Interreg North-West Europe
FCRBE
European Regional Development Fund

REUSE IN GREEN BUILDING FRAMEWORKS

Interreg NWE 739 - FCRBE

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This report has been produced as part of the project Interreg NWE 739: *Facilitating the Circulation of Reclaimed Building Elements (FCRBE)*, October 2018 - January 2022. It corresponds to Deliverable WP.LT.D.1.3 'A report on the integration of reuse in existing green building certification schemes'.

http://www.nweurope.eu/fcrbe

This document also benefited from the support of the European Regional Development Fund through the Interreg NWE programme, and the Brussels-Capital Region through the PREC programme.

The FCRBE project is a partnership between Bellastock (France), the Belgian Building Research Institute (Belgium), Brussels Environment (Belgium), the *Centre Scientifique et Technique du Bâtiment* (France), the Construction Confederation (Belgium), Rotor (Belgium), Salvo (United Kingdom) and the University of Brighton (United Kingdom).

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Introduction

The Interreg FCRBE project aims to Facilitate the Circulation of Reclaimed Building Elements in North-Western Europe. This deliverable is part of an activity aiming at consolidating the long-term effects of the project by stimulating a favorable framework for reuse in the construction industry. This activity targets on one hand 'hard' policy makers, for whom roadmaps and recommendations (including those related to the regulatory framework) are addressed[1]; and on the other hand 'soft' policy makers, which are seen as organisations that have an impact on the practices of the industry through the tools, instruments and frameworks they develop.

This document focuses more specifically on decision-making support frameworks that help building owners, designers and specifiers in general to develop 'greener' and more sustainable buildings. All these frameworks have a common objective to accompany building developers to make better decisions and opt for more sustainable solutions through the design and built phases of a building project. Some of these frameworks result in a final rating or even a certification (usually involving some sort of third-party assessment). Others are only intended to support iterative decision-making throughout the design process without necessarily resulting in a rating or a global score.

All these frameworks cover a wide range of themes related to sustainability in the largest sense of the term. The purpose of this report is to analyse to what extent these frameworks address the topic of reusing building materials - and if so, how they do it and how much it weighs in the global rating (if any). As a result of this analysis, we elaborate a series of recommendations for sustainable frameworks developers on how to improve the integration of reuse into these frameworks and rating systems.

Reuse: a crucial facet of the circular economy

The circular economy can be defined as an economy based on activities that contribute to extending the use-value of existing goods[2]. Circular economy is often contrasted with linear economy, which characterises most of the mainstream economy. Linear economy structurally hinges on the sale of newly manufactured goods, which are usually swiftly used and discarded. By opposition, circularity aims to extend the life cycles of products as long as possible, in order to reduce the pressure on raw resources, prevent waste and avoid the environmental impacts related to the production of new goods.

Some of the core principles of the circular economy echo the waste hierarchy enforced by the European Union in the Waste Directive, according to which waste prevention must be prioritised over waste generation, management and elimination[3]. Reuse is usually mentioned as one of the main strategies to operate the transition towards more circularity in the construction industry (alongside repairing, remanufacturing, upgrading...). It is also in complete accordance with the waste hierarchy and its focus on prevention. Reuse indeed contributes to maintaining and lengthening the use-value of building materials and products when the building to which they belonged must be demolished (partially or totally).

Once dismantled from the building, reclaimed building materials usually involve light operations such as cleaning, sorting, restoring... These operations are a good way to foster local economic activities. They also contribute to preserving the cultural value of the materials - beyond the mere environmental benefits.

In practice, 'reuse' is sometimes mixed up with 'recycling' - i.e. a waste management strategy

1 See 'A roadmap to foster reuse pratices in the construction sector : a collection of inspiring actions for public authorities' published by the Interreg FCRBE project (https://www.nweurope.eu/FCRBE).

2 'The circular industrial economy manages stocks of manufactured assets, such as infrastructure, buildings, vehicles, equipment and consumer goods, to maintain their value and utility as high as possible for as long as possible; and stocks of resources at their highest purity and value.' Walter R. Stahel, *The Circular Economy*. A User's Guide. London, New York: Routledge, p.6.

3 Waste Directive 2008/98/CE - Art 4.1

consisting in transforming building materials and products back into raw materials, often by means of chemical and physical transformations. This confusion is detrimental to reuse.

It is estimated that the salvage and reclamation trade is declining in NWE. A better consideration for this approach in existing tools widely used by the construction industry would be an interesting leverage to foster, support and further develop the reclamation sector and reuse practices in general.

The following table summarizes two important phases for reuse: reclamation and reuse.

STRATEGY	***DETAILS***
Fostering the reclamation of reusable building materials	**Objective**: avoiding wasting reusable building materials by identifying their potential to be reused (either on the same site or somewhere else) **Phase**: prior to the demolition (partial or total) of an existing building Main actors concerned: building owner(s) and contractor(s) in charge of the demolition works **Actions**: • Conducting a reclamation audit prior to the works • Planning a careful dismantling phase during the demolition works • Dismantling carefully the concerned batches of materials, in light of reusing them In most cases, this will be considered as a strategy to prevent the production of demolition waste by keeping existing resources in circulation and in use.
Encouraging the use of reclaimed building materials in renovation and new building works	**Objective**: maximising the quantity (by volume or mass) of reclaimed building materials likely to be reused in a new project development **Phase**: construction of a new building or renovation works of an existing building Main actors concerned: building owner(s), architect(s), contractor(s) and indirectly, suppliers **Actions**: • Sourcing of reclaimed materials, either from the same site or from other sources (such as reclamation dealers) • Integration into the building project[4] In most cases, this will be considered as a strategy to lower the environmental impact of construction by using reclaimed materials instead of new materials with a higher environmental impact.

Main strategies to foster reuse at the different steps of a building life cycle.

4. To learn more about the different sourcing strategies and integration steps, read the Reuse Toolkit: Procurement strategies, published by the Interreg FCRBE Project (https://www.nweurope.eu/FCRBE).

As we will see in the analysis, other forms of 'reuse' are also mentioned in different Sustainable Building Frameworks. Although these are fully complementary to the reuse practices defined above, they are not directly the focus of the FCRBE project and, therefore, they are not directly addressed in the present report.

STRATEGY	*DETAILS*
Facilitating the future reuse of building elements	**Objective**: designing buildings that can evolve with future changes without wasting resources. It covers different approaches such as keeping apart the different layers (structure, skins, etc.), opting for reversible connections, capitalising information about building components, etc. **Phase**: design **Actors**: designers
Fostering the use of construction waste	**Objective**: using left-overs, unused materials, etc. Although it is an interesting resource management strategy, this approach should not be confused with reuse as it targets materials that have not been used yet. **Phase**: construction or renovation **Actors**: mostly contractors (who sometimes already have their own internal system to deal with these materials) and manufacturers who implement different forms of take-back solutions
Fostering best practices in terms of waste management among the future occupants	**Objective**: organising the future building space in order to optimize the household waste management by future occupants. This approach targets a waste flow completely distinct from that of building materials. **Phase**: design / occupancy **Actors**: architects

Other strategies involving reuse.

Green buildings frameworks

There are many different sustainability frameworks being used in the construction industry. They all allow building designers, developers and stakeholders to measure their efforts in developing greener buildings. That is, buildings that consume less energy, use resources more efficiently and limit their impact on the environment during a building's whole life cycle. The exact scope and specific areas of focus vary for each framework, and they increasingly include strategies and actions that relate to the notion of circular economy in the wide sense of the term: reusing resources, but also fostering recycling practices and designing for future change, etc.

They usually involve a system with different levels of achievements. Some of these schemes are coupled with a certification system, resulting in a dedicated label being affixed to the buildings to reflect the commitment of its developers[5].

These systems have an influence that goes further than the scale of specific projects. Since they rely on well-defined sets of standards, some of them have become genuine tools for policy-making. In some regions, regulators have adopted the

5. Note that not all the labels used in the construction industry are supported by a certification system.

protocols defined in specific green building rating systems or sustainability frameworks to set mandatory standards. They are also increasingly used in public procurements to set ambitious goals in terms of sustainability, circularity and exemplarity.

In this regard, they are powerful tools to foster the development of reuse practices in large building projects.

Most of these frameworks are in constant evolution. New versions are increasingly integrating circularity, which reflects a major trend in the construction industry. After a strong focus on the energy performance of buildings in use (which was the main source of GHG emissions), new concerns are now addressing the GHG emissions and other environmental damages arising from the production of new materials.

Research methodology

To conduct this research, we made a first selection of existing frameworks. The decision criteria are mostly based on the relevance for the FCRBE Interreg NWE project's covered area (either because the framework has been developed within the area or because it is widely used in the area).
This report analyses the following frameworks:

1. BREEAM
2. LEED
3. HQE
4. BCCA
5. DGNB
6. GRO
7. Level(s)

Each framework has been analysed through the scope of reuse practices. This work has been conducted based on the most recent versions of the labels freely available online[6]. When we did not have access to all the criteria, it is explicitly specified in the text. Finally, the research was completed by some articles and research publications, all mentioned in the bibliography.

The analysis has been guided by the hypothesis defined above in the section *Reuse: a crucial facet of the circular economy*. When going through the criteria of each system, we kept in mind the following questions:

- Is reuse correctly defined?
- Is the Lansink's ladder waste management hierarchy followed?
- Which importance is given to reuse? Is reuse a strategy to focus on to get the label or to achieve a good/better score?
- Does reuse appear where it is the most expected?
- How is reuse integrated into building life cycle analysis (if any)?

How to read this document?

The following information has been synthesized for each system:

- Short introduction to the label: creation, philosophy, scope…
- A summary of positive and negative aspects of each scheme with regards to reuse
- In annex, a table summarises each label structure where criteria that impacts reuse are highlighted

Caution: The tables summarizing the criteria are not fully representative to the actual frameworks, as they only serve to point out what we considered as relevant for reuse practices. They do not replace a complete overview of the frameworks.

