FutuREuse

The environmental impact of reuse in the construction sector

Belgian Building Research Institute and Centre Scientifique et Technique du Bâtiment for

Interreg
EUROPEAN UNION
North-West Europe
FCRBE
European Regional Development Fund

REUSE IN THE CIRCULAR ECONOMY

In the European Union and around the world, construction materials have a massive impact on climate change, ecosystems collapsing and natural resource overconsumption. As a waste prevention strategy, reuse is a great solution to overproduction and natural resource depletion.

Despite its waste prevention potential, the salvage and reclamation trade is largely overlooked, especially in the context of formal construction projects. Better consideration for this approach in tools widely used by the construction industry would be interesting leverage to foster, support and further develop the reclamation sector.

THE FCRBE PROJECT

FCRBE stands for Facilitating the circulation of reclaimed building elements and aims to increase by 50%, the amount of reclaimed building elements being circulated on its territory, by 2032. The project involves 7 partners:
Rotor, lead partner (BE), **Bellastock** (FR), **Brussels Environment** (BE), **The university of Brighton** (UK), **Salvo** (UK), **Construction Confederation** (BE), **Belgian Building research Institute** (BE) and the **Scientific and Technical Center for Building** (FR)
For more information on FCRBE: *http://www.nweurope.eu/fcrbe*

FUTUREUSE: 7 SHORT INTRODUCTIONS TO THE WORLD OF REUSE

This is one of a series of seven booklets that have been produced to serve as a taste of what the FCRBE project aims to achieve. The subjects span the broad spectrum of reuse, covering considerations before, during and after with useful information to guide and inspire working with reclaimed materials. The booklets also highlight environmental benefits, clarify grey areas and frequently asked questions regarding best practices, whilst sparking curiosity for a future where use is reuse.

CONTENT

Foreword

According to the standard which specifies the stages in a Life Cycle Assessment, EN 15804, all the outputs from disassembly, dismantling, demolition etc. leaving a building must initially be considered as waste and will also attain end-of-waste status if they meet an established set of criteria. However, although this convention determines the system boundary for LCAs, it does not necessarily match the legal position. In legal terms, a material removed with a view to being recovered or reused does not necessarily need to pass through the 'waste' stage after it has been removed.

In some countries, a distinction is made between the terms recovery and reuse. This allows them to distinguish between products which pass through the waste stage and those that do not. However, since all products pass through the waste stage in an LCA, no such distinction is made in that context. The present booklet therefore uses terms relating to recovery and reuse interchangeably.

Introduction

Across Europe, the issue of circular economy and reuse in the construction industry is high on the political agenda. Environmental concerns such as the pressure on primary resources and climate change mean we need solutions so we can move more quickly towards sustainable development in the sector. One such solution is reusing materials. Life Cycle Assessment (LCA) is a tool which helps with decision-making by assessing the environmental impact of building materials, building elements and whole buildings. An LCA quantifies the environmental performance of reusable or reclaimed products, so they can be compared to identify the main factors which will improve this impact.

The present booklet therefore begins by setting out how to quantify the environmental impact of a reclaimed construction product in line with European standards. We go on to show why simply assessing the global warming potential (in terms of the CO_2 equivalent released into the atmosphere) is not enough to give a full overview of this environmental impact. We set out several case studies, and end with some points to note when assessing the environmental performance of reclaimed products.

1.

Measuring the environmental impact of a reclaimed material

Life Cycle Assessment – General Principles

Life Cycle Assessment (LCA) is a method for quantifying a product's environmental impact throughout its life cycle. It is based on drawing up an inventory of inputs (e.g. raw materials, energy resources) and outputs (emissions into the air, earth or water). In the context of buildings and building materials, an LCA usually takes into account the following life cycle stages: production, transportation and installation on site, use, and end-of-life [1].

LCA results are expressed using multiple indicators which reflect potential effects on the environment with regard to a variety of issues. These include for instance global warming, resource and ozone layer depletion [2].

The main principles for the LCA are described in international standards ISO 14040 and 14044. In addition, the European construction sector has specific standards: EN 15804 which applies at product level, and EN 15978 which applies at building level.

Drawing up an LCA can help businesses achieve multiple objectives:

- To identify a product's main sources of environmental impact, throughout its life cycle
- To optimise specific operations and thus reduce their impact, for example when choosing modes of transport, inputs and production methods.
- Drafting an Environmental Product Declaration (see below).

