and maintenance) for the transport of pre-products;
- Long term emissions.

29

ALLOCATION RULES

The energy and material consumption were allocated to the product based on the annual production volume of ceramic tiles of the plant. No further allocation was applied in the life cycle (LC) modules following the production stage. Some ceramic waste is recycled in-house. Energy recovery, packaging and end of life materials of the product were taken into consideration.

COMPARABILITY OF CONSTRUCTION PRODUCTS EPDS

Note that EPDs of construction products and services may not be comparable if they are not in line with EN 15804 (CEN/TC 350 2019), EN 15942 (CEN/TC 350 2011) and the comparability conditions as stated in ISO 14025 (ISO/TC 207/SC3 2006).

10

23 - A functional unit is the reference measure of the studied product in a Type III environmental declaration based on one or more information modules [EN 15804:2012+A2:2019].
Alternatively, a declared unit provides only the quantity of a product as the reference.
This is a common functional unit for floor coverings. Alternative, mass, e.g., 1 kg of tiles, could be used in combination with the service life.

24 - The reference service life is an important parameter, particularly when analysing the LC stage B – Use, since it directly relates to the environmental impacts of maintenance and other use stage activities.
The RSL is defined as the expected service life under standard (reference) in-use conditions.

25 - This declares the year(s) and location that is representation by the input data.

26 - Other common LCI databases are:

- GaBi
- ELCD

An alternative to LCI databases are Input-Output databases, such as EXIOBASE.

27 - Summarizes which life cycle stages and modules are included.

28 - It is important that the cut-off criteria does not lead to a hiding of data, in contrast, its objective is to make the calculation process more efficient.

29 - Allocation sets how much of the environmental impact that is caused can be attributed to the product under study. In this case, (production) volume is used as the decisive parameter. Besides weight/volume, the most common parameter used in allocation is cost.

2. Life cycle assessment (LCA) information

2.2 System diagram 30

30 -A more detailed diagram of the input and output flows of the production process can be included here to help the reader better understand

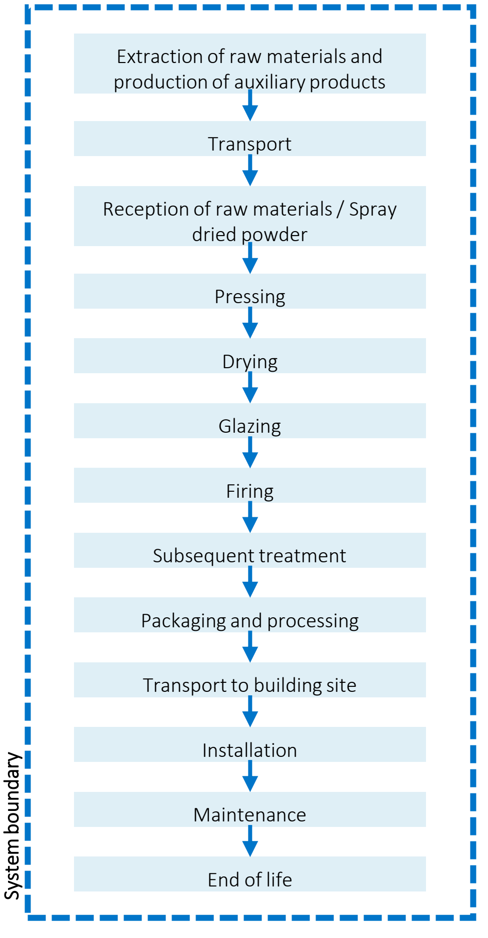


Figure 1: Life cycle stages of of the tile evaluated in this EPD

2. Life cycle assessment (LCA) information

31

2.3 Description of relevant life cycle stages

This EPD analyses the life cycle stages A, B, C and D, which is referred to as a “cradle-to-cradle LCA”. Only the following LC modules are relevant for the analysed floor tiles. The remaining modules are considered negligible due to their low impact.

A1 - EXTRACTION AND PROCESSING OF RAW MATERIALS

This step includes the extraction and eventual processing of raw materials.

32

A2 – TRANSPORT

Raw materials and auxiliary materials come from truck or truck, boat and truck again.