For ease of reading we adapted the terminology of each system to make it more uniform: criteria are classified under Main objectives, which are divided into Sections and sometimes Sub-sections. Usually, each criterion can help earn the credits (or points) that add up to define the reached level.

In the conclusion of this document, we reflect on what can be learned from the comparison of these frameworks. We also formulate recommendations to enhance reuse practices through such schemes.

Finally, it is important to underline that this study only focuses on reuse, with the goal to enhance its inclusion in green buildings frameworks. The point is not to classify these instruments in any way, nor to give an opinion on their general structure and operation. The sole aim of our recommendations is to raise awareness about reuse as a strategy to significantly contribute to more sustainable and less impacting buildings.

6 When one national version and one international version were both recently released, the preference has been given to the national version.

1. BREEAM (Building Research Establishment Environmental Assessment Method) - UK New Construction

General information

Creation

BREEAM was set up in 1990 in the UK by Building Research Establishment (BRE) Group, a former government-funded research laboratory. The most recent version for new construction is the 'UK New Construction 3.0', released in 2018.

Scope

BREEAM has been used in more than 80 countries, becoming one of the most commonly used certification systems worldwide. Beside the original UK version, several countries in Europe have developed country specific BREEAM schemes: the Netherlands, Spain, Norway, Sweden and Germany.

The UK New Construction scheme applies to new domestic and non-domestic projects (offices, services, etc.). Other BREEAM schemes cover master-planning, civil engineering and public realm, in-use commercial buildings and refurbishment and fit-out. Several other sustainability labels set BREEAM as a benchmark.

Global functioning

Credits are earned for the efforts made in 10 different categories. Each category has a weight percentage, with 9 of 10 categories summarizing up to 100% rating and the 10th category, 'Innovation', optionally adding up to 10% (although total score cannot exceed 100%). Each category consists of several issues (referred to as 'sections' in this document). Issues also set minimum standards that vary depending on the final rating the project is aiming for. The benchmarks are:

- Outstanding (>85%)
- Excellent (>70%)
- Very good (>55%)
- Good (>45%)
- Pass (>30%)
- Unclassified (<30%).

Certification can be received at different stages of a project development, from design stage (DS) to post-construction stage (PCS) and post-occupancy stage (POS).

BREEAM and Circular Economy

In 2018 in the Netherlands, a research group formed by the Dutch Green Building Council (DGBC), Metabolic, SGS Search and Redevco Foundation published a framework for circular buildings based on the BREEAM certification scheme adapting the existing BREEAM system to include circular economy models. The proposed solutions focus on the reuse of building materials. The research aims to integrate the created scheme in the BREEAM Netherlands certification process and possibly also in the international version[7].

Framework analysis

The global functioning of BREEAM's framework is well adjusted for developing reuse practices. The two chapters that directly feature reuse are unsurprisingly Materials and Waste. The framework acknowledges the importance of both the construction phase and the building's global footprint.

Although the very detailed evaluation system makes it hard to analyse the potential weight of reclaiming and reusing components without case studies and specific analysis (such as life cycle cost, building life cycle assessment or credit calculators), reuse practices are clearly accounted for their positive impact.

It is also positive to see that reuse practices are well covered and associated to their relevant category: salvage of materials from the to-be-demolished building with a resource management

7. B. Kubbinga (Circle Economy), . Bamberger (Circle Economy), E. van Noort (DGBC), D. van den Reek (DGBC), M. Blok (Metabolic), G. Roemers (Metabolic), J. Hoek (Metabolic), K. Faes (SGS Search), *A Framework For Circular Buildings - Indicators for possible inclusion in BREEAM*, August 2018 (see complete reference in bibliography).

plan, integration of reclaimed materials into the new construction, and design for disassembly and future reuse of the building's components.

The Waste section considers reuse only as a waste prevention strategy, while the Materials section rather focuses on the choice of materials to be implemented in the building and on the global sourcing methodology. The latter includes aspects such as setting a sustainable procurement plan, defining targets, and reporting all along the project. There is not a reuse-specific criterion, but reuse is one of the most rewarding alternatives (in terms of credits) in the choice of sustainable materials.

Besides the above two sections, a few adaptations regarding the reuse of materials in other criteria such as the choice of equipment or the choice of sustainable timber are possible. This allows the designer to propose reclaimed materials.

It is also observed that BREEAM is one of the only frameworks that does not ask for a life cycle analysis (LCA) at the building scale but at a material scale. Credits are then awarded considering the quality of the tool and the method on one hand, and the scope of analysed building elements on the other. This is explained as an intermediate measure, waiting for more reliable LCA tools.

Besides the above-mentioned positive aspects, a few weaknesses remain:

- **A slight bias towards same-site reuse**. It seems the default scenario is that reuse is associated with either same-site reuse or designing for future reuse. There is little mention of the possibility to purchase reclaimed materials from professional salvage dealers, nor to have them reclaim reusable materials prior to the demolition.
- **Waste hierarchy unequally emphasised.** In some subsections, recycled materials are more consistently encouraged than reclaimed materials.
- **Relatively low credits for reuse.** Overall using reclaimed materials alone is not enough to reach outstanding results in the Material sections. Focusing on materials such as timber, recycled materials or modularity would bring much more credits.

2. LEED (Leadership in Energy and Environmental Design) - Building Design and Construction (BD+C)

General Information

Creation

LEED certification was created in the United States in 1993 by the US Green Building Council (USGBC). LEED system is inspired by BREEAM certification. Since 2015, the 4th generation of this label intended to have 'a stronger emphasis on materials'. The last updated version (v4.1) was released in 2021. The most recent version, among other things, improves the balance between high ambitions and achievability.

Scope

LEED is one of the most commonly used certification labels worldwide, alongside BREEAM, with more than 93.000 registered and certified projects. It is still most common in the USA.

The certification covers several categories relative to the project scale (building, neighborhood, homes, cities and communities, etc.), and sub-categories depending on the project typology (schools, retail, new construction and major renovation, etc.).

Global functioning

The system has an overall of 110 credits to be earned but also sets prerequisites (i.e. mandatory actions that have to be undertaken to be eligible). The certification counts 4 levels of benchmarks:

- Platinum: 80+ credits
- Gold: 60-79 credits
- Silver: 50-59 credits
- Certified: 40-49 credits

Rather than specific standards, LEED sets benchmarks to achieve. LEED puts forward a working methodology rather than quantitative measurements. Therefore the description of some criteria leaves space for interpretation.

LEED and Circular Economy

The information table which compares the current version with the previous one states that in the newest version of Material and Resources categories *'greater emphasis and weighting is given to embodied carbon reductions through building reuse, salvage, whole building LCA, and EPDs'*.

In the description of the strategies promoted by LEED, reuse is featured as the second preferred option. It is stated that *'LEED has consistently rewarded the reuse of materials. LEED V4 now offers more flexibility and rewards all material reuse achieved by a project - both in situ, as part of a building reuse strategy, and from off site, as part of a salvaging strategy'*[8].

Framework analysis

Overall this new version of LEED lives up to the expectations raised in the introduction. Reuse is taken into account in different criteria, covering a wide range of situations (for instance, considering the possibility to reuse technical equipment in certain circumstances). The definition of reuse is quite complete: it covers both same-site and off-site practices and distinguishes reclaiming from reusing, each corresponding to specific criteria. Even though reuse and recycling are both offered as alternatives to standard practices, the distinction between them is clear and reuse is given more value as a way to lower carbon emissions

The criterion for 'Building life-cycle impact reduction' is also very interesting when looking at the two alternative options to get credits: the first one states that building conservation and reuse ensure the impact reduction looked for. The second option is to run a global life cycle analysis (LCA) of the building, with different benchmarks

8 *LEED v4: Building Design + Construction Guide* | USGBC, accessed on April 15, 2020. https://www.usgbc.org/guide/bdc

of proven impact reduction to get credits. Reuse combined with conservation is then presented as a direct alternative to LCA.

As a result, a project with a high reuse ambition can already fill in many criteria. Some efforts are made to avoid the prejudice of reclaimed materials by inadequate regulatory requirements. For example it is specified for refrigerant equipment that 'When reusing existing *HVAC equipment*, [the project team has to] *complete a comprehensive CFC phase-out conversion before project completion'*. Another very positive aspect is that many requirements for materials include a note on how to adjust to reuse specificities when it comes to medical equipment or low-emitting materials. This is an implicit acknowledgment of the fact that reclaimed elements can be introduced wherever there is an opportunity to do so in the project.

A few aspects could be improved though, as detailed in the points below:

- **Absence of reclamation audit.** Conducting a proper reclamation audit is a key step to foster both same-site and off-site reuse strategies. In the current framework, a waste management plan is a pre-condition within a criterion but it is not directly assessed. The integration of salvage and reuse considerations is encouraged by the award of 1-2 credits... This is balanced by the fact that salvaging of materials is encouraged through other credits, but only for on-site reuse. A proper reclamation audit could be an incentive for more salvaging, including towards off-site reuse destinations.
- **All-inclusive Construction and Demolition Waste management prerequisite and credit.** It is positive to see reuse well integrated in both benchmarks. However the combination of Construction waste, Demolition waste and waste prevention through design in a credit awarded by up to 2 points seems to underestimate the importance of these topics. Considering that these 3 topics include high environmental benefits and a role to stimulate the reclamation market, they seem to receive too little attention.
- **A slight confusion between reuse and building conservation.** At some points, the term reuse is used to cover the retaining of structural elements. Confusion between preservation of the existing stock and flow of reclaimed/reused materials can lead to biased results. It would benefit from making a clear distinction between these two complementary objectives.

3. HQE (High Environmental Quality) - Sustainable Building

General information

Creation

The HQE Association was founded in 1996 following the Earth Summit of 1992. In 2017, it merged with the French branch of Green Building Council to become the HQE-GBC association.