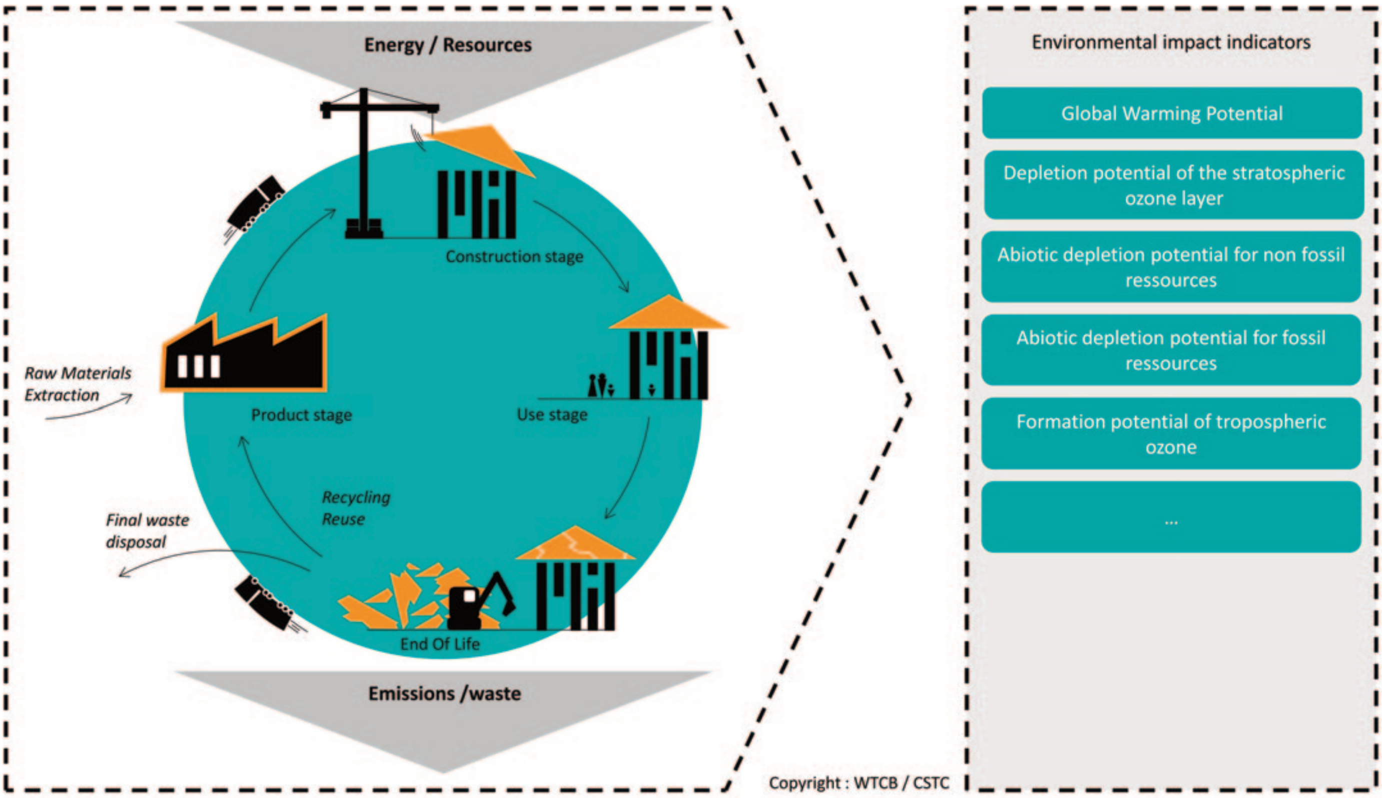


Diagram 001: Shows selected environmental impact indicators reflecting various potential environmental effects of a product during life cycle stages

These general principles also apply to reused products. In some specific contexts, LCAs also help:

- To quantify the value which a reused product adds compared to a new product
- To assess the extent to which reuse is more beneficial than recycling or energy recovery.

The European LCA framework for construction industry products

Standard EN 15804 establishes rules for drafting Environmental Product Declarations (EPD).

Environmental Product Declarations

An EPD[1] "*provides quantified environmental information [using an LCA] for a construction product or service on a harmonised and scientific basis. It also provides information on health related emissions to indoor air, soil and water during the use stage of the building*."[2]

Several European countries have public databases where EPDs issued by manufacturers and professional associations or unions can be recorded and consulted. which to assess the environmental impact of buildings. Each EPD entered can be viewed as a basic unit to use when working out the LCA for a building.

To date, the EPDs entered are mainly for new products. However, there is no reason why EPDs should not be created for reused products and added to these databases.

Construction product life cycles: quantifying the impacts and benefits of reuse

Standards EN 15804 and EN 15978 specify the various life cycle stages for a product or construction, using a modular approach ranging from A1 to C4 (see Diagram 002).

Where a material is recoverable – it can be reused or recycled – and leaves the current life cycle to be used in a subsequent life cycle, EN 15804 establishes the boundary between these two life cycles as the point where waste generated by the first cycle is no longer considered as 'waste' (see box).

COUNTRY	EPD PROGRAMME AT PRODUCT LEVEL		EXAMPLES OF LCA TOOLS AT BUILDING LEVEL
France	INIES	www.inies.fr/accueil	ELODIE ClimaWin OneClick LCA Pleiades ACV ThermACV Béa ArchiWIZARD Vizcab COCON
Belgium	B-EPD	www.health.belgium.be/fr/base-de-donnees-pour-declarations-environnementales-de-produits-epd	TOTEM
United Kingdom	BRE Global	www.greenbooklive.com/search/scheme.jsp?id=246 https://www.bregroup.com/impact	BRE created a specification to consistently measure LCA at building level, it is called IMPACT. There are a number of tools that are IMPACT compliant: ADW Developments, One Click LCA, eTool

Table 1: EPD database and LCA tools applicable at building level

1. In France, EPDs for building and decorating products are called *Fiches de Déclaration Environnementale et Sanitaire* (FDES) and provide information about the product's impact on health and user comfort, and on the environment.

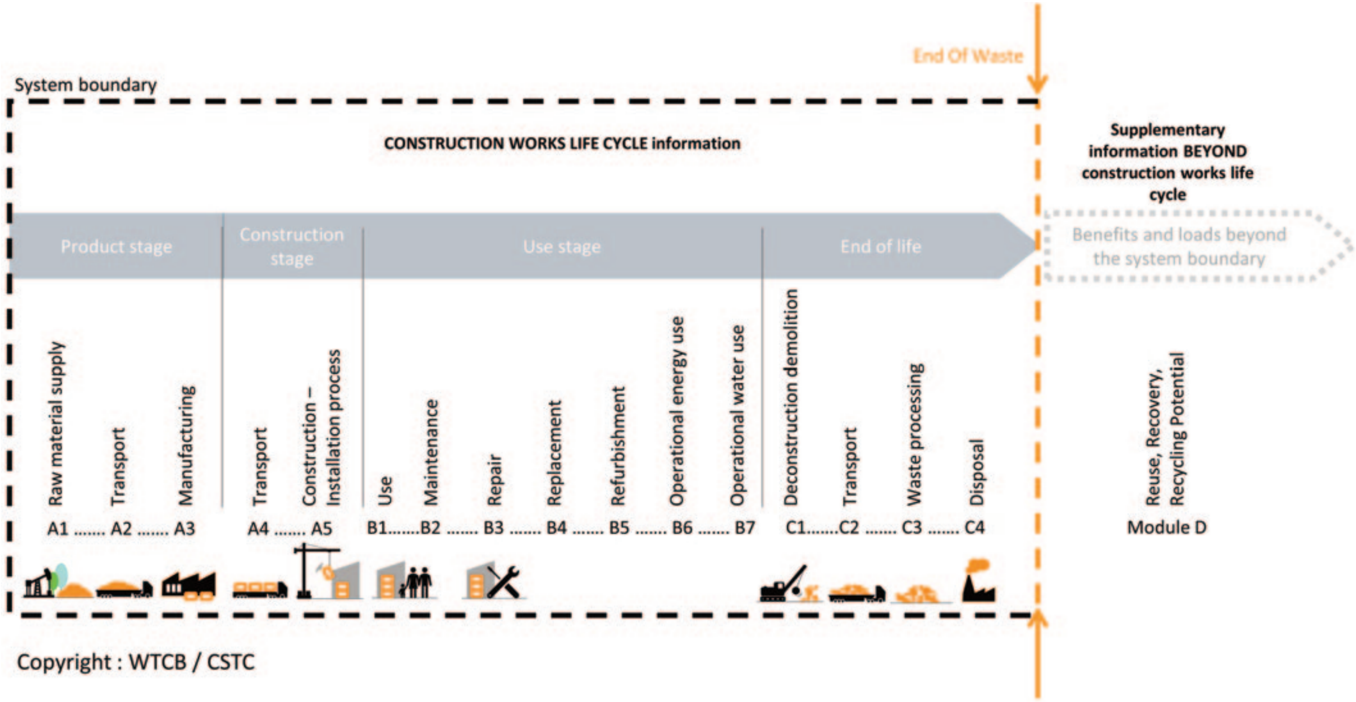


Diagram 002: Distribution of information modules A1 to D across the various life cycle stages according to EN 15804

The recovered material, product or construction element reaches its 'end-of-waste state' where the following conditions are met [2]:

- "the recovered material, product or construction element is commonly used for specific purposes"
- "a market or demand, identified e.g. by a positive economic value, exists for such a recovered material, product or construction element"
- "the recovered material, product or construction element fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products"
- "the use of the recovered material, product or construction element will not lead to overall adverse environmental or human health impacts"

As a result, and in line with the Polluter Pays Principle, all impacts occurring before the end-of-waste state are allocated to the first life cycle (which generated the recoverable waste) and all impacts occurring afterwards are allocated to the second cycle (which uses the secondary material). Thus where items are reused, the first cycle bears all the impact associated with manufacturing the product (such as a removable wall panel), but also benefits from not having to process the waste at the end (perhaps by incineration or landfilling). This processing is avoided because the item is reused. Accordingly, the second life cycle benefits from not bearing the impact associated with primary production (of a new wall panel, for example) and only bears the impact of processes linked to reuse (or recycling). These processes occur after the end-of-waste state is reached (which may be when the wall panel is transported and reconditioned).

