A FRAMEWORK FOR CIRCULAR BUILDINGS

indicators for possible inclusion in BREEAM

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Publication date
August 2018

EXECUTIVE SUMMARY

This report provides a general framework for circular buildings and proposes concrete strategies and indicators for possible inclusion in BREEAM New Construction and Refurbishment & Fit-Out (NC & RFO). The aim of the report is twofold: to provide stakeholders from government, business and academia with a basic framework to approach circularity in buildings, and to accelerate the transition to a circular built environment by suggesting strategies and indicators for integrations into leading global standards for sustainable buildings like BREEAM.

The definitions used in the framework are aligned with the Transition Agenda for circular construction in The Netherlands. The proposed strategies further build on the strategies presented in the recently published Roadmap for Circular Land Tendering as well as on a range of existing frameworks and tools. The suggested indicators are either adaptations of existing indicators in BREEAM RFO and NC, or entirely new indicators. The final list of suggested indicators was created with input from external experts.

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1. INTRODUCTION

Linear trends in the built environment
Our current economy, which is based on exploiting non-renewable energy sources, and the linear way in which we harvest, consume and discard materials, has detrimental effects on our climate and the environment, and cannot be sustained anymore. Global warming, resource scarcity, acidification of oceans and disruption of ecosystems are some of the consequences of our current behavior, which are becoming increasingly threatening to our economy as well.

The way we develop cities can mitigate these impacts, by designing and constructing our buildings for low energy and resource consumption. Though our cities occupy only around 3% of the world's land surface area, their residents consume 75% of natural resources and account for 60 – 80% of humanity's greenhouse gas footprint. The global trend towards urbanisation is projected to continue, with the global urban population rising from 54% at present to over 60% by 2025. The growing pace of urbanisation leads to increasing demands on infrastructure and buildings, and growing consumption of product and services. This makes cities one of the most critical intervention points for reducing human impact on the environment, creating sustainable local economies, and increasing the average quality of human life.

Within cities the built environment has the potential to play a key role in reducing environmental impacts, as this is the place where the energy transition and circular transition come together. The construction industry accounts for about 50% of our total use of raw materials. Furthermore, the built environment is responsible for 40% of CO2 emissions and 36% of energy consumption. Addressing these impacts through circular and climate neutral development is thus crucial.

Sustainable building frameworks are pushing the industry forward
Sustainability frameworks have emerged in the last decades to account for responsible and sustainable practices. BREEAM is the world's leading sustainability assessment method for masterplanning projects, infrastructure and buildings. It addresses a number

of lifecycle stages such as New Construction, Refurbishment, In-Use and Demolition & Disassembly. Globally almost 2,3 million buildings have been registered for assessment since the standard was launched in 1990.

Circular economy principles can accelerate positive impacts

The incorporation of circularity principles in such frameworks has only begun recently. Sustainability frameworks have pushed the sector forward, yet caveats remain, in particular with regard to disassembly, reuse and repurposing of buildings and materials. Circular economy principles can provide solutions to further develop and improve sustainability frameworks from both material and system perspectives. The Roadmap for Circular Land Tendering for the city of Amsterdam is a milestone in this regard, and is used as a first step to further incorporate the principles of the circular economy into existing assessment frameworks such as BREEAM.

The right time to suggest practical strategies for circular buildings

The Circular Buildings project is timely for two reasons:

- Circularity in the construction sector is high on public and corporate agendas. The Dutch government has globally set the tone with the recent publication of the Transition Agenda for a circular construction sector. At European level, circular construction has gained traction as well. Many companies have already taken the first steps to become circular. In this transitional period, there is a clear need for uniform frameworks and practical strategies to boost the transition.

- The Dutch versions of BREEAM New Construction (NC) and BREEAM Refurbishment and Fit-Out (RFO) are in the process of being developed, based on the existing Dutch version called BREEAM-NL Nieuwbouw en Renovatie. This represents a great opportunity to discuss the potential introduction and testing of indicators - both for the international standard as well as for the Dutch adaptation - that improve the circularity of buildings.

2. OBJECTIVES

The objectives of this project are twofold:

1. **To provide a basic strategy indicator framework for a circular building.**

   In order to identify circular indicators for possible inclusion in BREEAM, it was first necessary to develop a framework encompassing the key impacts, strategies and sub-strategies for a circular building. This basic framework is not only relevant to analyse opportunities to increase the circular impact of BREEAM, it also provides a source of inspiration for elaborating strategies in other projects and programmes that aim at making the built environment more circular.