Scope

The HQE certification is mainly used in France, although an international version also exists. It applies only to non-residential buildings, with specific versions for schools, commercials, hotels, etc. A recently released version is dedicated to the development of eco-districts. It is delivered by Certivea.

As of today, despite the rise of new certification schemes, HQE is considered as the most important French certification for construction in France. Its specificity (at the French scale) is to cover a wide range of construction and environmental performances. It is structured along four main commitments: responsible management, quality of life, respect of the environment and economical performances.

HQE's sustainability approach is mainly oriented toward social indicators, such as health and comfort. This is also reflected in environmental indicators, where significant weight is given to the building occupancy phase[9].

Global functioning

The framework distinguishes two parts: 'Sustainable Management System' (SMS) and 'Technical requirements part' (TR). The second part covers 3 main themes: 'Quality of life', 'Respect of environment' and 'Economic performance'.

The SMS provides a very detailed project framework, from planning to the final project delivery:

- definition of performance objectives
- distribution of responsibilities
- collaborative work and communication
- development of purchase policy
- waste management plan
- monitoring and reporting
- ...

The project team is invited to set its own ambitions, which can go from M1 to M5 (M stands for 'Maturity'). Each recommendation is accompanied by a method on how to reach each level of maturity.

The technical requirements work as a normal certification framework earning credits for each achievement. The final score is translated into stars, with 4 levels of rating:

- Effective: 1 to 3 stars
- Very effective: 4 to 6 starts
- Excellent: 7 to 9 stars
- Exceptional: 10 to 12 stars

The first and second levels correspond more or less to the requirements enforced by current regulations[10].

HQE and Circular Economy

Circular Economy is presented as a cross-cutting issue and is present throughout 60 targets. Most of them focus on the optimisation of flows (waste, energy, water, social services...) during the occupancy of the facilities.

Concerning construction, eco-design and design-for-change are stressed as crucial approaches. The waste hierarchy is not defined, neither are its successive levels (reduction, conservation, reuse, recycling, energy combustion). The reduction or treatment of waste is often globally and generally referred to as valorisation - understood as any way to redirect waste away from landfill.

9. In the V3.0 version analysed in this document (see annex).
10. G. Allix (Le Monde), Le label HQE s'étend des bâtiments aux écoquartiers, issued in *Le Monde,* French newspaper on May 11th 2020 (see complete reference in bibliography)

Framework analysis

All in all, HQE is not entirely adverse to reusing building materials and products. For instance the Sustainable Management System could be used to accompany a reuse operation. Such an action might allow a project team to reach a few HQE targets promoted. However reuse is quite absent from the technical requirements of this certification scheme. Project teams who would opt for fostering reuse would not find a lot of resources in this scheme.

In general, HQE focuses more on lowering the energy consumption of the building in use than on the choice of low-impact materials. In addition, HQE displays a few biases when it comes to reuse. The main critics in this regard are:

- **Too general waste management strategies.** HQE promotes any strategy to deviate waste from the landfill during the construction and the occupancy phases of a building. It refers to the general notion of 'valorisation' to designate strategies as different as combustion with energy recovering, recycling and reuse. When it comes to dealing with the flows of materials of the demolition phase, such an approach has shown to be detrimental to reclamation and reuse. More generally, there is a lack of balance between the building construction and the building exploitation criteria.
- **Not enough attention paid to the integration of reclaimed building materials.** Reusing building materials is correctly defined and promoted in the introduction of the section 'Smart use of energy and natural resources'. The main content of this section however focuses on reducing the environmental impacts of the occupancy phase, and neglects the integration of reclaimed building materials. Designing for future adaptability of the building is a much more rewarding strategy in comparison.
- **Confusion between circular and local economy.** In theory, this is a promising aspect for reuse: HQE fosters the use of local chains of actors from a local economic development perspective. Yet this section does not refer explicitly to existing reclamation and salvage stockholders. It may also give the impression that reclaimed materials are not enviable if they come from more than 150 km away which for many will not be true[11]. This confusion is reinforced by the fact that a project buying locally sourced recycled or even new materials earns the same credits as if using reclaimed ones.

11. Salza, Matériuum, *Construire le réemploi - Etat des lieux et perspective : une feuille de route*, report for the Swiss Federal Office for the Environment (OFEV), 2020.

4. BBCA (Bâtiment Bas Carbone) - Low-carbon Building

General information

Creation

The BBCA label was created in 2016 by the Association for the Development of Low-carbon Building (Association pour le Développement du Bâtiment Bas Carbone), an association of actors from the construction industry including developers, architects, construction professionals and a few public authorities. According to Jean-François Coroller, founding member of BBCA, their goal was to outreach the focus on building energy consumption. Acknowledging that the construction phase represents about half of the GHG emissions of the building lifespan, the BBCA Association wanted to shift the debate toward carbon footprint during the whole life-cycle.

Scope

The BBCA framework focuses specifically on carbon emissions to promote 'exemplary performances of low-carbon buildings'. The BBCA label promotes low carbon approaches for construction with the main focus on:

- Construction phase (choice of materials, sobriety...).
- Occupancy (low-carbon and renewable energies...).
- Carbon storage (bio-based materials).
- Circular economy (selective deconstruction, reuse, mutualisation of spaces, design for change, extension potential).

The label is used only in France. The label has achieved a number of important construction industry successes since 2016. In 2018 40 non-residential buildings had been certified. BBCA can be applied to new construction (non-residential and residential buildings) and refurbishment projects. The latest version was updated in 2018 for refurbishments and under development is a green system for assessing district development. A temporary label can be delivered at the end of the conception phase (on the tender for works basis), then a final label at the reception of the building. Having the E+C- label is a prerequisite to get the BBCA one.

Global functioning

BBCA proposes a new kind of system, in which there are no points awarded to defined targets. This approach cancels out the debate on targets weighting coefficients. BBCA's scheme draws on methods regulated at national or European level, providing a common tool to calculate the GHG emissions of what has been identified as the most critical aspects of the building lifecycle. BBCA relies almost entirely on the E+C- methodology for the assessment of the GHG emissions for each criteria.

The BBCA label promotes two approaches:

- Assessing avoided GHG emissions and carbon stored through 7 criteria, all measured with the same indicator (1 point = 1 CO2kg/m²/year).
- Awarding additional points for practices fostering climate innovation.

Carbon calculations from each of the 7 indicators of the first axis are summed up using the following formula. It refers to the greenhouse gas emissions and carbon storage indicator GHGproject BBCA (expressed in kg equivalent to CO2/m2 of building floor area):

$$GHG_{project\ BBCA} = GHG_{deconstruction} + GHG_{PCE} + GHG_{empty\ delivery} + GHG_{worksite} + GHG_{energy} + GHG_{water} + Carbon\ storage$$

Where:

$GHG_{deconstruction}$ = greenhouse gas emissions arising from the demolition of an existing building

GHG_{PCE} = greenhouse gas emissions arising from the production of construction products and equipments

$GHG_{empty\ delivery}$ = greenhouse gas emissions arising from the construction of offices floor in which future interior design are still to be installed

$GHG_{worksite}$ = greenhouse gas emissions arising from the construction process

GHG_{energy} = greenhouse gas emissions arising from the energy used by the building

GHG_{water} = greenhouse gas emissions arising from the water consumption

Carbon storage = quantity of biogenic carbon stored in the building

The method explains how to calculate each of these parameters.

The formula to calculate the final score takes in account both greenhouse gas emissions and the carbon storage indicator (GHGproject BBCA), to which additional points can be gained from innovative actions:

$$\textit{BBCA score} = \textit{'Emissions and Carbon Storage' points} + \textit{Climate Innovation points}$$
$$= [\ (GHG_{max\ BBCA} - GHG_{project\ BBCA})\ /\ 10\ ] + \textit{Climate Innovation points}$$

The attribution of the label is decided following this global score as such:

- The BBCA Standard: from a score of 0.
- The BBCA Performance: from a score of 15 points.
- The BBCA Excellence: from a score of 30 points.

The label is first delivered after the design phase (as a temporary label) and then when the building is completed (definitive label). For the design phase, it is possible to indicate a global performance target per lot, documented with Environmental Product Declarations. This offers an interesting opportunity to provide an initial global objective even if all the materials are not precisely known yet, which fits very well with a reuse strategy. At the same time designers have to explain their objective to demonstrate its soundness and feasibility.

BBCA and Circular Economy

The benefits of BBCA is that it acknowledges innovative practices for circular construction which are not entirely valued in the current LCA methodologies. One of the two main chapters of BBCA referential for both new construction and refurbishments focuses on promoting circular economy.

A focus on E+C- label

In 2015, the French Government launched a national experiment to prepare and to test the future Energy & Environmental Regulation for buildings (also called 'RE2020', for Environmental Regulation 2020). The last major French regulation on buildings and environment dated from 2012. At the time it mostly focussed on the energy performances of buildings in use, translating the EU objectives on that matter into the French context. The RE2020, which will be effective from January 2022, represents a major shift from the last regulation since it also includes in its scope the carbon emissions arising from the manufacturing of building materials (drawing on the European Standard EN 15978[13]). The RE2020 provides a much more holistic approach to assess the environmental impacts of the construction industry.

The E+C- label was created to anticipate the enforcement of the RE2020. Developers were invited to use it on a voluntary basis.

The label is still relevant today since the RE2020 regulation came out to be less ambitious than the label itself (even though it aims to raise up its level of requirement over the next few years). Moreover it represents a very interesting soft-law instrument, clearly fostering the use of low-impact materials.

E+C- is a common ground for two other French labels: BBCA and Effinergie. Validating E+C- is a prerequisite to get these labels. This means the E+C- methodology is very close to that of BBCA and actually gives more details on how to calculate each indicator. It is not developed in this study because BBCA goes further in terms of fostering the reuse of building materials. It is however interesting to note that within the several optional criteria, only the one considering the choice of Products & Equipment (P&E) is mandatory. Indeed the potential impact of P&E is presented as the most important of all carbon contributors in all the steps of the building lifecycle.