This approach brings greater benefit to the wall panel's reuser rather than to the panel's first user who may potentially benefit from this material in the distant future. Usually, the greatest benefit arises from avoiding the use of raw materials to manufacture a new product – and not from avoiding a waste disposal process. Nevertheless, in the aim of promoting circular construction, the standard allows the first user of a reusable or recyclable material to transfer the net benefits generated by that recoverable material into the next life cycle via a specific module: module D. Module D lies beyond the system boundary, and cannot therefore be added to the total results obtained for the production, use and end-of-life stages (modules A,B and C). This module must be considered to contain additional information. Given the long lifetimes of construction materials, there is great uncertainty about the net benefits declared in module D. It is hard to predict how factors such as the rate of effective reuse and the future primary production avoided by using secondary materials (i.e. the manufacturing process, the energy mix) will have evolved in 60 years' time or more.

>> CASE STUDY: A STEEL BEAM

When a new steel beam is installed in a building, all the impact associated with extracting the iron ore, producing the steel in a blast furnace and manufacturing the beam is allocated to the first life cycle. If, when the building is demolished, the choice is made to give the beam a second life cycle by reusing it, the impacts associated with this second life cycle will be limited to the impact of transporting the beam to the second building site (assuming that it reached the end-of-waste stage on the first site). Module D for the new beam would therefore show as avoided impact (benefit), the production of a new beam.

2.

Looking beyond climate change

In Europe today, all eyes are on reducing greenhouse gas emissions, as shown by the global warming indicator in standard EN 15804. However, the LCA is a multi-criteria, multi-stage tool which can be used to assess many environmental impacts and all life cycle stages. This integrated approach can therefore be used to interpret the input processes in greater detail, confirm that the choice of reuse solution brings environmental benefits, and spot any environmental impacts specific to reuse.

Adopting a multi-criteria approach

Standard EN 15804+A1 for construction products and standard EN 15978, which applies to buildings, propose 7 impact indicators and 17 flow indicators across the whole life cycle. The later version EN15804+A2 published in 2019 proposes 6 additional impact indicators.

Examples of impacts that can be studied alongside the global warming indicator are the ozone depletion, acidification of soil and water, eutrophication, abiotic resource depletion, photochemical ozone formation, water and air pollution. By monitoring flow indicators, it is possible to analyse consumption of primary energy – renewable or non-renewable – or water; waste – hazardous or non-hazardous; and the quantity of components and materials intended for or arising from reuse or recycling.

Since it is difficult to negotiate a large number of indicators, and therefore parameters, at the same time, the selection of some relevant indicators will allow us to visualise possible compromises and help make decisions about reuse processes and construction choices.

The indicators associated with flows of materials, waste, and resource depletion are likely to be of interest when analysing the reuse potential of a product or building, or the environmental impact which could be avoided or caused by a reused product.

The following indicators can be used to show the value of efforts made upstream by a project owner who plans to deconstruct a building and make products available for reuse:

- Components for reuse, in kg: this directly visualises the total quantity of elements intended for a second life cycle.
- Non-hazardous waste disposed, in kg: a lower value under this indicator for a deconstruction solution with reuse scenario rather than waste disposal in landfill may underpin the indicator 'Components for reuse'. Yet we must ensure our analysis is in-depth, because a low value for this indicator may also be due to a significant quantity of hazardous waste, waste having been recycled, or even the design of the building for deconstruction being optimised to limit waste.

The upstream client may also quantify the deployment of reused components using the following indicators:

- Use of secondary materials, in kg: this indicator quantifies the elements from reuse. Once again, a more in-depth analysis will be required because this indicator also shows the use of materials from recycling.
- Depletion of abiotic resources (elements), in kg of antimony equivalent: this indicator shows the resource extraction from the available stock, excluding any anthropic stock, i.e. excluding resources contained in human-generated waste products and materials. The scarcer the resource, the more the indicator will reflect how critical it is to extract a resource available from a small stock.

Adopting a multi-stage approach

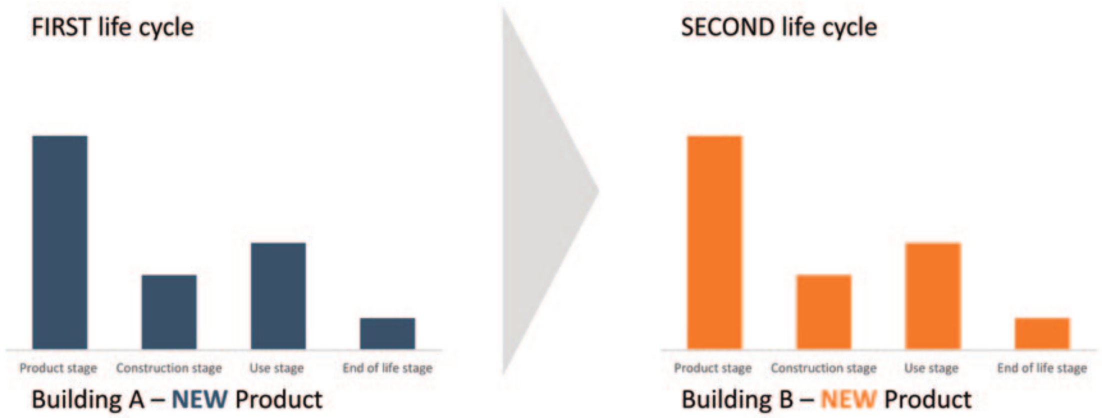
The multi-stage vision comprises studying all stages of the life cycle without focusing solely on the production stage. When we alter one of the parameters studied, impacts may be transferred from one life cycle stage to another.

Making a product available for reuse or reusing a product may change the stages in the first product life cycle, and also in the second. For instance:

- A selective upstream deconstruction stage may mean labour move and energy-consuming tool use
- A logistics transfer stage may occur, either via an intermediary or directly to the next building site
- An upstream sorting, refurbishment and/or reconditioning stage may be introduced. This upstream stage might involve sanding down or blasting, replacing worn parts, applying a new protective coating to a wooden or metal item.
- Equally, technical performance checks may be conducted throughout the above stages.

Diagram 003 shows an LCA comparison between two scenarios to show how the point where the impact sits shifts between life cycle stages. The first scenario does not involve any reuse. Building A and building B are built independently of one another, and each uses a new product. The second scenario shows a product taken from building A when it was dismantled being redeployed in building B.