33

A3 – PRODUCTION

This module includes the design and development, storage of raw materials, pulp preparation, forming (by pressing), drying, glazing or decoration, firing and choice, subsequent treatment (e.g., polishing), packaging and storage. Natural raw materials, processed materials and additives are used, in which the main ones are clays, feldspars, sands and kaolins. The manufacturing process begins with the receipt of the spray dried powder (produced in specialized external facilities according to the requirements of Cinca) which is stored in special silos.
It is followed by the forming stage, by powder pressing, followed by drying (fuelled with natural gas) and glazing. Depending on the aesthetic characteristics of the final product, this will vary the number and type of auxiliary equipment to be activated along the line, as well as the type of applications to be used. These applications are previously prepared in the glass and paints section, from the grinding of the compositions (of raw materials such as frits, pigments e.g., metal oxides etc.). It follows the single fired thermal process, which is carried out in continuous ovens, fed with natural gas. The material then follows for the choice and packaging, and there are quality control processes in the choice. The product can also undergo a subsequent treatment, cutting or rectification, which implies another drying; drying process using dryers fed with natural gas.

34

A4 – TRANSPORT TO CONSTRUCTION SITE

This module includes transport of floor tiles to the construction site.

35

A5 – INSTALLATION INTO THE BUILDING

This module describes the installation of tiles. All steps of the tile installation (such as adhesive usage) and processing of packaging waste (recycling, incineration, and disposal) are considered. For 1 m2 floor tile installation; 3.5 kg mortar and 1.5 L water usage was assumed. Credits from energy substitution are declared in module D.

36

B1 – USE

This module describes the use phase of the tiles. Since no releases (emissions) of substances to the indoor environment are expected during the use of the ceramic tiles, this stage is not relevant.

B2 – MAINTENANCE

This module is related to any activities to maintain the function of the product in its lifetime. It includes cleaning with water and detergent. Cinca recommends using detergent containing stain remover or neutral low-sulphate and rinse with tap water after cleaning. 0.2 mL detergent and 0.1 L water use is assumed to clean the surfaces of 1 m2 floor tiles.

B3 – REPAIR, B4 – REPLACEMENT, B5 – REFURBISHMENT

If the tiles are correctly installed, no repair, replacement or refurbishment process is necessary. For this reason, modules B3-B4-B5 are not relevant..

31 -Remember that according to the new EN 15804:2012 + A2:2019 the following LC modules are mandatory: A1, A2, A3, C1, C2, C3, C4, D

32 -Parameters that influence this transportation step, i.e., distance, mode of transportation, and fuel, should be known to the manufacturer. Therefore, this LC module A2 can be realistically modeled.

33 -This is the last LC module that the manufacturer has control of, therefore, allowing a robust data collection and LCA model. Starting from LC module A4, the model is scenario-based.

34 -According to the PCR for construction products and services, later, in section 4 Additional information, the scenario specifications of this transport step should be provided.

35 -According to the PCR for construction products and services, later, in section 4 Additional information, the scenario specifications of the product installation should be provided.

36 -According to the PCR for construction products and services, later, in section 4 Additional information, the scenario specifications of the LC stage B should be provided. For this product, only B2 Maintenance is relevant.

2. Life cycle assessment (LCA) information

B6 – OPERATIONAL ENERGY USE, B7 – OPERATIONAL WATER USE

These modules describe the use of energy and water, respectively, to operate technical building systems, e.g., heating, cooling, ventilation, lighting, hot water systems, etc. Since the tiles are not related to such systems the operational energy and water use are not relevant. Please note that the cleaning water is declared in module B2.

37

C1 – DECONSTRUCTION/ DEMOLITION

When the floor tile (or the building) reaches their end of life, a selective deconstruction process shall take place. The associated environmental impacts are low and therefore, can be neglected.

C2 – TRANSPORT OF WASTE

This module includes the transport of the recovered tiles and adhesive mortar to either a recycling facility or a final disposal site. An average distance of 50 km is assumed, from demolition site to waste processing plant, and from demolition site to inert landfill site for final disposal.

C3 – WASTE PROCESSING

This module includes the waste processing of recovered floor tiles for recycling and/or reuse.

C4 – DISPOSAL

This module includes all landfilling processes, including pre-treatment and site management.

38

D – BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARY

This module includes the benefits or burdens to the environment generated by reusable products, the recyclable materials and/or energy carriers that come out of a product system.