13. AFNOR, *Méthode de calcul pour évaluer la performance environnementale des bâtiments,* accessed June 4th, 2020.

Framework analysis

This label shows a global understanding and a real interest in the challenges of reuse. Although the system description is quite short (which is explained by the fact it relies on another framework and on the French and European regulation), it gives specific attention to reuse.

BBCA is clearly an instrument meant to promote and expand the use of EPD[14] so as to help enforce the national regulation. Currently EPDs are very uncommon in the reclamation industry however it is likely that in the future they could be progressively developed for reclaimed materials[15]. BBCA suggests an interesting workaround for existing practices, proposing to consider that emissions corresponding to the 'production' phase of reclaimed materials can be bypassed to calculate the global GHG emissions of the building. In this context, opting for reusing materials could seriously boost the score of a project.

In addition to this reuse strategies could also bring up to 10% of extra credits through innovation bonuses. These aim to acknowledge the other benefits of reuse (stimulation of local economy, creation of jobs, heritage preservation...) which are not accounted for elsewhere . At the same time a specific credit is also earnt if a reclamation audit is conducted.

E+C- and BBCA display a strong commitment towards fostering reuse strategies. The only minor downside is the small reward for reclaiming materials during the demolition phase.

14. EPD are called FDES in French (and therefore in BBCA's documents), meaning *Fiches de Déclaration Environnementale et Sanitaire.*
15. An EPD for reclaimed raised floors provided by a French salvage dealer has been released in May 2020: *Fiche de Déclaration Environnementale et Sanitaire du produit plancher technique de réemploi non revêtu monté sur vérins neufs*. Registered identification in INIES : 3-257:2020.

5. DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen) - New Construction

General Information

Creation

The DGNB certification scheme is run by the non-profit association DGNB (which stands for 'German Society for Sustainable Building' in English). The system originates from the private sector. It was created by 16 members of the construction and real-estate industry in 2007. Currently the association counts about 1200 members. Their products are listed in DGNB building product catalogue. The latest update is the DGNB System Version 2020 International.

Scope

DGNB states that its system focuses not simply on being green but rather balanced, equally weighted focus on environmental aspects, economic viability and users' needs. It emphasises the overall life cycle of the building.

The label is most commonly used in Germany and was created as BREEAM and LEED did not fully match the German legislation. Even though the framework is based on German law it can be adapted to country specific legislation based on the underlying international system, for example it is widely used in Denmark[16]. Up to today 1725 projects have received a DGNB certification or a pre-certification. DGNB certification can be applied to new constructions, renovation and existing buildings as well as buildings in use. The weighting of the criteria varies for each type of building (educational buildings, office and administration buildings, department stores etc.).

Global functioning

According to DGNB description on New Construction on their website, 'the DGNB System does not evaluate individual measures, but rather the overall performance of a building based on criteria'. The evaluation for New Construction is based on 37 criteria, subdivided into six forms of quality:

1. Environmental
2. Economic
3. Sociocultural and functional
4. Technical
5. Process
6. Site

Each criterion brings credits, which are categorised under different indicators. Bonus credits can complement some criteria. The final score is calculated as such:
('achieved points' / by 'total points available') * 'criteria share factor'.

The gained percentage of each criteria is summed up to get the overall score and rating for the building.

The levels of performance are:

- Platinum (>80%)
- Gold (>65%)
- Silver (>50%)
- Bronze (>35%)

DGNB states that applying only the minimum legal requirements would result in a DGNB rating of 12%. The average DGNB score for certified office buildings is 74%[17].

DGNB and Circular Economy

In 2018, DGNB released an update of the framework. It introduces a bonus system to reward applying principles of the circular economy. These bonus points have a positive impact on the certification process and DGNB organized a workshop between their association members in 2018 to address the circular economy. Their conclusions are gathered in the Circular Economy report[18].

16. SBi (Danish Building Research Institute) and 3XN Architects - *GXN, Guide to Sustainable Building Certifications*, issued in August 2018 (see complete references in bibliography).
17. Dr A. Braune, Dr C Lemaitre, S. Oehler, M. Holme Samsøe, U. von Gemmingen, F. Jansen (DGNB), *NO MORE EXCUSES - Sustainable is the new normal*, DGNB (German Green Building Council) issued September 2018 (see complete reference in bibliography).
18. DGNB, *Circular Economy - Closing loops means being fit for the future*, issued in January 2019 (see complete reference in bibliography).

The report includes general descriptions of a wide range of circular economy approaches. It includes an overview of the benefits of reuse, methods of facilitating future reuse and a description of the current reclamation market. The report however seems to prefer recycling over reuse under certain circumstances: *'Reprocessing for reuse or necessary transport may be very energy-intensive under certain circumstances and be based on the use of fossil fuels, or reused components may only have a very short service life in individual cases, so that recycling may be preferable to reuse.'*

Framework analysis

Overall the recent update of the DGNB certification sy stem is paying attention to the circular economy. It acknowledges the existence of the reclamation trade in the 'Circular Economy' bonus points. It is also interesting to see another example of a label developed in order to foster the implementation of national sustainable strategies, with a smart use of bonus credits.

The construction phase is considered from a holistic point of view, with economic, environmental, technical and process aspects all taken into account. The choice of materials, including reuse/recycling opportunities, are raised in all of these categories. Distribution of issues differs from the other certifications analyzed and show interesting alternatives.

Coupled with design-for-disassembly reuse can be a strategy to gain many bonus points but not a primary strategy to gain high overall results. Reuse-wise, some margins for improvement remain on the following aspects:

- **An unclear definition of reuse.** It is often assimilated to recycling. Despite the fact that reuse is above recycling in the waste regulation, recycling seems to be promoted above reuse. Moreover, off-site reuse seems to be mainly understood as take-back or leasing systems, so only in a close loop with a unique manufacturer (not referring to existing independent salvage dealers).
- **Slight bias towards 'tomorrow-reuse' instead of 'today-reuse'.** The DGNB system mostly prioritises efforts to enhance the future dismantling and reuse of new components installed today. Less attention is paid to the current integration of salvaged materials in the current constructions.
- **A consideration of sustainability at the level of the chemical composition of materials.** Even though this shows a strong attention to health and prevention of pollutants issues, it may create a disadvantage for reclaimed materials which have not been recently manufactured. The recommendation of specific measures regarding reclaimed materials concerning sanitary controls, based on scientific evidence, may dodge this difficulty.

6. GRO - Guide for Sustainable Building Projects Flemish Government

General Information

Creation

The first version of GRO was developed in 2017 for the governmental organisation responsible for managing the real estate of the Flemish Government (Het Facilitair Bedrijf). GRO is mainly a manual to help implement a uniform and holistic ambition in terms of sustainability in building projects. It replaces and updates the Guide to Valuation of Office Buildings.

GRO was updated in 2019 and the most recent version was published in 2020. The adjustments are mainly corrections of formula errors and recent changes in legislation and technical standards. The first versions of GRO are only in Dutch. A first French version was made available in May 2020.

Scope

GRO is currently only used in Flanders, the northern region in Belgium. It was originally developed for construction of government buildings but can be applied to private construction projects as well. GRO can be applied to all building functions: office buildings, tourist infrastructure, residential buildings, mixed-use buildings, etc., regardless of the size and scale of the projects.

Global functioning

The ambition of GRO is to achieve future-oriented buildings through an integrated design process. It hinges on the 'People Planet Profit' principle. Furthermore, GRO is based on principles of the circular economy and climate responsive design (use of natural low-tech and limit energy-consuming techniques).

Because GRO aims to be used for any type of project, its criteria have been set in a flexible way. GRO includes 26 quantitative and qualitative criteria divided into three categories: People, Planet and Profit.

Each criterion is described in a sheet in which the requirements, assessment and supporting evidence are defined. The relevance of the criteria can strongly depend on the form and content of a project. Additional criteria have been defined for the quality of the location but are only applied when the location of a project is still to be decided. Finally, three criteria have been defined to take into account climate responsive design. These only apply if the design team can have an influence on these aspects.

The assessment of a project is made on the basis of defined performance levels. The criteria are divided into three performance levels: good, better or excellent. A criterion can also score unsatisfactory if minimal performance levels have not been reached. The level of ambition can be set at the scale of a project or for specific criteria. For each category, the criteria and their performance levels are presented graphically in a spider diagram. No weighting factors are used for the criteria. For some criteria, bonus points can be earned by emphasising circular construction. In order to monitor the original ambition throughout the project, the supporting evidence is examined at each project phase: quotation, preliminary design, final design, procurement, provisional delivery and final delivery.

GRO operates without a control body for auditing the projects. Therefore, it does not result in a certification or a label. For the Facilitair Bedrijf's own projects, the operations are assessed by an internal expert at each stage.

GRO and Circular Economy

'The circular economy offers the tools to develop and improve the interests of people,nature (planet) and economy (profit) hand in hand.'[19]

GRO is firmly committed to circular construction. GRO considers that fully closed cycles and no waste is an idealised state, which may never be achieved. However, it does offer a clear and inspiring objective. Bonus points can be earned in several criteria for an advanced circular approach.

19. *GRO Gebruikershandleiding - versie 2020*. Accessed June 29, 2021. https://www.vlaanderen.be/vlaamse-overheid/werking-van-de-vlaamse-overheid/bouwprojecten-van-de-vlaamse-overheid/gro-op-weg-naar-toekomstgerichte-bouwprojecten

Framework analysis

Two criteria of GRO address the issue of reusing building components and materials: MAT1 'Retaining of resources' and MAT2 'Material choice'.