1st scenario: No reuse. Installation of a new product in building A, then installation of a new product in building B



2nd scenario: Reuse. Installation of a new product in building A, then reuse of the product in building B

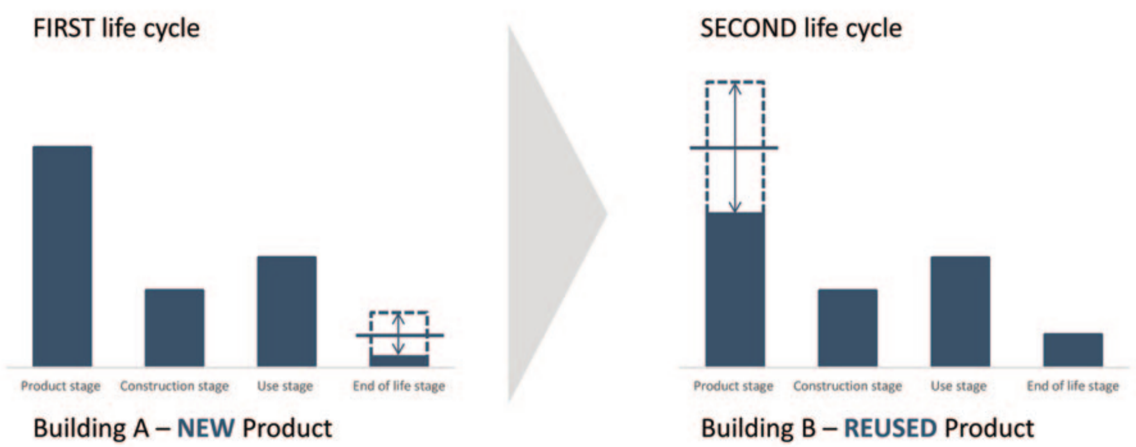


Diagram 003: Comparative Life Cycle Assessment between one scenario without product reuse and one scenario with reuse.

In most cases, the second scenario – with reuse – will demonstrate a clear environmental benefit, although some additional impacts may occasionally be generated. However, checks must be performed to ensure:

- That additional, end-of-life impacts are not created by an overly complex logistical circuit, a dismantling method which still generates too much waste or uses disproportionate resources, or by adding non-reusable packaging to the reused product.
- That the remanufacturing process generates less of an impact than manufacturing a new product would.

The specific case of reusing wood-based products (and other products of organic origin)

Assessing the impact of wood-based products on climate change is relatively complex. Besides the conventional parameters used for LCAs, the underlying logic here also involves the idea of biogenic carbon. In order to fuel their growth, plants metabolise the CO_2 present in the atmosphere through photosynthesis. Trees are thus a major carbon reservoir, and continue to play this role even when cut down and processed into consumer products. This explains why many LCAs for wood-based products show negative values in the production stage. These negative values denote the quantity of carbon captured and sequestered by plants (biogenic carbon). Yet this reasoning is only valid on two conditions:

- The wood used must be from sustainably managed forests, and a new tree must be planted to replace the original one. The forest management must also comply with this resource renewal rate. In spite of responsible local forest management efforts, there is a global trend towards deforestation and replacing forests with urban or agricultural areas.
- The wood-based product must not release the biogenic carbon it contains too quickly. It should be noted that wood-based products must be kept in circulation for as long as possible if they are still to play their carbon storage role and avoid releasing greenhouse gases (CO_2 and/or methane).

Reusing wooden elements plays an important role in maintaining the carbon stored in the built environment over the long term. Reuse provides an alternative to incineration and to the wood producing methane.

However, assessing the overall environmental impact of a wood-based construction element must also take transport into account. Some batches of wood for reuse which are available in north-west Europe will have been imported from North America (e.g. barnwood) or Southeast Asia. These long journeys have repercussions on the global impact. It may be more beneficial to turn to local industries involved in responsible resource management than to import wood for reuse from the other side of the world.

We would also like to emphasise the heritage aspect of wooden building elements and the fact that the market for reuse can be a source of wood not otherwise available locally. One example would be African ekki wood reclaimed from its initial use in shipping. These factors are hard to quantify and go some way beyond the issue of a carbon balance.

In conclusion, we consider that in most cases reusing wooden elements is a strategy which can extend the lifetime of existing materials and conserve the biogenic carbon stored in wood-based construction products. This strategy also helps relieve the current pressure on forests.

3.

The practical benefits and impacts of reuse

Reuse vs. other approaches

There are many environmental benefits of reusing as opposed to recycling or reusing materials as opposed to new materials. Diagram 4 shows how reuse can eliminate the impacts associated with both extracting raw materials such as iron ore and manufacturing products such as steel beams. In contrast, recycling allows savings to be made in terms of extracting raw materials like iron ore, but still requires a manufacturing stage such as melting down and reshaping into a beam. Thus the savings to be made by reusing rather than recycling can be significant. It is therefore much more environmentally beneficial to reuse a steel beam than it is to melt it down and recycle it into a new bar. The main advantage of a reused material over a new, reusable material is that it saves on environmental impact immediately, rather than making hypothetical future savings.