   The following approach was taken to reach this objective:

   - Define circularity for buildings
   - Identify desired impacts and key strategies, building on the strategies identified in the Roadmap Circular Land Tendering
   - Take inspiration from existing strategy and indicator frameworks (including BREEAM, other standards amongst which LEED, DGNB, Crade to Cradle

2. **To suggest circular strategies and indicators for possible inclusion in BREEAM.**

   The key objective of this report is to propose strategies and indicators for possible inclusion in the international BREEAM New Construction (NC) and Refurbishment and Fit-Out (RFO), as well as the Dutch versions of these standards.

   The following approach was taken to reach this objective:

   - Perform a gap-analysis of BREEAM based on the strategy framework, to answer the question which indicators are fully covered, which ones are only partially covered and which are not yet addressed by BREEAM.
   - Identify - with the support of experts in the field - and describe key indicators that have the highest potential of improving the circularity of a building.

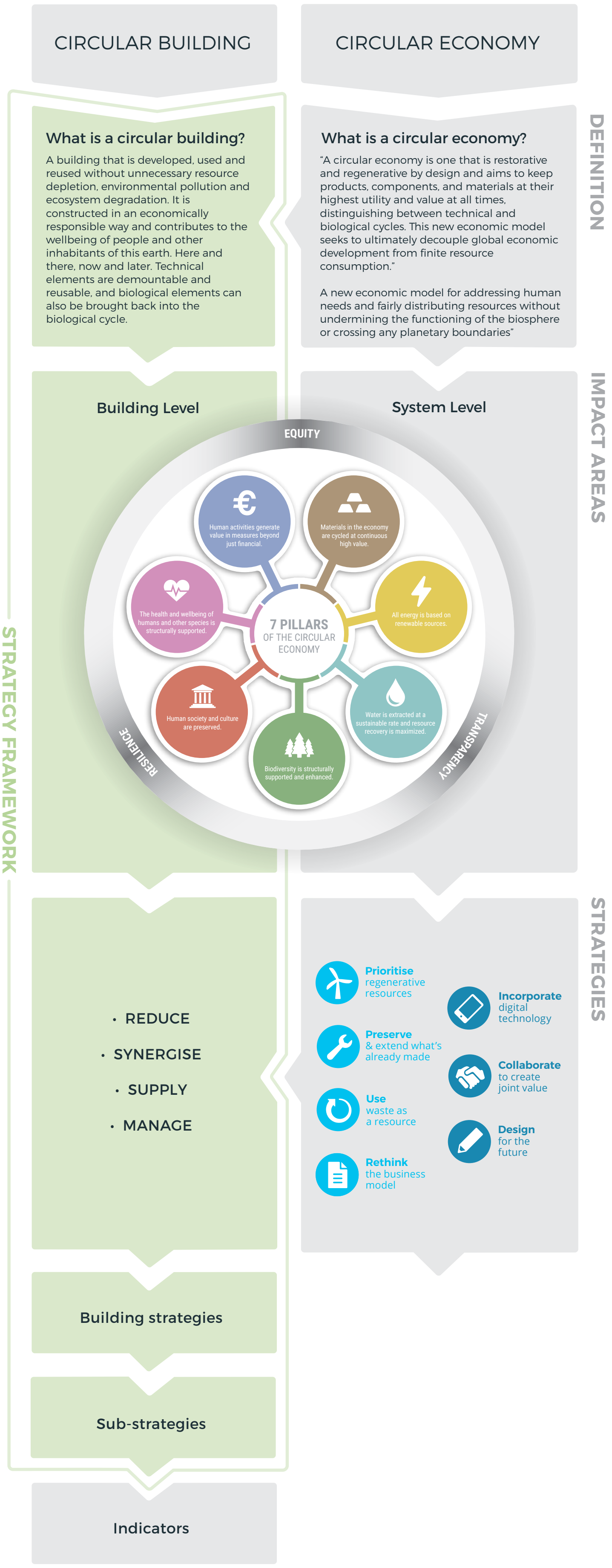
3. STRATEGY FRAMEWORK FOR CREATING CIRCULAR BUILDINGS

This chapter presents a *general strategy framework* for designing and constructing circular buildings. Using the building blocks visualised in figure 1, first an introduction is given of basic circular economy concepts (section 3.1), starting with *definition and desired impacts areas* (also referred to as *performance characteristics*) to *general circular strategies* for implementing circularity. To define what a circular building is, the same approach is followed in section 3.2: starting with a *definition of a circular building*, followed by desired *impacts areas* and practical *building design strategies* that create the desired impacts. Section 3.3 describes the building design strategies and *sub-strategies* in more detail, thus completing the *building design the strategy framework*.