To get a minimum score for the MAT1 criterion, it is required to conduct a demolition audit. It includes the identification of the reuse potential. A better score can be obtained if the project managers commit themselves to preserve a certain percentage of these existing resources through retaining parts of the building and/or reusing building components (20% (in mass) for a 'good' score, 40% for an excellent score and a bonus point if 75% can be retained). Note that GRO makes no distinction here between retention and reuse.

The MAT 2 criterion draws on the use of Totem, an Environmental Impact Assessment tool developed by Belgian authorities[20]. In itself, the MAT2 criterion is not explicitly referring to the practice of reusing building materials. However, Totem includes a possibility to model reuse strategies, which usually lead to a significant improvement of the global score. The MAT2 criterion also includes aspects related to local and 'socially responsible' materials. These could possibly apply to reclaimed materials originating from the local reclamation trade, although this is not explicitly addressed in the GRO framework[21].

Some remarks can be formulated about the way GRO incorporates reuse aspects:

- **Definition of reuse.** Although the glossary gives a relatively precise definition of 'reusing materials'[22], in practice, reuse is often mixed up with retaining strategies (sometimes referred to as 'adaptive reuse'[23]). These two approaches would benefit from a better distinction. Retaining parts of a building can be seen as a 'stock management' strategy. The materials that are already there do not move. By contrast, reusing materials would be a 'flow management' strategy. Materials are put in circulation. These two strategies involve different types of actions and actors. Reclaiming materials requires more labour than preserving an existing structure, for instance. They also involve quantities with very different orders of magnitude. When it comes to the MAT1 criteria, the best score (75% in mass of preserved materials) will usually be obtained just by retaining existing foundations and structure, without making any additional effort towards reuse.
- **A bias towards same-site reuse.** Although the different approaches of reuse are quite largely defined (retaining an element in its original form and location, dismantling an element and reusing it on site or in the future project, reusing some parts of an existing element), they mostly address same-site reuse strategies. Off-site reuse is worth only 50% of the score.

20. See the report *Reuse in Environmental Impact Assessment tools*, published by the Interreg FCRBE project (https://www.nweurope.eu/FCRBE).
21. *GRO Criteria voor site en gebouwen - versie 2020*. Accessed October 11, 2021, p. 150.
22. 'Materials are reused when they are deviated from waste flows and used again with no or little further reprocessing. Reused materials can apply to following cases: if objects or installations are integrally reused, if materials can be reused without the need for further reprocessing (except for cleaning), if materials can be reused after minimal processing (cut to dimension, sandblasting...).' *GRO Gebruikershandleiding - versie 2020*. Accessed October 11, 2021, p. 45 (free translation).
23. See for instance the table on page 14 of *GRO Gebruikershandleiding - versie 2020*. It declines reuse into 'adaptive reuse of buildings' and 'reuse of building materials'.

7. Level(s) - European Framework for Sustainable Buildings

General Information

Creation

The development of the Level(s) framework started in 2015 and was initiated by the European Commission's Directorate-General for the Environment. In 2017 the Level(s) beta version was published followed by a beta phase between 2017 and 2019. The Level(s) indicators were tested by more than 130 projects (both residential and non-residential, in new buildings and renovation) in 21 EU member states. After incorporating results and feedback from this testing phase, the final version of the Level(s) framework was officially launched by the European Commission in October 2020.

Scope

'The Level(s) common framework is based on 6 macro-objectives, which describe what the strategic priorities should be for the contribution of buildings to EU and Member State policy objectives in areas such as energy, material use and waste, water and indoor air quality.'[24]

The following aspects are assessed for measuring the sustainability performance of buildings along their lifecycle:

- environmental performance
- health and comfort,
- life cycle cost and value
- potential risks to future performance.

The Level(s) framework is closely linked to EU objectives such as the global 2030 sustainable development agenda and the goals of the European Green Deal for a sustainable building sector. Part of the actions described in the new Circular Economy Action Plan and the Renovation Wave Strategy.

Level(s) provides a common EU approach for assessing the environmental performance of buildings by combining multiple existing standards. It is a voluntary reporting framework that helps built environment and sustainability professionals, investors and policy makers to improve and optimize the sustainability performance of buildings. Unlike other certification schemes that are considered in this study, Level(s) is a reporting tool, not a certification scheme with specified benchmarks. While Level(s) puts the user on a path towards being able to go through with more advanced certification schemes, the main purpose is to get professionals to embrace life cycle performance thinking[25]. In addition to reporting, the results can also be analysed in order to support design decisions, hot spots of environmental impact along the life cycle, etc.

Global functioning

The common framework is organized into three levels that represent different stages in a building project (design, build and as-built/use phase). For each level, the degree of detail of the reporting process can be defined. The higher the level chosen for a project, the closer the results reflect the actual performance of the building as built and in use.

Level 1: The conceptual design for the building project – the simplest level as it entails early stage qualitative assessments of the basis for the conceptual design and reporting on the concepts that have or are intended to be applied.

Level 2: The detailed design and construction performance of the building – an intermediate level as it entails the quantitative assessment of the designed performance and monitoring of the construction according to standardized units and methods.

Level 3: The as-built and in-use performance of how the building performs after comple-

24. N. Dodd, S. Donatello and M. Cordella, *Level(s) – A common EU framework of core sustainability indicators for office and residential buildings, User manual 2: Setting up a project to use the Level(s) common framework* (Publication version 1.1), 2021
25. Level(s) Putting Circularity into Practice, European Commission website, accessed on June 29th, 2021 (see bibliography for complete reference)

tion and handover to the client – the most advanced level as it entails the monitoring and surveying of activity both on the construction site and of the completed building and its first occupants.

Each indicator has a guidance document (user manual) with an introductory briefing, followed by instructions on how to use the indicators at each level and lastly guidance and further information for using the indicator.

Macro objectives

1. Greenhouse gas emissions along a buildings life cycle
2. Resource efficient and circular material life cycles
3. Efficient use of water resources
4. Healthy and comfortable spaces
5. AdaptationAdaption and resilience to climate change
6. Optimized life cycle cost and value

Indicators

1.1. Use stage energy performance (kWh/m2/yr)
1.2. Life cycle Global Warming Potential (CO2 eq./m2/yr)

2.1. Bill of quantities, materials and lifespans
2.2. Construction & Demolition waste and materials
2.3. Design for adaptability and renovation
2.4. Design for deconstruction, reuse and recycling

3.1. Use stage water consumption (m3/occupant/yr)

4.1. Indoor air quality
4.2. Time outside of thermal comfort range
4.3. Lighting and visual comfort
4.4. Acoustics and protection against noise

5.1. Protection of occupier health and thermal comfort
5.2. Increased risk of extreme weather
5.3. Sustainable drainage

6.1. Life cycle costs (€/m²/yr)
6.2. Value creation and risk factors

Framework analysis

In the Level(s) guidance documents reuse is defined as 'operation by which a product, or a part thereof, having reached the end of one use stage is used again for the same purpose for which it was conceived.' Both on-site and off-site reuse are mentioned. In addition Level(s) also defines a waste hierarchy where a distinction is made between reuse of over-ordered materials and reuse of already-used materials. Furthermore, guidance is given on the preparation for demolition activities to improve the reuse potential. Several examples of reuse, recycling and recovery (backfill) are presented (in order of decreasing environmental benefit) as alternatives to disposal of main construction and demolition waste fractions. Indicator 2.4 is completely focused on the design for deconstruction, reuse and recycling. The calculation of the indicator is based on the German Green Building Council's (DGNB) ease of recovery and recycling criterion TEC1.6. For this indicator, therefore, similar conclusions can be drawn as in the analysis of DGNB.

Some considerations can be made about how the accounting of reuse in Level(s):

- **A slight bias toward future reuse.** While reuse is extensively covered, the guidance documents heavily focus on ease of disassembly and future reuse potential but lack information about incorporating reclaimed materials in current projects.
- **Level(s) is a voluntary scheme where implementers are free to choose which levels and indicators to consider.** As a result, reuse may not be covered in their final environmental performance analysis. Moreover, without calculation or targets to reach, it is difficult to assess the effective impact given to reuse in this framework.

Conclusion: best practices and recommendations

The green buildings frameworks analysed here present differing approaches towards reuse with each system operating different choices in the distribution of its themes and weighting methods. It does however seem that most of these frameworks are paying an increased attention to circular practices in general and in particular to reuse. A fact evidenced by the most recent updates of these schemes.

Based on the analysis of the different systems and from a thorough understanding of the specificities of reuse practices and reclaimed building materials, it is possible to summarise a few recommendations.

Make reuse a priority over recycling

In the current regulatory hierarchy of waste treatment strategies, reuse is above recycling. It is the case that reuse corresponds to a waste prevention strategy (since keeping goods in use avoids waste altogether) while recycling clearly concerns waste. This distinction should be reflected in the definition and the weighting of each criteria dealing with these issues.

Although complementary in practice, not making a clear distinction between reuse and recycling usually ends up with perfectly reusable elements being discarded as waste and consequently crushed, shredded or melted.

Do not confuse retaining building with reusing materials

Retaining (parts of) an existing building and reusing building materials are two complementary prevention strategies: they avoid waste production and offset the impacts arising from the production of the new materials that would be necessary to rebuild a new project. However, they also differ on some aspects.

In essence, retaining a building is a stock management strategy. It concerns things that are already there and that are kept where they are. They do not move nor are they transformed. By contrast, reclaiming and reusing building materials is a flow management strategy. Materials are put in circulation. Even if they do not move very far (as in same-site reuse approaches), they require labour for their dismantling, storing, cleaning, processing and re-installation.

The quantities involved can also vary greatly and sometimes by different orders of magnitude. In this sense, it is preferable to have two distinct criteria in order to prevent reuse aspects to remain underrepresented.

Consider both on-site and off-site reuse

Both strategies are equally valid. They each come with their own challenges, pros and cons. Some labels analysed here present a bias towards same-site reuse. Extending this view to include reclaimed materials sourced from elsewhere considerably expands the range of reuse opportunities.