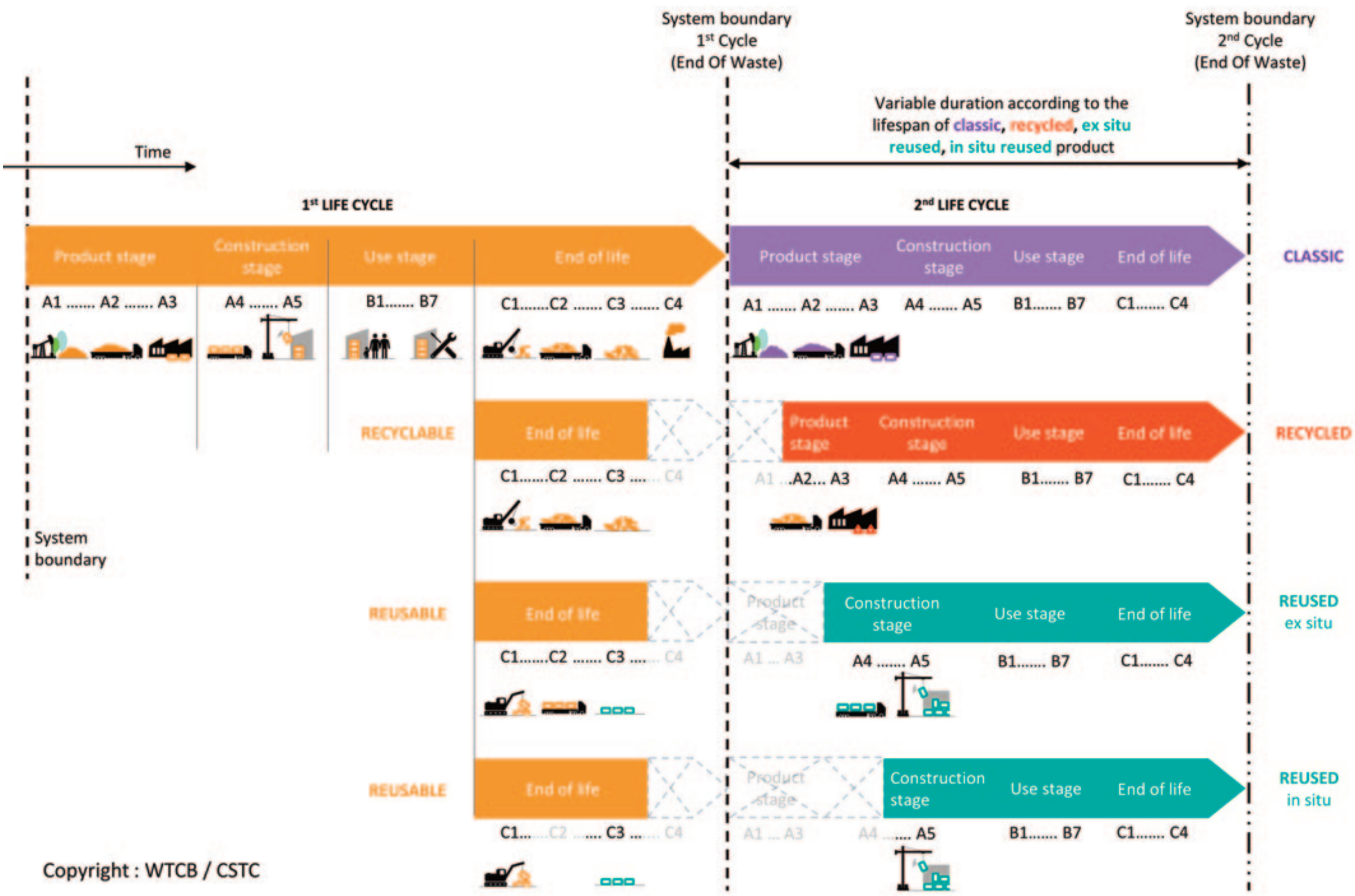


Diagram 004: The impact of recycling and reuse on life cycle modules

Case studies

Below are two case studies to show the benefits of reuse. Each covers a different period: 60 years for the bricks and 10 for the carpet tiles. The results are the aggregated scores from the impact indicators specified in EN 15804+A2, section C.4, normalised and weighted according to the PEF method (http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml).

Normalisation : Expression of the results from various environmental impact categories in relation to a common reference [1]. For example, with the PEF method, the normalisation reference is the total European impact for a given impact category over one reference year. [3].

Weighting: Once the results of the various environmental impact categories have been normalised, they are multiplied by different weighting factors to reflect the relative importance of the various indicators [1].

Aggregation: the aggregation stage involves totalling up the results obtained for the various impact categories (eventually after weighting and normalisation) to attain a single score in figures.

Environmental impacts: the reuse of bricks

Figure 001 compares the environmental impact of a $1m^2$ wall built using:

- Reused bricks, 95% recycled at end-of-life
- New bricks, 95% recycled at end-of-life
- New bricks, reusable at end-of-life (reuse rate estimated to be 57% at end-of-life).

Table 2 gives an overview of the main assumptions used to calculate the benefits and impacts associated with recycling or reuse (module D).

	RECYCLING	REUSE
Recycling/reuse rates	95%	57%
'End-of-waste' state reached/ boundary between cycle 1 and cycle 2	After being crushed at the recycling centre	After being cleaned at the recycling centre
Avoided impact beyond this life-cycle boundary due to reuse/recycling (module D)	Production and transportation (100 km) of primary aggregate (for highways use)	Production and packaging of new bricks
Impact associated with reuse/recycling allocated to the next cycle (module D)	Transportation of secondary aggregate (30 km)	Packaging of reused bricks

Table 2: Overview of the assumptions made to calculate the benefits and impacts associated with brick recycling or reuse (module D).

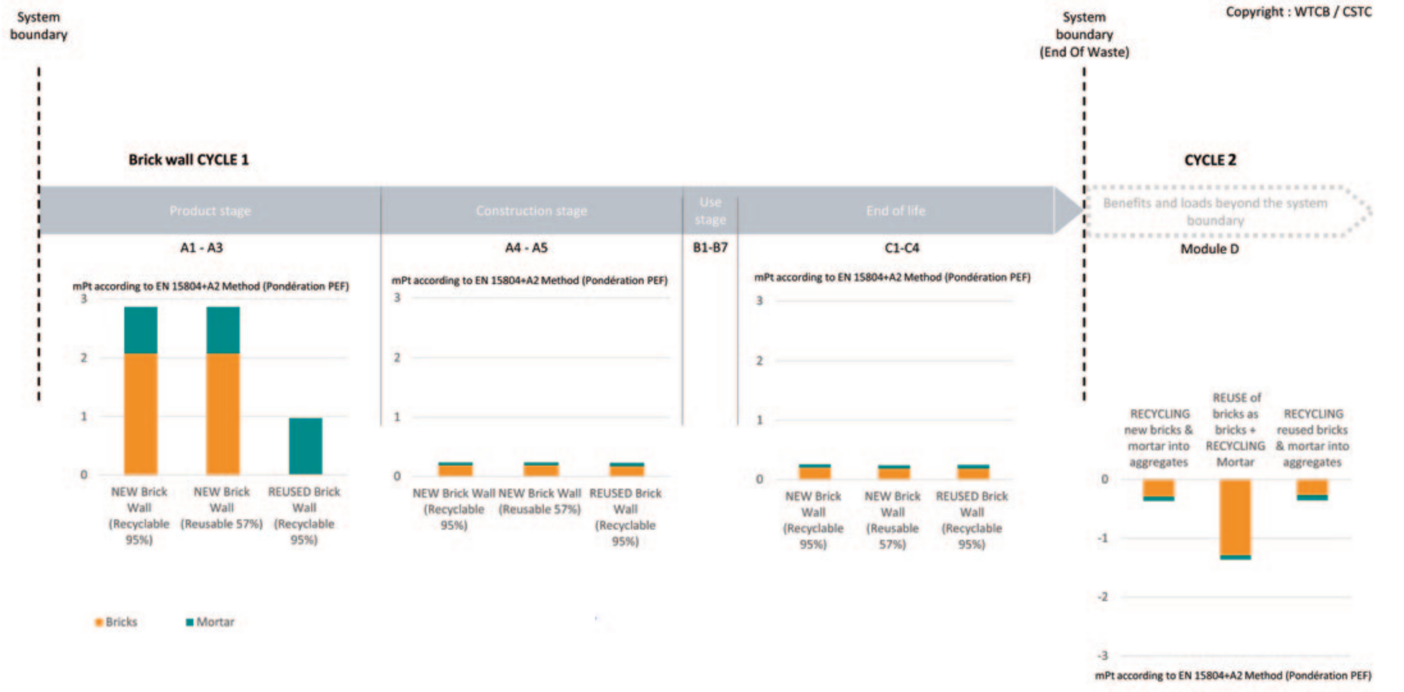


Figure 001: Comparing the environmental impact of three 1m² walls built using new recyclable bricks, new reusable bricks and reused bricks

The results show that the impact associated with the new-brick wall was considerably greater than that associated with the reused-brick wall. The main difference is due to the impact for brick production. The production stage for the wall with reused bricks only comprises the impacts from mortar production and brick packaging, since the impact from producing the bricks themselves (extracting the clay and firing the bricks) was taken into account during the first life cycle.