3.1 Definition of a circular economy

The concept of a circular economy has arisen in response to the negative impacts of our currently linear economy, that is based on the principle of 'take, make and waste'. In a circular economy, waste is eliminated and the value of our resources is optimised for both people and the environment. This is not simply a matter of resource efficiency, but requires a systemically different approach to our economy.

For this report, two definitions have been adopted. The first is provided by the Ellen MacArthur Foundation (EMF), a global leader in circular economy thinking. EMF gives the following definition of a circular economy: "A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. This new economic model seeks to ultimately decouple global economic



What is a circular building?

A building that is developed, used and reused without unnecessary resource depletion, environmental pollution and ecosystem degradation. It is constructed in an economically responsible way and contributes to the wellbeing of people and other inhabitants of this earth. Here and there, now and later. Technical elements are demountable and reusable, and biological elements can also be brought back into the biological cycle.

What is a circular economy?

"A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. This new economic model seeks to ultimately decouple global economic development from finite resource consumption."

A new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries"

Figure 1: set-up of the strategy framework.

development from finite resource consumption."

The second definition used for this report considers the circular economy from a broader sustainability perspective; Eva Gladek defines it as "A new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries". This stresses the importance of operating within the safe zone of the planetary boundaries (Steffen et al, 2015), while making sure that minimal social standards are met (Raworth, 2017). Based on these two definitions impact areas that a circular economy should take into account and positively impact can be identified.

3.1.1 Desired impacts of the circular economy

The frameworks from Rockstrom (planetary boundaries) and Raworth (doughnut economics) give many impact areas for a sustainable world. The fact that these frameworks take into account the global system is good in itself, yet the many impact areas they cover also make it difficult and complex to define strategies and monitor impacts. Moreover, the impact areas are not defined from a circularity perspective.

A more practical approach to ensuring both positive natural and social impacts of applying circular strategies is given by Metabolic's 7 performance characteristics of a circular economy (see figure 2). This framework accounts for the optimal use of materials, energy and water resources, while it also supports positive impacts on biodiversity, human culture and society, health and wellbeing and the creation of multiple forms of value.

A short description of the performance characteristics of a circular economy is given here:

1. **Materials are incorporated into the economy in such a way that they can be cycled at continuous high value.** A priority is placed on preserving material complexity, by cascading materials in their most complex form for as long as possible (e.g., as products rather than components, and as components rather than materials). Material cycles should be designed to be: of lengths relevant to human time scale and the natural cycles to which they're connected, matched to material scarcity, and as geographically short as possible. Materials should not be mixed in ways that they can no longer be separated and purely recovered, unless they can continue to cycle infinitely at high value in their mixed form. Materials should be used only when necessary: there is an inherent preference for dematerialisation of products and services.
2. **All energy is based on renewable sources.** Density of energy consumption should ideally be matched to density of local energy availability. Conversion and transport of energy should be avoided. The system should be designed for maximum energy efficiency without compromising performance and service output of the system.
3. **Water is managed in a 100% circular fashion.** Water use is matched within the capacities of the local water cycle and it is ensured that all resources are successfully recovered from utilised water.
4. **Biodiversity is structurally supported and enhanced.** Habitats, especially rare habitats, should not be encroached upon or structurally damaged through human activities. Preservation of ecological diversity is one of the core sources of resilience for the biosphere.
5. **Human society and culture are preserved.** Processes and organisations should make use of appropriate governance and management models and reflect the needs of affected stakeholders. Activities that structurally undermine the well-being or existence of unique human cultures should be avoided at high cost.
6. **The health and wellbeing of humans and other species are structurally supported.** Toxic and hazardous substances should ultimately be eliminated, and in the transition phases towards this economy, minimised and kept in highly controlled cycles. Economic activities should never threaten human health or well-being in a circular economy.
7. **Human activities generate value in measures beyond just financial.** The choice to use (scarce) resources should maximise value generation across as many categories as possible rather than simply maximising financial returns. Forms of value beyond financial include: aesthetic, emotional, ecological, etc.

In addition to the seven performance characteristics, it should be ensured that any circular system is designed in a resilient, transparent and equitable manner. In order to create positive impacts in the above areas, several general strategies can be followed. These strategies are explained next.