In this perspective, it is important to acknowledge the central role of professional salvage and reclamation dealers. In many contexts, they represent the best allies to implement ambitious reuse objectives, while fostering a local, environmental-friendly and actually circular economy.

It is also useful to acknowledge the variety of possible paths for reusing materials: commercial reclamation, donation, reuse on site, reuse by the contractor on another site.

Foster both supply and demand

The best way to develop a truly circular economy for building materials is both to ensure that reusable materials are effectively salvaged when they are no longer needed in an original building and to encourage the integration of reclaimed materials in new construction and renovation developments. A failure to foster both ends of the trajectory will result in imperfect loops (either a shortage of materials for reclamation professionals or an over-accumulation of potentially reusable materials with no demand).

In practice, it means that reuse should be considered at the moment of the (partial or complete) demolition of a building as well as during the construction works.

Acknowledge the specificities of reclaimed materials

In many ways reclaimed materials differ from newly-produced industrial materials. Reclaimed materials are more variable. They are less consistently documented. They involve more manual labour. They are usually kept in circulation thanks to a large range of very small, small or medium companies, which are not always able to undertake considerable R&D efforts. Of course, reclaimed materials also present interesting qualities, if only from an environmental perspective.

In practice, however, it may result in reclaimed materials being at odds with current practices in the construction industry. Despite this challenge, some frameworks and instruments presented here propose inspiring workarounds to foster reuse.

Implicit acknowledgement of the environmental benefits of reuse

When it comes to assessing the environmental impact and more specifically the greenhouse gases emissions, the construction industry increasingly relies on Life Cycle Analysis and this is reflected in the evolution of sustainable certification systems. Yet, as of today, Life Cycle Analysis is rarely undertaken for reclaimed materials. The efforts needed to develop an Environmental Product Declaration could be an obstacle for many SMEs active in the reclamation industry.

From a mid-term perspective, it could result in a paradoxical situation in which reclaimed materials are not considered, not because they would be less performing but simply because they lack the adequate documentation. However, we see a few interesting strategies in the existing frameworks to avoid this issue. For instance, BBCA and DGNB are considering that the impacts of reclaimed materials can simply be bypassed in the assessment of the global greenhouse gases emissions. Although this approach can be discussed from a technical and scientific point of view, it usually results in boosting the overall score by reusing materials.

The last version of LEED presents another interesting workaround method. They postulate that preserving existing structures and materials is necessarily a good way to reduce the environmental impacts over the whole life cycle. Therefore, when opting for these approaches, project managers are not required to provide any LCA at all. This is indeed an efficient way to encourage reuse!

Emissions of volatile organic compounds

Some green building certification schemes (such as LEED) consider that the emissions of VOC are much lower after 1 year of use. Reclaimed materials older than 1 year are therefore considered to comply with this requirement by default. This, of course, is in line with the scientific literature on the topic. In practice, it facilitates reuse since no extensive technical documentation is required to earn this credit.

Recognise extra benefits of reuse

It is very interesting to see how the schemes try to balance the difficulties of acknowledging alternative practices (such as reuse) by awarding extra credits. BBCA explains that its 'Circular economy bonuses' aim to recognise benefits that cannot always be included in a calculation, especially for innovative practices. Reuse is not always considered as an innovative practice itself, when it is already declined in several other criteria. It can also often help to indirectly earn credits for sustainable process management (covering innovative procurements, logistics issues, etc). But an ambitious reuse objective can be a way to reach extra-credits for 'Exemplary performances'. The bonuses also credit the extra-environmental benefits, suchs the positive impact on the local economy. Another benefit which is still not really acknowledged is the cultural benefits of reuse.

Summary of the reuse strategies encouraged in the certification systems

STRATEGY	***SUSTAINABLE CERTIFICATION SCHEMES APPLYING IT***
Encourage reuse via bonuses or by-default high scores in criteria concerning the environmental impact of chosen materials.	BREEAM, LEEDS...
Consider that the production phase of a reclaimed product accounts for 0 in the assessment of environmental impacts.	BBCA, DGNB...
Consider that reclaimed building materials older than 1 year automatically comply with the requirements about VOC emissions. For requirements regarding specific equipment, add an adaptive note for reclaimed materials.	LEED, BREEAM...
Foster the conduction of reclamation audit before demolition.	BREEAM, LEED, HQE...
Actively encourage the preservation of (parts of) existing buildings.	LEED, BBCA, GRO...
Valorise with extra-credits the reuse benefits which cannot be measured elsewhere in the referential: innovation effort, local economy stimulation, patrimony preservation, complex process management.	BREEAM, LEED, HQE, DGNB, BBCA...

Main strategies to foster reuse at the different steps of a building life cycle.

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17. USGBC, *LEED v4 - Reference Guide for Building Design and Construction*, U.S. Green Building Council website, accessed on April 15th 2020. https://www.usgbc.org/guide/bdc
18. USGBC, *LEED v4.1 Building Design and Construction*, U.S. Green Building Council, published April 9th 2021
19. USGBC, *LEED v4.1 Building Design and Construction - Getting started guide for beta participants*, U.S. Green Building Council, April 2021.

Annexes

1. BREEAM - Complete analysis table

The framework analysed here is the BREEAM New Construction 3.2 standard for new buildings released in 2019[26].

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	CREDITS
1° Management	Responsible construction practices	Responsible construction practices	Reclaimed wood is one of the options to gain credits[27].	Prerequisite
		Environmentally and socially considerate management of the construction site	Reuse might have an indirect impact for this criterion.	6
3° Energy	Energy efficient equipment		Reuse of electrical equipment does not comply by default, as it may not be the most efficient energy option. But it can be validated if either of the following criteria is demonstrated: 1. The existing electrical appliances meet the criteria for inclusion on the Enhanced Capital Allowance Scheme Energy Technology Product List, 2. Reusing the old equipment would, over the course of its life, be a more energy efficient option than specifying a new equipment.	2

26. 'BREEAM UK New Construction 2018.' Accessed June 4th, 2020., and September 27th, 2021. https://www.breeam.com/NC2018/content/resources/output/10_pdf/a4_pdf/print/nc_uk_a4_print_mono/nc_uk_a4_print_mono.pdf.
27. *'As an alternative to virgin timber and wood-derived products from a Legally harvested and traded timber/Legal and Sustainable source, 'recycled timber' is acceptable. For the purposes of these pre-requisites, 'recycled timber' is defined by BREEAM as: Recovered wood that prior to being supplied to the assessed project had an end use as a standalone object or as part of a structure and which has completed its lifecycle and would otherwise be disposed of as waste. The term 'recycled' is used to cover the following categories: pre-consumer recycled wood and wood fibre or industrial by products but excluding sawmill co-products (sawmill co-products are deemed to fall within the category of virgin timber), post-consumer recycled wood and wood fibre, and drift wood. It also covers reclaimed timber which was abandoned or confiscated at least ten years previously.* BREEAM requires documentary evidence that all reclaimed/recycled timber products meet the definition of 'recycled timber' given above.' Source: BREEAM website (https://kb.breeam.com/wp-content/plugins/breeamkb-pdf/pdf/?c=252)

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	CREDITS
6° Materials	Environmental impact from construction products	Life Cycle Analysis (LCA)	LCA works in combination with Environmental Product Declarations (EPD). It can be assumed that reuse is considered as having a lower impact at the construction and demolition stages in the LCA tools, but there is no specific indication making this clear.	5
		Environmental Product Declarations (EPD)	EPD works as a tool for LCA. No specific details on reuse are mentioned here.	1
	Responsible sourcing of construction products	Prerequisite - Legal and sustainable timber	100% of timber-based products used must be 'Legal and Sustainable' as per the UK Government's Timber Procurement Policy.[28]	Prerequisite
		Enabling sustainable procurement	A sustainable procurement plan must be used by the design team to guide specification towards sustainable products, with the following requirements: • Be in place before Concept Design. • Include sustainability objectives [...]. • Include a requirement for assessing the potential to procure construction products locally where possible. • Monitoring of the effective implementation of the sustainable procurement plan.	1

28. Reused materials specified for the development are considered equivalent to materials covered by certification schemes that fall within tier 3 of the Responsible Sourcing Tier Levels and Criteria. Source: https://www.breeam.com/BREEAM2011SchemeDocument/content/09_material/mat03.htm

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	CREDITS
6° Materials	Responsible sourcing of construction products	Measuring responsible sourcing	Assessment is run with the Mat03 Calculator. According to the Guidance note 18[29], same site reuse is most highly rewarded with 10 scores[30] and is defined as *'Construction products/materials reused in-situ or within the same construction site, with only minor processing that does not alter the nature of the construction product/material* (e.g. cleaning, cutting, fixing to other construction products)'. To compare, the second highest minimum score is 7 cts and is awarded to 100% FSC wood. Without running a case study it is difficult to understand which weight is given to reuse, but same-site reuse definitely seems to be valued as a low carbon impact solution. Reusing materials from out of the site is not mentioned (while using recycled materials is strongly encouraged).	4
	Material efficiency		Reuse is presented as one example of material efficiency opportunity (next to the use of recycled materials). It is considered both for the use of materials that can be recycled/reused in the future and for the use of presently recycled/reclaimed materials. To get the credit, the project team must set targets and report on opportunities at each step, from *preparation and brief to construction*.	1

29. The Guidance Note 18 plans specific measures for materials considered as being sustainable, but which might be disadvantaged by the absence of EPD (GN18: BREEAM Recognised Responsible Sourcing Certification Schemes and BREEAM Applicability V3.2.).
30. The Mat03 Calculator has an integrated rating system of scores. 10 scores relates to the evaluation within this system.