Module D shows that the environmental benefit to the next life cycle from reuse (i.e. not making new bricks) will be greater than the benefit from recycling (i.e. not producing primary aggregate). Brick production has a greater environmental impact than quarrying and crushing rocks. Yet it is not certain that this impact will be avoided in the next life cycle, which is predicted to begin 60 years from now. We therefore advocate prioritising an immediate reduction in impact by employing reused bricks now, rather than hypothesize that the bricks will be reused in 60 years' time.

Environmental impacts: Reuse of carpet tiles

In this example, we study the environmental impact of covering 1 m² of floor with:

- New carpet tiles, using adhesive on the concrete screed finish, incinerated at their end-of-life (Option 1).
- New carpet tiles, loose-lay, reusable at their end-of-life (Option 2).
- Reused carpet tiles, loose-lay, incinerated at their end-of-life (Option 3).

Given that the use stages for each of these three options are identical, they are not considered. For reusable tiles (Option 2), the study assumes a reuse rate of 70%. The tiles are assumed to have reached their end-of-waste stage after they have been cleaned at a specialist centre. In this instance, the avoided impact during the next life cycle – accounted for in module D – is the production of new carpet tiles.

Figure 002: Comparing the environmental impact of three 1m² floor coverings: reused loose-lay carpet tiles; new carpet tiles with adhesive; and new loose-lay carpet tiles.

On the basis of Figure 002, we can see that the environmental impact of tile production for the reused tiles is much smaller than the impact for the new tiles. This is because all the impact for producing the reused tiles has already been allocated to the first life cycle. We can also see that there is little difference in impact between the new tiles with adhesive and the new, loose-lay tiles. However, the difference in fitting method does significantly influence the end-of-life stage. The tiles with adhesive cannot be reused, and are incinerated. The overall impact from the new tiles with adhesive (impacts from modules A+B+C) is therefore greater than that from the new, loose-lay tiles.

Module D for the carpet tiles incinerated at end-of-life (both the reused tiles and the tiles with adhesive) corresponds to the avoided impact (production of electricity and heat from fossil fuels) due to the usable energy generated during incineration (Incineration rate 95%, calorific value for bitumen: 30.06 MJ/kg and calorific value for plastic: 30.79 MJ/kg). For the new, reusable tiles (reuse rate estimated at 70%), the impact avoided during the second life cycle corresponds to the production of new tiles. This remains hypothetical, since that life cycle is predicted to begin in 10 years' time.

4.

Reuse in perspective

An LCA gives a broader perspective on the potential impact of reusing a product. But taking into account the specific circumstances of reuse also means considering aspects not yet included in current LCA methods.

Assessing the lifetime of a reused product

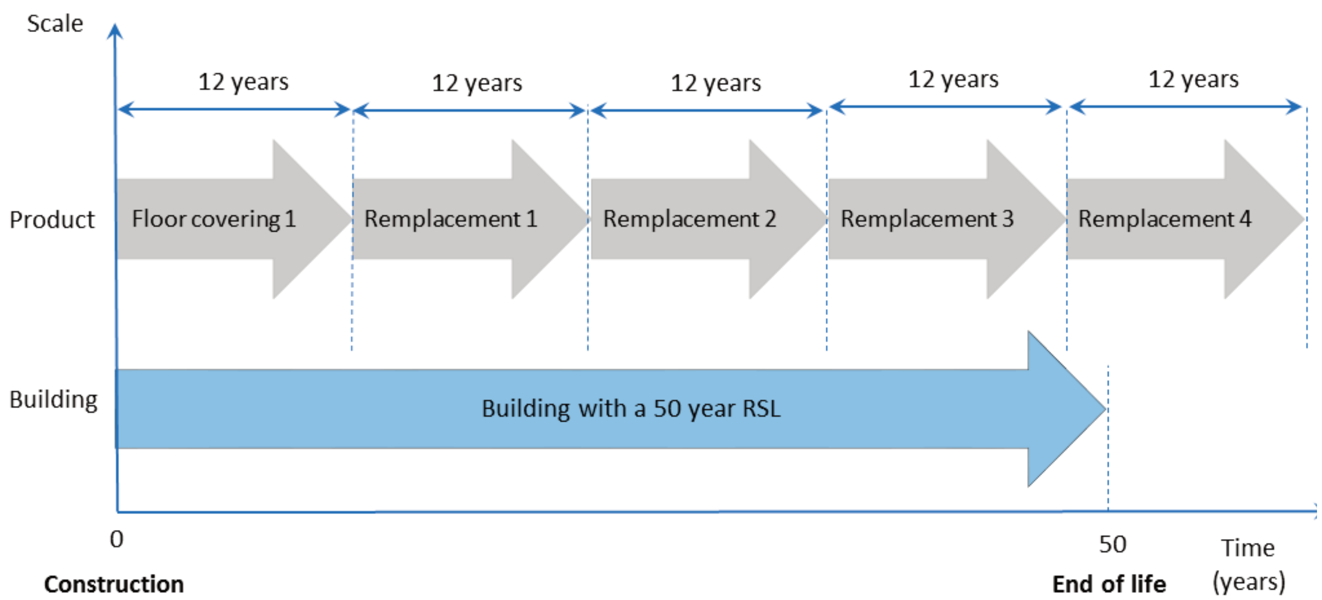
Standard EN 15804 takes into account the lifetime of new products, which it describes as their Reference Service Life (RSL). Environmental impact is calculated for a product's whole RSL. The concept of RSL is especially important at the whole-building level, since this will make it possible to ascertain the number of product replacements over a building's lifetime.

Examples of taking the RSL into account at building level:

A floor covering has a RSL of 12 years. It is installed in a building with an RSL of 50 years. Given the floor-covering replacements, the impact of the floor coverings to take into account at building level (see Figure 3) will be:

$$\text{Totalimpact}_{\text{Coverings}} = \text{Impact}_{\text{Covering}} \times (1 + \text{number}_{\text{replacements}})$$

Depending of specific national regulations, the total may be the result of the division or the whole number, rounded to the upper unit.



Source illustration CSTB

Figure 003: Replacements of a construction product during the life cycle of the building

The RSL for a new product is calculated on the basis of a set of criteria. These criteria are based on product standards, the CE mark, their suitability for use, and good practice during installation and use. When an EPD is drafted, the manufacturer may refer to specific requirements for the market on which the product is distributed.