37 -According to the PCR for construction products and services, later, in section 4 Additional information, the scenario specifications of the LC stage C should be provided. For this product, only C2-C4 are relevant.

38 -According to the PCR for construction products and services, later, in section 4 Additional information, the scenario specifications of module D should be provided

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

2. Life cycle assessment (LCA) information

2.4 System boundaries

39

(✓ = module included, x = module not included)

	Product stage			Construction process stage		Use stage							End of lide stage				Resource Recovery stage
	Raw material supply	Transport	Manufacturing	Transport	Construction installation	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Modules declared	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

It is assumed that LC stages B1, B3-B7, and C1 are not relevant (NR) for the analysed tiles since the required material and energy, as well as produced emissions are minor. For more information, please refer to section 4.

39 -A table should be included to provides the reader with an overview of LC modules that are included in the EPD.

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

40

3 Environmental impact results

3.1 Potential environmental impact – mandatory indicators according to EN 15804

41

Results per functional unit												
Indi-cator	Unit	A1-A3	A4	A5	B1	B2	B3 - B7	C1	C2	C3	C4	D
GWP	kg CO_2 eq.	1.72E+01	7.58E+00	1.56E+00	*NR*	2.82E-01	*NR*	*NR*	6.60E-02	6.14E-02	6.68E-02	-5.11E-02
ODP	kg CFC_{11}	2.52E-06	1.40E-06	1.29E-07	*NR*	3.59E-08	*NR*	*NR*	1.20E-08	1.15E-08	1.21E-08	-1.83E-08
AP	kg SO_2 eq.	6.00E-02	5.14E-02	5.09E-03	*NR*	1.83E-03	*NR*	*NR*	1.80E-04	4.71E-04	4.64E-04	-2.60E-04
EP	kg $(PO_4)^{3-}$ eq.	5.86E-03	5.76E-03	5.39E-04	*NR*	1.37E-04	*NR*	*NR*	3.00E-05	1.02E-04	9.72E-05	-5.04E-05
POCP	kg C_2H_4 eq.	3.00E-03	1.89E-03	2.40E-04	*NR*	1.02E-04	*NR*	*NR*	8.40E-06	1.13E-05	1.47E-05	-9.61E-06
ADP-non-fossil	kg Sb eq.	6.26E-06	1.53E-08	2.62E-07	*NR*	2.89E-07	*NR*	*NR*	1.40E-10	1.19E-10	1.46E-10	-5.19E-08
ADP-fossil	MJ	2.54E+02	1.16E+02	1.40E+01	*NR*	1.02E+01	*NR*	*NR*	1.00E+00	9.50E-01	1.02E+00	-7.46E-01
Acro-nyms	GWP = Global Warming Potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential, Accumulated Exceedance; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone; ADP-non-fossil = Abiotic depletion potential for non-fossil resources; ADP-fossil = Abiotic depletion of resources - fossil fuels											

3.2 Use of resources

42

Results per functional unit												
Indi-cator	Unit	A1-A3	A4	A5	B1	B2	B3 - B7	C1	C2	C3	C4	D
PERE	MJ	2.40E+01	2.73E-01	7.87E-01	*NR*	1.51E-01	*NR*	*NR*	2.46E-03	1.71E-03	4.32E-03	-2.52E-01
PERM	MJ	2.64E+00	0.00E+00	0.00E+00	*NR*	0.00E+00	*NR*	*NR*	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PERT	MJ	2.66E+01	2.73E-01	7.87E-01	*NR*	1.51E-01	*NR*	*NR*	2.46E-03	1.71E-03	4.32E-03	-2.52E-01
PENRE	MJ	2.63E+02	1.16E+02	7.42E+00	*NR*	1.04E+01	*NR*	*NR*	1.01E+00	9.54E-01	1.02E+00	-1.9E+00
PENRM	MJ	0.00E+00	0.00E+00	0.00E+00	*NR*	0.00E+00	*NR*	*NR*	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PENRT	MJ	2.63E+02	1.16E+02	7.42E+00	*NR*	1.04E+01	*NR*	*NR*	1.01E+00	9.54E-01	1.02E+00	-1.9E+00
SM	kg	0.00E+00	0.00E+00	0.00E+00	*NR*	0.00E+00	*NR*	*NR*	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RSF	MJ	0.00E+00	0.00E+00	0.00E+00	*NR*	0.00E+00	*NR*	*NR*	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NRSF	MJ	0.00E+00	0.00E+00	0.00E+00	*NR*	0.00E+00	*NR*	*NR*	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FW	m^3	2.13E-02	1.95E-03	8.74E-05	*NR*	5.79E-05	*NR*	*NR*	1.69E-05	1.58E-05	1.68E-05	-9.77E-05
Acro-nyms	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy re-sources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water											

15

40 -This is the central part of an EPD as it presents the results from the product LCA.