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	CREDITS
7° Waste	Construction waste management	Construction waste reduction	Involves considering which materials to reuse (only in case of a demolition prior to the construction). One credit is awarded for the achievement of management requirements: • - Pre-demolition audit if there is any existing building on site. • - Definition of reduction targets through reuse and recycling. • - Monitoring of those targets. • - Etc A second additional credit is awarded if those procedures allow the sorting, reuse and recycling of at least five basic materials (ceramics, excavated materials, plasterboard, concrete and timber).	2
		Diversion of resources from landfill	Encourages non-demolition and awards demolition waste diversion from landfills. Encourages waste sorting either on-site or through a licensed contractor for recovery.	1 cts
	Design for disassembly and adaptability		Exposed and reversible connections, avoidance of unnecessary toxic treatments and standardisation are to be considered for this achievement. The aim is to facilitate the future reuse of the building components, so it is not directly related to the reuse issues analysed here.	2 cts

MAIN OBJECTIVE	*SECTION*	*SUB-SECTION*	*REUSE INTEREST*	*CREDITS*
10° Innovation	Demonstration of exemplary level performance criteria (among all referential criteria) - *Only criteria linked to reuse are presented here*	Environmental impacts from Construction Products - Building LCA (Mat 01)	If a specific subsection requirements (see Materials section) are completed, plus opportunities are identified for reducing environmental impacts during Concept Design, using LCA (1 credit)	Within the limit of 10 credits: Exemplary level criteria credits individual to each section + 1 innovation credit for each innovation application approved by BRE Global
			If a specific subsection requirements are completed, plus LCA is aligned with Life cycle costing (LCC) (1 credit)	
			If all this subsection requirements are completed, plus a third party verifies the LCA (1 credit)	
		Responsible sourcing of construction products (Mat 03)	If all this subsection requirements are completed, plus core building services (n/a to shell only assessments) (1 credit)	
		Construction waste management (Wst 01)	If exemplary levels are reached diverting non-hazardous construction, demolition and excavation waste from landfill (1 credit)	

2. LEED - Complete analysis table

Two successive versions were analysed in the timeframe of this study. The first one was actually a beta-version published in January 2020, used as a testing ground with project teams before opening the LEED v4 program to public registration[31]. In September 2021, the updated V4.1 version was analysed and some modifications regarding reuse aspects were taken into account.

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
3° Sustainable Sites	Site assessment		The assessment includes in its topics the identification of building materials with existing recycle or reuse potential. A reclamation audit is not specifically asked. It is simply said that 'the survey or assessment should demonstrate the relationship between the site features and topics listed above and how those features influenced the project design; give the reasons for not addressing any of those topics'.	1 ct

31. 'LEED certification for new buildings | USGBC.' Accessed April 13, 2020. https://www.usgbc.org/leed/rating-systems/new-buildings.

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
5° Energy and Atmosphere	Fundamental refrigerant management		When reusing existing HVAC&R equipments, complete a comprehensive CFC phase-out conversion before project completion.	Prerequisite
6° Materials and Resources	Building life-cycle impact reduction *(to encourage adaptive reuse and optimize environmental performance of products and materials)* -> Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials life-cycle assessment. Achieve one of the following options.	Option 1 Building and Material Reuse	Maintain the existing building structure, envelope and interior nonstructural elements. Reused or salvaged materials from off-site that are incorporated into the building can also contribute to the credit calculation. However, reuse materials contributing toward this credit may not contribute toward MR credit 'Sourcing of raw materials'. Path 1 and 2 reward projects that reuse structural and/or nonstructural elements based on the project area. Path 1 and 2 can be combined for points. • Path 1: Maintain existing structural elements (walls, floors, roofs and envelope). [...] Calculate the reuse of the existing project area according to Table 1 (see doc nr 1 below this table). • AND/OR Path 2: Maintain Interior nonstructural elements (1ct), for at least 30% of the entire completed building, including additions (see doc nr 2 below this table).	5-6 cts

32. Credits indicated here represent the largest rating possible, which may vary depending on the sub-category of the project. For example, in *the Location and Transportation* section, sub-section 1,, 8-20 credits can be gained with the Core & Shell subcategory, against only 5-9 credits with the Healthcare subcategory. This table takes the minimum and maximum scores, which are specified in the introduction of each section.

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
		Option 2 Whole Building Life-cycle assessment	For new construction, conduct a cradle-to-cradle life cycle assessment of the project's structure, enclosure and select one or more of the following paths below to earn up to 4 points. • Path 1: conduct a life cycle assessment (LCA) of the project's structure and enclosure (1ct). • Path 2: Conduct a LCA of the project's structure and enclosure that demonstrates a minimum of 5% reduction, compared with a baseline building in at least three of the six impact categories listed below*, one of which must be global warming potential (2cts). • Path 3: Conduct a LCA of the project's structure and enclosure that demonstrates a minimum of 10% reduction, compared with a baseline building in at least three of the six impact categories listed below, one of which must be global warming potential (3cts). • Path 4: meet requirements of path 3 and incorporate reuse and/or salvage materials into the project's structure and enclosure for the proposed design. Demonstrate reductions compared with a baseline building of at least 20% reduction for global warming potential and demonstrate at least 10% reduction in two additional impact categories listed below (4 cts). For paths 2, 3 and 4 listed above, no impact category assessed as part of the life-cycle assessment may increase by more than 5% compared with the baseline building. Include a narrative of how the LCA was conducted and if applicable for paths 2, 3 and 4 what changes were made to proposed buildings in order to achieve the related impact reductions. [...]. *Reuse would fit in the 'Global warming potential' (greenhouse gases) in kg CO2e) category.	1-4 cts

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
	Environmental Product Declarations (EPD) *Intent : to encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.*		Option 1: 'use at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the disclosure criteria". Those products must have an EPD which conforms with one of the mentioned ISO standards. Option 2: 'use products that have a compliant embodied carbon optimization report or action plan separate from the LCA or EPD. Use at least 5 permanently installed products sourced from at least three different manufacturers.	1-2 cts

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
	Sourcing of raw materials		For that the material manufacturer has to meet at least one of the responsible sourcing and extraction criteria. Reuse of materials is one of them and is defined as including 'salvaged, refurbished, or reused products'. Products meeting materials reuse criteria are valued at 200% of their cost for the purposes of credit achievement calculation. Alternative options are products purchased from a manufacturer that participates in an extended producer responsibility program, bio-based materials, FSC wood products, products with recycled content (meeting a threshold). Those options could be complementary and reuse is one of the most rewarding. The value of responsible materials must reach 15% of the total value of permanently installed building products in the project to get 1 credit, and 30% to get 2 credits.	1-2 cts
	Furniture and medical furnishings		Salvaged and reclaimed furniture more than one year old at the time of use. Products meeting materials reuse criteria are valued at 200% of their cost for the purposes of credit achievement calculation. Alternative options are products purchased from a manufacturer that participates in an extended producer responsibility program, bio-based materials, FSC wood products, products with recycled content (meeting a threshold).	1 cts (applies only to Healthcare projects)

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
	Construction and demolition waste management *Intent: To reduce construction and demolition waste disposed of in landfills and incineration facilities through waste prevention and by reusing, recovering, and recycling materials and conserving resources for future generations. To delay the need for new landfills facilities that are often located in frontline communities and create green jobs and materials markets for building construction services.*		Diversion (1ct) and Waste Prevention (1-2cts) are distinguished as 2 alternative options. They can be complementary but only in the limit of 2 cts, so it is not possible to execute both at their highest level of requirement. The measurement hinges on a Waste Management Plan which must be developed from start and followed up all along the project. Option 1: Diversion of at least 50% of the total construction and demolition materials from landfills and incineration facilities. AND/OR Option 2: Waste prevention through reuse and source reduction design strategies. Material salvaging can be a strategy, in combination with diversion to recycling (required threshold is at least 75% of waste mass). Application of reuse strategy is emphasized. Materials reclaimed on site should not be included in the calculation, because they are not counted as waste. Remark: for projects taking place in Europe, requirements for reuse can be replaced by waste-to-energy systems that meet European directives, in case reuse markets are not sufficient. In this case, project teams must demonstrate that reuse and recycling strategies were exhausted before sending material to combustion. Waste prevention awards 1ct if the project generates less than 75 kg/m², 2 cts if less than 50 kg/m².	1-2 cts
7° Indoor Environmental Quality	Low-emitting materials		Alongside emission standards for new materials, an alternative criterion applies to reclaimed materials: they are considered compliant with low-emission requirements if more than one year old. This applies to all interior fit outs (flooring, wall panels, ceiling, furniture...).	1 cts

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
8° Innovation (max 5 cts for this objective)	Option 1: Innovation		Achieve a significant, measurable environmental performance using a strategy not addressed in the LEED system.	1 ct
	Option 2: Pilot		Achieve one pilot credit from USGBC's LEED Pilot Credit Library. Some of those can indirectly reward reuse: 'Procurement of Low Carbon Construction Materials', 'Circular products' (sub-criterion 'Closed Loop Products', 'Green training for contractors, trades and service workers', etc.	1 cts
	AND/OR Option 3: Additional strategies	More Innovation achievements	Such as defined in Option 1 above.	1-3 cts
		More Pilot achievements	Exemplary performance	1-3 cts
		Exemplary performance	Exemplary performance	1-2 cts

Table 1. Points for reuse of building materials

Percentage of completed project surface area reused	Points BD+C	Points BD+C (Core and Shell)
25%	2	2
50%	3	3
75%	4	5

Doc nr 1: extract from 'LEED V4.1, Building design and construction', p.96.

Path 2: Maintain Existing Walls, Floors and Roofs (1-3 points):

Maintain the existing building structure (including floor and roof decking) and envelope (the exterior skin and framing, excluding window assemblies and nonstructural roofing materials).

Percent of existing walls, floors and roof reuse	Points
25%	1
50%	2
75%	3

Doc nr 2: extract from 'LEED V4.1, Building design and construction', p.96.

3. HQE - Complete analysis table

The framework analysed here is the 3rd version of HQE-Sustainable Buildings, for offices and the hospitality sector, issued in January 2019[33].