Parameters determining service life according to [2]:

- Declared product properties (at the gate) and those of any finishes, etc.
- Design application parameters (if instructed by the manufacturer), including references to any appropriate requirements and application codes.
- An assumed quality of works
- External environment, (for outdoor applications), e.g. weathering, pollutants, UV and wind exposure, building orientation, shading, temperature.
- Internal environment (for indoor applications), e.g. temperature, moisture, chemical exposure
- Usage conditions, e.g. frequency of use, mechanical exposure
- Maintenance, e.g. required frequency, type and quality and replacement of replaceable components.

The RSL for a reused product must be assessed, because it might not match the RSL for a new product. In so doing, you might ask the following questions:

- Is my reused product capable of meeting the same product standards and requirements as a new product, and can I guarantee the safety of building occupants? If so: You may be able to apply the same lifetime as for a new product.
- If not, ask: Am I able to determine other tests which would allow me to establish and justify a different RSL?
- If my reused product will not be used in the same way as the new product from which it originates, what are the requirements for its use?

Sample RSL justification:

The company Mobius [5] drafted the EPD for its product – 1m² of reused, uncoated technical flooring. It applied the same tests to this reused flooring as it applies to new technical flooring, and the reused flooring met the requirements. The company also stated the requirements for the product to be used in the building, in the context of the French market, and the RSL of 25 years was retained.

RECYCLING	VALUE
Reference Service Life	25 years
Declared properties of the product at the factory gate	Product with a load rating compliant with standard EN 12825
Design application parameters	Product compliant with standard EN 12825
Assumed quality of works	Installation compliant with French standard NF DTU 57.1 – Raised access floors
External environment	The product is not exposed to an outdoor environment
Internal environment	The product must be fitted in accordance with French standard NF DTU 57.1 stating requirements for raised access floors created, using movable panels on a height-adjustable structure
Usage conditions	The product is intended for pedestrian traffic
Maintenance	The product does not require maintenance

Source [5]

Table 3: Illustration justifying the reference service life of a reused technical floor

The key factors in evaluating Module D

Assessing the benefits and impacts beyond the system boundaries (module D) for a reusable element and quantifying the impact of a reused product are based on numerous hypotheses which may have a significant impact on the results, such as:

- The reuse rate
- The end of waste state
- The substituted primary materials
- The point of functional equivalence

The reuse rate is an essential element, since it can be used to determine the quantity of product which can be used again in the next life cycle, and therefore the quantity of primary material avoided in that next cycle. The higher the rate, the more circular the material use. This parameter indicates the level of circularity for the product being assessed [4]. However, it is not always straightforward to determine this in advance, because it depends on the condition the element is in once it has been removed. The required technical performance has to be guaranteed to use the product for the second life cycle.

It is often difficult to determine the end-of-waste state, but this is also a factor in determining the allocation of impacts to the first life cycle (new, reusable product) or the second (reused product). Take the example of tiles intended for reuse: The end-of-waste state can be assumed to have been reached either on the demolition building site, or after cleaning and reconditioning. In the first case, the impact of transporting and cleaning the tiles will be allocated to the reused tiles (the second life cycle), as shown in Diagram 005 (point EOW 1). In the second case, it will be allocated to the new tiles (first life cycle) (point EOW 2 on Diagram 005).

In order to assess the environmental impact beyond the system boundary, it is also necessary to establish which primary material has been replaced by secondary material. This is not always easy. A secondary material can replace several primary materials, each of which has a different environmental impact. Hence in the case of a wooden stair tread which is to be reused, it may be employed in place of a virgin wood stair tread, or as a windowsill in place of a stone or thermostatically coated steel windowsill. The impact thus avoided, reported in module D, will be very different depending on what the wooden stair tread is replacing.

Besides determining which primary material has been replaced, you must also establish whether the reused product can perform all the same functions as the new product (whether it has reached the point of functional equivalence). In the above case of tiles, you might consider that functional equivalence has been achieved after the reused tiles have been cleaned (point FE 1 on Diagram 006). Yet in Belgium the transportation of new tiles to a building site usually involves a greater distance than the transportation of reused tiles (there are no tile