The presented results in this mock EPD are an average of two existing EPDs of similar products, namely:

- DAP 004:2019 for Porous body ceramic tiles from Pavigrés Cerâmicas, S.A.
- DAP 001:2021 for Grés Porcelânico from Grés Panaria Portugal, S.A.

These two EPDs were selected based on a comparison of type of product, geographical and temporal scope, product geometry. The two selected EPDs have different functional units. The environmental impact results were converted using the density of the tiles.

41 -The PCR for construction products and services defines this set of environmental impact categories to be included in the EPD.

42 -The PCR for construction products and services defines this set of parameters describing the use of resources to be included in the EPD.

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

3 Environmental impact results

3.3 Waste production and output flows

3.3.1 Waste production

43

Results per functional unit												
Indi-cator	Unit	A1-A3	A4	A5	B1	B2	B3-B7	C1	C2	C3	C4	D
Hazardous waste disposed	kg	3.06E-04	1.94E-05	2.74E-06	*NR*	4.47E-06	*NR*	*NR*	1.70E-07	1.57E-07	1.81E-07	-2.7E-06
Non-hazardous waste disposed	kg	1.08E+00	9.21E-04	9.15E-03	*NR*	4.49E-03	*NR*	*NR*	8.00E-06	1.54E-05	8.1E+00	-4.3E-01
Radioactive waste disposed	kg	1.99E-04	7.94E-04	3.45E-05	*NR*	8.52E-06	*NR*	*NR*	6.90E-06	6.50E-06	6.85E-06	-2.2E-05

44

3.3.2 Output flows

45

Results per functional unit		
Indicator	Unit	Results
Components for re-use	kg	*N/A*
Material for recycling	kg	11.617
Materials for energy recovery	kg	0.043
Exported energy	MJ by energy carrier	*N/A*

43 -The PCR for construction products and services defines this set of parameters describing different waste categories to be included in the EPD.

44 -Sometimes these other output flows are declared by LC stage.

45 -The PCR for construction products and services defines this set of parameters describing other types of output flows to be included in the EPD.

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

46

4 Additional information

4.1 Construction stage (A)

4.1.1 A4 – Transport to site

47

The scenarios for LC stage A4 regarding transport to the construction site are in accordance with EN 17160 regarding product category rules for ceramic tiles (CEN/TC 67 2019). The following table presents assumed parameters for the estimated transport-related impacts.

Per functional unit	
Parameter	**Value**
Type of vehicle (in accordance with the EU directive 2007/37/EC)	Lorry with 25 tons load capacity
Type of fuel	Diesel
Fuel consumption	35 l/km
Assumed travel distance (one way)	200 km
Capacity of use (round trip)	70% (load capacity)
Transported load	17500 kg (16 pallets)
Density of load	2360 kg/m^3

4.1.2 A5 – Installation in the building

The scenario for LC stage A5 regarding the installation of floor tiles in the building was defined according to the options defined in EN 17160 (CEN/TC 67 2019) and in Almeida (2019). The option chosen was 3.5 kg of cementitious adhesive for each m2 of tiles. The loss of material considered was 3%.

Per functional unit		
Medium sized tiles	**Unit**	**Value**
Cementitious adhesive	3.5	kg
Water	1.5	l

4.2 Use stage (B)

4.2.1 Reference service life

Per functional unit		
Parameter	**Unit**	**Value**
Reference service life	years	50
Deviation from work size	mm	± 0.5
Estimated quality of the work, if installed as recommended by the producer	--	Very high since the tiles characteristics outperform the defined EN ISO 10545 standards regarding Water absorption, Modulus of rupture (N/mm2), Breaking strength (N) min, Resistance to deep abrasion.
Maintenance (cleaning)	--	Cleaning of the tiles does not cause mechanical wear and does not influence the service life.