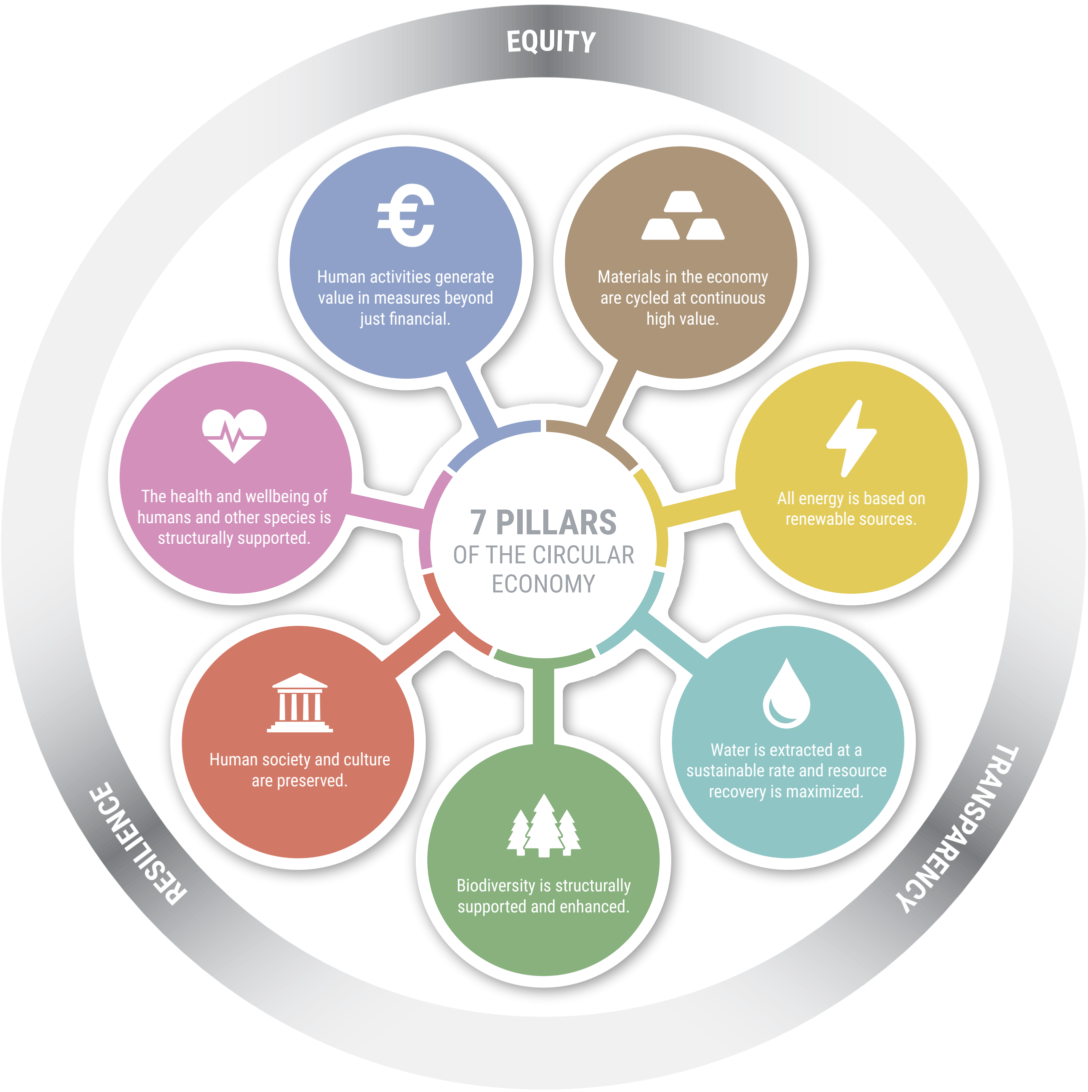


Figure 2: the performance characteristics of a circular economy.

3.1.2. General circular strategies

It is important to understand which circular economic activities should be undertaken, in order to achieve positive social and natural impacts. Synthesising a number of existing strategy frameworks, Circle Economy developed 7 general circular strategies (see figure 3). Three strategies (Prioritise regenerative resources, Preserve and extend what's already made, and Use waste as a resource) focus on optimising material use and cycling. The other four (Rethink the business model, Design for the future, Incorporate digital technologies and Collaborate to create joint value) act as enabling strategies. These general strategies can be applied to any sector.