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
1° Organisation appropriate to the quality, performance and dialogue goals	Context and site analysis		Recommendation to look for potential 'local mining with a reuse potential' and 'local reuse or recycling chains'[34].	M1 to M5
			Inventory of the building's products and equipment (for buildings already in-use). This inventory is presented as essential for the technical parts of the referential 'Environmental impacts on lifecycle' and 'Air quality'.	
	Planification	Risk management		M1 to M5
		Risk management		
	Means and resources	Means and resources		M2 to M5[35]
		Procurement strategy and purchasing policy		
		Communication and involvement of interested stakeholders		
		Documented information	The tender for works must include a 'Charter for a Low Environmental Impact Worksite', with which contractors will have to comply. It is used to organise the waste management (reduction, storage, sorting, valorisation). This document must be displayed on the work site.	
			Drafting of a 'Worksite Charter', including the organisation of waste management.	

33. CERTIVEA *'Référentiel HQE HQE Bâtiment Durable V3*. 0', January 2019, France
34 See *'Référentiel HQE HQE Bâtiment Durable V3*. 0' p.39 : tableau des critères d'analyse du site
35. Except for one exigence accessible for the M1 level: treatment of claims (p. 53).

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
2° Steering to keep the project under control	Realisation of works		Identification of waste produced during the construction, by type and by waste treatment strategy.	M2 or M4
			Control and optimisation of waste management and valorisation.	M2 or M5
	Commissioning			NR
3° Evaluation to ensure a continuous improvement	Evaluation			M1 to M5
	Improvement			
Technical requirements				
2° Respect of environment	Smart use of energy and natural resources	Energy	Reuse is pointed out in the introduction as 'one of the sustainable ways to reduce the use of consumed raw resources'. Then, the energy sub-section gives a lot of attention in its own introduction to construction materials: 'the energy cost for manufacture, replacement and end-of-life treatment of construction materials is non-neglectable regarding the energy consumption during the occupancy phase. This statement leads to take into account all the building lifecycle so as to assess correctly the global environmental impact'[36].	(more than 39 cts, difficult to assess because must be associated with specific calculation for energy)
	Limitation of pollutions	Works waste (Dech 3.1)	Fosters 'waste valorisation' which likely includes any waste management strategy that deviates demolition waste from landfill and combustion without heat/electricity recovery.	12
		Fight against climate change	This section is presented in relation with the energy section, since 'just like for energy, the GHG emissions can be assessed over the whole building life cycle'. In effect, the assessment mainly focuses on the occupancy phase.	5
	Environmental impacts on life cycle		Part based on the E+C- framework (not mandatory to complete the label requirement).	6

NR = Not researched

36. Short translation - See document 'Référentiel HQE HQE Bâtiment Durable V3 .0', p.335

4. BBCA - Complete analysis table

The framework analysed first was the BBCA Labeling standard for New Construction V3.0 issued in 2018. It was then updated with a second analysis of version 3.1 published in 2021.

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
Greenhouse gas emissions and carbon storage ($GHG_{project\ BBCA}$)	Sustainable construction and carbon storage	GHG Indicator for 'Deconstruction'	This indicator encourages conservation of the existing structure by accounting the emissions saved by avoiding demolition.	$GHG_{deconstruct}$ [37]
		GHG Indicator for 'Deconstruction'	In carrying out an LCA, the carbon emissions for reclaimed products can be considered as accounting for 0.	GHG_{PCE}
Climate innovation (10 points in total)	Circular economy	Preliminary selective deconstruction	Requires: • A resource diagnosis. • A protocol attached to requirements for a proper selective demolition in the call for contractors.	1
		Reuse of construction products and equipments	Reusing building materials and products is strongly encouraged. Concerned stakeholders have to demonstrate the truly reclaimed origin of the reused materials and show that dismantled materials are going to be effectively reused. Different means of proof are suggested to do so.	Total mass of reused materials divided by total floor surface times 5 (Mass / Surface * 5[38])
		Design for adaptive use		3 max
		Design for extension		3 max

37. Total mass of reused materials divided by total floor surface times 5 (Mass / Surface * 5)
https://www.batimentbascarbone.org/wp-content/uploads/2018/10/2018_09_20_R%C3%A9f%C3%A9rentiel_Label-BBCA_Neuf_Version-3.0.pdf.
38. Formula : points for reuse = mass of reuse products used / (building floor area * 5)

5. BBCA - Complete analysis table

The full criteria catalogue for a specific scheme is reserved to members. However, separate descriptions per criteria are available on the DGNB website[39]. Even though DGNB website indicates 50 sustainability criteria in total, 37 are available online (the ones for new construction offices) and were used for this study.

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
1° Environmental quality (22,5%)	Building life cycle assessment (ENV 1.1)	LCA assessment	The impacts of reclaimed components are not to be computed in the life cycle analysis. By default, they are given a value of 0 regarding carbon emissions.	100 9,5%[40]
		Circular economy bonus	The impacts of reclaimed components are not to be computed in the life cycle analysis. By default, they are given a value of 0 regarding carbon emissions.	0
	Sustainable resource extraction (ENV 1.3)	Sustainably produced raw materials	Aims to reduce raw material extraction, either by purchasing sustainably produced raw materials (with a link with a sustainable procurement criteria), or by considering any secondary raw materials alternative. Recycled content is specifically encouraged. It is not clear if reused materials can be accounted, since they are not purchased from a manufacturer and may not be considered as 'raw resources'.	100 2,4%
		Secondary raw materials		

39. 'Overview of the criteria | DGNB System.' Accessed June 4, 2020. https://www.dgnb-system.de/en/buildings/new-construction/criteria/index.php.
40. How to read the weighting system: the credits show the reuse value in the context of the criteria, while the percentage shows the reuse value in the context of the whole system. So the amount of credits upon 100 attributed within each criteria will be multiplied by their respective weight factor to get to the final score.

MAIN OBJECTIVE	SECTION	SUB-SECTION	REUSE INTEREST	WEIGHT
2° Economic quality (22,5%)	Life cycle cost (ECO 1.1)	Life cycle cost	Aims for a 'sensible and conscious reuse of economic resources throughout the entire life cycle of a building'. 3 indicators reward the development and monitoring of the LCC	10,0%
		Circular economy bonus - Reuse	Awarded if a 'significant portion of the relevant reference value of components is demonstrably reused or implemented [...] via business models that conform to the circular/sharing economy concept and ensure or significantly support recyclability [...].'	10
4° Technical quality (15%)	Ease of recovery and recycling (TEC 1.6	Ease of recycling	These indicators aim to foster the future proper dismantling of components, so as to facilitate recycling and reuse at the end of the life cycle.	100 3% share
		Ease of recovery		
		Ease of recovery, conversion and recycling in the planning process		
		Circular economy bonus 1: Reuse or material recovery	Rewards reuse or material recovery in order to create a comparable product. Those options are referred to as"recycling paths'.	20 (1 credit per Standard Building Component)
5° Process quality (12,5%)	Sustainability aspects in tender phase (PRO 1.4)	General requirement	Requires to include sustainability aspects regarding material qualities in specifications.	100 1,6
		Circular economy bonus - Recycling materials	Awarded if the tender specifications explicitly require that recycled/secondary materials (post-consumer) are to be reused or used for the mineral construction products.	10
	Construction site / Construction process (PRO 2.1)	Circular economy bonus: Waste prevention on the construction site	Innovative/new concepts, construction methods or technologies that significantly reduce the amount of waste generated are used on the construction site.	10

6. GRO - Complete analysis table

As GRO does not consider weighting between criteria, the weighting column is disregarded in the framework analysis. The version analysed was the most recent in 2021.

MAIN OBJECTIVE	SECTION	REUSE INTEREST
Planet	MAT1 Raw materials conservation	Reuse of on-site building elements and materials 1. Preparation of inventory for analysis of reuse potential. Here 3 type of reuse are distinguished: • Retention of the element in its original location (foundations, carcass structures, joinery, load-bearing internal walls, site paving, etc). • Disassembly of the element and reuse in its entirety (stripped, cleaned, etc), either or another site or on the same site. • Partial reuse of an element (for example a system wall where only the inner panel is reused). 2. Percentage of on-site reuse building elements and materials
	MAT2 Materials selection	Indirect accounting of reuse through a Life Cycle Analysis, where reclaimed materials should be considered to have a lower impact (but this is not clearly stated in the referential)
	MAT3 Materials Passport	Material passports are encouraged in order to anticipate future reuse of raw materials in buildings
Profit	TOE1 Circular and future-oriented design	Buildings must be designed by taking into account dismantling and future reuse, recycling of materials
Location	MA2 Soil and land use	In case of reuse of listed buildings: existing buildings on the site are appropriately designated, the valuable parts restored and integrated into the project. This criteria is more oriented toward building conservation but can also be compliant with some cases of on-site reuse.

7. LEVEL(S) - Complete analysis table

Level(s) is not a certification scheme and consequently does not award a single score or weighting of the 16 indicators. Therefore, the weighting column is not considered in the framework analysis. The framework analysed was the most recent in 2021.

MAIN OBJECTIVE	SECTION	REUSE INTEREST
2° Resource efficient and circular material life cycles	2.1 Bill of quantities, materials and lifespans	Assessment of the potential reuse of fit-out materials (ease of disassembly)
	2.2 Construction & demolition waste and materials	Identification of elements for reuse on-site and consideration of possibilities for reuse, recycling and recovery of different waste fractions
	2.3 Design for adaptability and renovation	Indirect incentive to keep building elements in place
	2.4 Design for deconstruction, reuse and recycling	Main focus on design for deconstruction, ease of reuse (standardized dimensions, modular building services, design that supports future adaptability)
6° Optimized life cycle cost and value	6.1 Life cycle costs	Indirect consideration of reuse in the LCC methodology

Reuse in Green Building Frameworks

Rotor and the Belgian Building Research Institute
Interreg NWE 739 - FCRBE
November 2021