48

46 -This section includes two types of information:

- technical information that were used for the scenario development
- environmental information that does not result from the LCA and that can cover a range of topics

An important issue that should be covered in this section is carbon offset, carbon storage and delayed emissions. However, this is not relevant here.

Additionally, the EPD owner, i.e. manufacturer, can use this section to provide more details about their environmental performance strategy and work.

47 -As mentioned before, starting from LC module A4 the calculation is based on a scenario as the manufacturer can only project the path of its product after it leaves the factory gate.

48 -This is a very important parameter as it directly influences the estimated lifetime of the product, thereby directly influencing the lifetime impact results.

[LOGO EPD OWNER/
MANUFACTURER]

[LOGO EPD
PROGRAMME]

4 Additional information

4.2.2 B1 – Use

According to the product category rules for ceramic tiles - EN 17160 (CEN/TC 67 2019), the environmental impacts generated during the use phase are very low and can therefore be disregarded. The ceramic tiles are robust and have a hard and abrasion resistant surface. No environmental impacts are expected during the use phase. 49

49 -Other products might cause emissions to the indoor air, or release substances to the soil and water. These effects should be specified here.

4.2.3 B2 – Maintenance

According to the product category rules for ceramic tiles - EN 17160 (CEN/TC 67 2019), the environmental impacts generated during the use phase are very low and can therefore be disregarded. The ceramic tiles are robust and have a hard and abrasion resistant surface. No environmental impacts are expected during the use phase.

Parameter	Unit	Value
Detergent	ml/l water	0.2
Water	l/m²	0.2
Total cleaning cycles during service life	--	26’000 50

50 -This estimate is calculated as follows:
260 days per year * 2 times per day * 50 years = 26’000 cleaning cycles

4.2.4 B3 – Repair

In general, the lifetime of stoneware tiles is equal to the lifetime of the building. Repair, replacement and refurbishment are not necessary for stoneware tiles. Thus, according to EN 17160 (CEN/TC 67 2019), tiles do not require repairs during the use phase and therefore no impact should be declared in the repair phase.

4.2.5 B4 – Replacement

In general, the lifetime of the stoneware tiles is equal to the lifetime of the building. Repair, replacement and refurbishment are not necessary for stoneware tiles.

4.2.6 B5 – Refurbishment

In general, the lifetime of the stoneware tiles is equal to the lifetime of the building. Repair, replacement and refurbishment are not necessary for stoneware tiles.

4.2.7 B6 – Operational energy use

This module is not relevant for tiles according to EN 17160 (CEN/TC 67 2019).

4.2.8 B7 – Operational water use

This module is not relevant for tiles according to EN 17160 (CEN/TC 67 2019).

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

4 Additional information

4.3 End of life stage (C)

4.3.1 Modules C1 – C4

The end-of-life stage consists of four modules C1-C4. Hereafter more information about the consideration of these modules in the present EPD:

- Regarding C1 – Demolition/ deconstruction: According to EN 17160, this phase is not relevant for tiles.
- Regarding C2 – Transport to waste processing: The deconstructed tile residues are transported by lorry from the construction site to a container or treatment plant. An average distance of 20 km is assumed, in line with the reference scenario of EN 17160.
- 51 C3 – Waste processing for reuse, recovery or recycling: An end-of-life scenario for the waste treatment is defined in the table below.
- C4 – Disposal: An end-of-life scenario for the waste treatment is defined in the table below

Parameter	Unit	Value
Recycled tiles (C3)	%	70
Landfilled tiles (C4)	%	30

52

4.3.2 Circularity indicator

The material circularity indicator (MCI) for 1 m2 of tiles with a weight of 20.6 kg can be calculated as follows based on the guidelines by the Ellen MacArthur Foundation (2015a, 2015b):