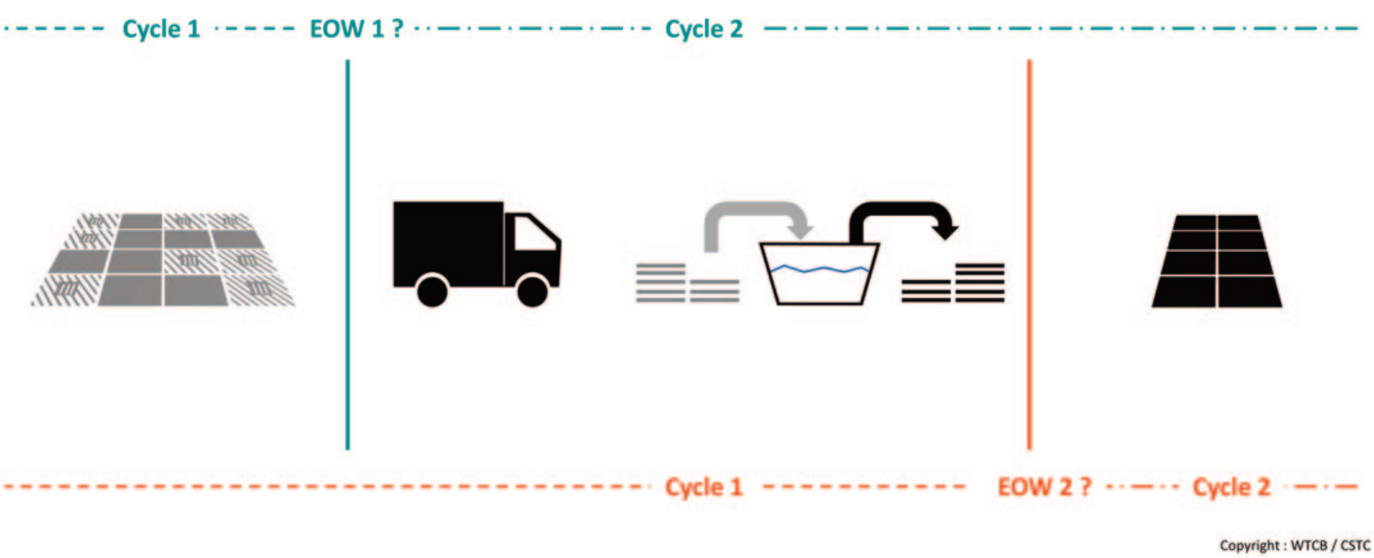


Diagram 005: Assessing the end-of-waste state for reused tiles

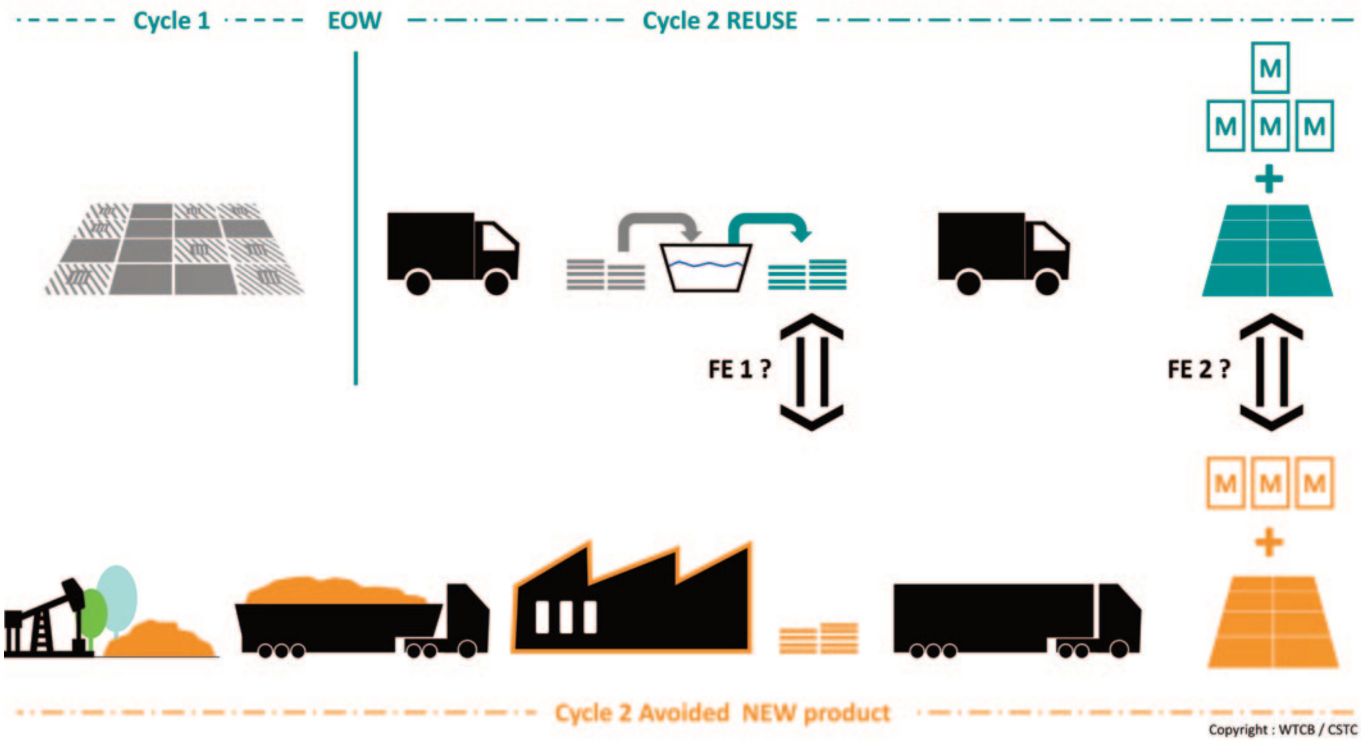


Diagram 006: Assessing functional equivalence for reused tiles

factories in Belgium, but there are many old buildings). Also, compared with new tiles, a larger quantity of mortar will be needed to affix reused tiles. The point of functional equivalence would therefore more correctly be placed after the tiles have been fitted at the new site (point FE 2 on Diagram 006).

Indicators of resource scarcity: Keeping an overview and examining other potential benefits

We saw above how reuse can remove the need for resource consumption. However, it must be noted that environmental indicators linked to resource depletion are much more finely balanced in the case of scarce resources, or resources which are complex to extract; this is often in the context of global stocks. Zinc, silver, gold and copper are examples of such resources: if these are present in a product, they will have a major effect on the indicator for resource depletion.

For so-called abundant resources, for instance where a reused product contains clay or stone, the LCA will need a more localised study of resource availability. In that case, it will be worth asking the following questions:

- Is there pressure on the availability of the resource in question at local level?
- Can I benefit financially from avoiding transporting a primary material? For example, the cost of transporting concrete granules in France doubles every 100 km. Reducing transportation will also help reduce environmental impact.

Other additional points for study could include considering and analysing the socioeconomic impact at local level – especially any contribution to maintaining or creating local jobs, maintaining knowledge and skills, and conserving materials of cultural value.

Encouraging producers to take charge of products' end-of-life

People drafting LCAs for construction industry products often find that producers have not taken responsibility for the products' end-of-life. By default, scenarios are drawn up on the basis of generic national or European-level data, and often based on disposal by either landfill or incineration. European Commission Directive no. 2008/98/EC of 19 November 2008 on waste introduces the concept of Extended Producer Responsibility or EPR. This obliges the producer to assume responsibility for the end of their products' lives either by making a financial contribution to a producer responsibility organisation which will manage the end-of-life treatment, or by making a financial and technical contribution to end-of-life management streams that is to say by organising the processing streams themselves.

Where a producer wants to claim their product can be reused, this reuse can only be considered in an EPD if they can prove that it actually occurs. The producer is therefore responsible for taking action on this, within the limits of what is technically and financially possible.

This action could include:

- Producers interacting with end-of-life stakeholders to keep up-to-date with their activities on reuse and to raise awareness among them of reuse
- Expanding and taking charge of their own recovery and reuse streams
- Teaming up with other reuse stakeholders

Conclusion

In recent years, environmental efforts in the construction industry have focused on the use phase and on reducing the energy consumed by building occupants. However, half of the environmental impact throughout a building's life cycle comes from the materials it is made with, and in particular from their manufacture. That is why reuse has emerged as a major concern, both as part of the circular economy and for the whole construction industry. We have seen that European standards now offer a framework for the environmental assessment of construction products using Life Cycle Assessments. Although this method is now mainly applied to new products, it should also be applied as a basis for reused products. The examples comparing LCAs for items reused, recycled and disposed of show how much there is to be gained from reuse, especially through the immediate reduction in environmental impact. The gains include saving materials, removing the production step and replacing it with a much more modest refurbishment stage, and eliminating the impact associated with waste disposal and incineration.

Developing and reinforcing the reuse activities already underway will bring direct short-term and medium-term benefits. For instance, it may be interesting if public authorities, research centres and corporate stakeholders were to organise a joint, coordinated campaign. The campaign would use standardised methods to take an objective look, through their own practice, at the environmental impact of reusing products already on the market. This approach would demonstrate one of the major projected benefits of reuse, verified through case studies: it helps reduce the environmental impact of the construction industry.

These benefits could be greater still if construction product manufacturers took charge of the end of their products' lives and worked to improve their reusability.

Beyond the product level, reuse still holds great potential for further research, for example into resource scarcity indicators. The results of this research could benefit the LCA methodology, the wider construction sector and the whole manufacturing industry.

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WITH THANKS TO

Michaël Ghyoot, Sébastien Paulet and Susie Naval from Rotor, Laetitia Delem, Lisa Wastiels from BBRI and Mona Nasseredine from CSTB for their review and contribution on the content.

AND ALSO TO

Sara Morel and Becky Moles from Salvo (United Kingdom) for their work on the English version.

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