- Total mass of the tiles $M_{tiles} = 20.6\ kg$
- Amount of virgin material $V_{tiles} = 20.6\ kg$ (assuming no recycled material is used for production)
- Amount of unrecoverable waste $W_{tiles} = W_0 + \frac{(W_F+W_C)}{2} = 6.18 + \frac{(5.05+5.05)}{2} = 11.23\ kg$
  - with amount of waste going to landfill or energy recovery $W_0 = M \times 0.3 = 6{,}18\ kg$ (based on EoL scenario for C4)
  - with amount of waste generated to produce any recycled content used as feedstock W_F=M*0.7*0.35=5.05 kg (assuming a closed loop where the efficiency of the recycling process used for recycling the product at the end of its use phase, is equal to the efficiency of the recycling process used to produce the recycled feedstock)
  - with amount of waste generated in the recycling process $W_c = M \times 0.7 \times 0.35 = 5.05\ kg$ (based on EoL scenario for C4 and on García-Ten et al. (2015))
- Linear flow index $LFI_{tiles} = \frac{(V_{tiles}+W_{tiles})}{(2M_{tiles})} = \frac{20.6+11.23}{2\times 20.6} = 0.77$
- Product utility $X_{tiles} = \frac{L_{tiles}}{L_{av,tiles}} \times \frac{U_{tiles}}{U_{av,tiles}} = 1$ (assumption due to a lack of data)
- $MCI_{tiles} = \max\left(0, 1 - \frac{0{,}9}{X_{tiles}} LFI_{tiles}\right) = \max\left(0, 1 - \frac{0{,}9}{1} \times 0.77\right) = \max(0, 0.31) = 0.31$

In this case, the MCI is equal to the Product Circularity Indicator as the tiles represent a product and are analysed isolated here.

51 -The "polluter pays-principle" states that emissions caused by the waste disposal in module C4 are part of the product system under study. Yet, if this process generates energy through e.g., incineration, which can substitute energy in the following product system, then these benefits should be assigned in module D as a benefit ”beyond” the system boundary. Please refer to the PCR of construction products and services for more information.

52 -Please note that the sections ”Circularity indicator” and ”Disassembly for recovery, reuse and recycling” are not yet recommended in the PCR on construction products and services. However, the new EN 15804 amendment A2 from 2019 already requires a revision of PCR. In the future, it can be expected that a quantitative assessment of the circularity potential of construction products will become more important..

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

4 Additional information

4.3.3 Disassembly for recovery, reuse and recycling

The design for disassembly analysis of the functional unit of tiles can be seen in the table below. The embodied energy refers to PENRT, while the embodied carbon refers to GWP, both for LC modules A1-A5.

CRITERIA	CERAMIC TILES Embodied Energy per FU 386.62 MJ Embodied Carbon per FU 26.37 kg of CO2 eq. (53)	
	SUB-CRITERIA	WEIGHT
Type of connection	(54) Hard chemical connection – Cement bond	0.1
Accessibility of connection	(55) Freely accessible	1.0
Crossings	(56) Modular zoning of objects	1.0
Form containment	(57) Open, no inclusions	1.0
DISASSEMBLY POTENTIAL		(58) 0.78

This means that the potential design for disassembly of 1 m2 of tiles amounts to:

$$DfD_{tiles} = \frac{(0.1 + 1.0 + 1.0 + 1.0)}{4} \times 386.62\, {}^{MJ}/_{m^2} = 299.63\, {}^{MJ}/_{m^2}$$

$$DfD_{tiles} = \frac{(0.1 + 1.0 + 1.0 + 1.0)}{4} \times 26.37\, {}^{kg\ of\ CO_2eq.}/_{m^2} = 20.44\, {}^{kg\ of\ CO_2eq.}/_{m^2}$$

4.4 Benefits and loads beyond the product system boundary (D)

Module D considers recycling credits for recovered stoneware materials and packaging, as well as energy credits from thermal recovery of packaging waste.

According to EN 17160 (CEN/TC 67 2019), after the demolition/deconstruction stage, ceramic tiles can be crushed and used in a variety of different applications:

- Backfilling for road construction;
- Concrete aggregates;
- When the tiles are crushed, they form recycled ceramic aggregates that can be integrated as a partial replacement for natural aggregate in hot mix asphalt (Zanelli et al. 2021);
- Recycled ceramic aggregates can be used in landfill construction (Zanelli et al. 2021);
- Recycled ceramic aggregates can be used in the construction of base courses in secondary roads (Zanelli et al. 2021).

In Portugal, the recovery rate of ceramic materials from construction and demolition waste is approximately 75% according to the Portuguese Environment Agency (APA 2019)

53 -Embodied energy and carbon are common measures but it is also possible to refer to other embodied impacts.

54 -The tiles are fixed to the floor using cementitious adhesive.

55 -After breaking a couple of tiles to find an entry point, the connection between tiles and floor is freely accessible.

56 -The tiles are laid on top of the floor without being obstructed by other objects.

57 -The tiles are laid side by side and close with the wall.

58 -This means that 78% of the embodied impacts could be recovered.

[LOGO EPD OWNER/ MANUFACTURER]

[LOGO EPD PROGRAMME]

59

References

59 -The last section of an EPD is a list of references that were mentioned within the text of the EPD..

Almeida, M. 2019. Environmental performance of products in the ceramics sector in Portugal (In Portuguese: Desempenho ambiental de produtos no sector cerâmico em Portugal). Doctoral thesis, Aveiro, Portugal: Universidade de Aveiro. https://ria.ua.pt/bitstream/10773/27772/1/Documento.pdf. Accessed February 7, 2021.

APA. 2019. Construction and Demolition Waste - Results 2018 - Recovery rate (In Portuguese: Resíduos de Construção e Demolição - Resultados 2018 - Taxa de valorização). Amadora, Portugal: Agência Portuguesa do Ambiente. https://apambiente.pt/sites/default/files/_Residuos/FluxosEspecificosResiduos/RCD/ResiduosConstrucaoDemolicao.pdf. Accessed July 20, 2021.

CEN/TC 67. 2019. EN 17160 - Product category rules for ceramic tiles. Brussels, Belgium: European Committee for Standardization.

CEN/TC 350. 2011. EN 15942 – Sustainability of construction works – Environmental Product Declarations – Communication format business-to-business. Brussels, Belgium: Comité Européen de Normalisation.

CEN/TC 350. 2019. EN 15804 – Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products. Brussels, Belgium: European Committee for Standardization.

Dias, A.C., L. Arroja, and M. Almeida. 2020a. Product category rules (PCR) - Floor coverings (In Portuguese: Regras para a categoria de produto - Revestimentos de pavimento). Aveiro, Portugal. https://daphabitat.pt/assets/Uploads/rcp/pdfs/19127ea1da/RCP-Revestimentos-de-pavimento_versao-1.1_nov2020.pdf. Accessed March 8, 2021.

Dias, A.C., A. Baio Dias, C. Rocha, F. Freire, H. Gervasio, J.D. Silvestre, and M. Almeida. 2020b. Product category rules (PCR) - Basic module: Construction products and services according to the EN 15804:2012 + A1:2013. Aveiro, Portugal. https://daphabitat.pt/assets/Uploads/rcp/pdfs/3cca8d9f85/RCP-mb_EN-v2.1_2020_18.11.2020.pdf. Accessed March 8, 2021.

Ecoinvent. 2021. Ecoinvent - Life cycle inventory database. https://www.ecoinvent.org/home.html. Accessed January 19, 2021.

Ellen MacArthur Foundation. 2015a. Circularity indicators: An approach to measuring circularity - Overview. https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Project-Overview_May2015.pdf. Accessed November 11, 2020.

Ellen MacArthur Foundation. 2015b. Circularity indicators: An approach to measuring circularity - Methodology. https://www.ellenmacarthurfoundation.org/assets/downloads/insight/Circularity-Indicators_Methodology_May2015.pdf. Accessed February 25, 2021.

García-Ten, F., M. Quereda, C. Albalat, D. Villalba, V. Zaera, and M. Mestre. 2015. Life Ceram - Zero Waste in Ceramic Tile Manufacture. Key Engineering Materials Key Engineering Materials, Vol. 663, pp. 23–33.

ISO/TC 207/SC3. 2006. ISO 14025 - Environmental labels and declarations - Type III environmental declarations - Principles and procedures. International Organization for Standardization.

PRé Consultants. 2021. SimaPro Life Cycle Analysis. https://www.pre-sustainability.com/simapro. Accessed April 19, 2017.

Zanelli, C., S. Conte, C. Molinari, R. Soldati, and M. Dondi. 2021. Waste recycling in ceramic tiles: a technological outlook. Resources, Conservation and Recycling 168: 105289.

Iceland Liechtenstein Norway grants

CIRCULAR BUILDINGS