A short description of the general strategies for a circular economy is given below:

- **Prioritise regenerative resources:** Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way
- **Preserve & extend what's already made:** While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take-back strategies when applicable
- **Use waste as a resource:** Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling
- **Rethink the business model:** Consider opportunities to create greater value and align incentives that build on the interaction between products and services
- **Design for the future:** Account for the systems perspective during the design process, to use the right materials, to design for appropriate lifetime and to design for extended future use
- **Incorporate digital technology:** Track and optimise resource use and strengthen connections between supply chain actors through digital, online platforms and technologies that provide insights
- **Collaborate to create joint value:** Work together throughout the supply chain, internally within organisations and with the public sector to increase

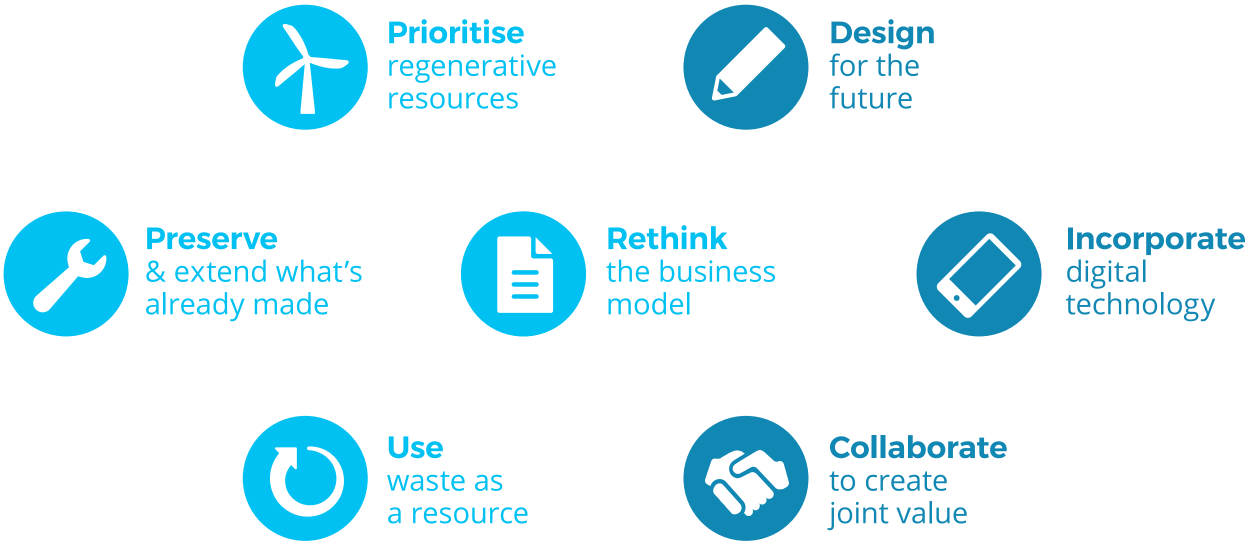


Figure 3: the general strategies for a circular economy.

transparency and create joint value

These general strategies can be used to derive the four specific *building design strategies* described in 3.2.2.

3.2 Defenition of a circular building

The agenda for the transition to a circular built environment in The Netherlands, called the Transition Agenda (see Box 1), uses a broad definition that includes buildings and infrastructure. The definition used for the purpose of this project is a modified version of this definition, with a specific focus on circular buildings. A circular building can be defined as:

> ***A building that is developed, used and reused without unnecessary resource depletion, environmental pollution and ecosystem degradation. It is constructed in an economically responsible way and contributes***

Box 1 - Alignment with Dutch Government transition agenda for circular construction

In 2016, the Dutch government initiated the Circular Economy programme, aimed at developing a fully circular economy in the Netherlands by 2050. As part of this programme, five sector specific transition agenda's have been published, including the construction sector.

The definition of circular building in the transition agenda is given as: "the development, use and reuse of buildings, area's and infrastructure, without avoidable depletion of natural resources, pollution of the environment or negatively impacting ecosystems. Construction which is economically responsible and contributes to wellbeing of humans and animals, now and in the future". Throughout the agenda there is a strong emphasis on the necessity of a uniform, accessible and reliable measuring instrument to assess circularity and with which the added value of circular buildings can be measured and clearly communicated. In addition, the transition to a circular economy calls for the development of supply and demand for circular products and processes and for market mechanisms which facilitate this. In the period between 2018 – 2021 new policy, regulations and laws relating to circularity will be developed, introduced and enforced from a national to a regional scale. The government has announced the gradual transition from measures that aim to voluntarily stimulate circular development to compulsory measures for circularity such as minimum standards.

The criteria of circularity proposed for inclusion in BREEAM align both with the definition of circular building and with the main aims that are set out throughout the transition agenda. Inclusion of circular criteria works towards better measurement and communication. Material accounting increases the ease of recovery and reuse of materials and as a consequence increases value and demand. And inclusion would precede new laws and regulations, meaning that buildings assessed using the BREEAM standard are well equipped for the future.

> ***to the wellbeing of people and the biosphere. Here and there, now and later. Technical elements are demountable and reusable, and biological elements can also be brought back into the biological cycle.***

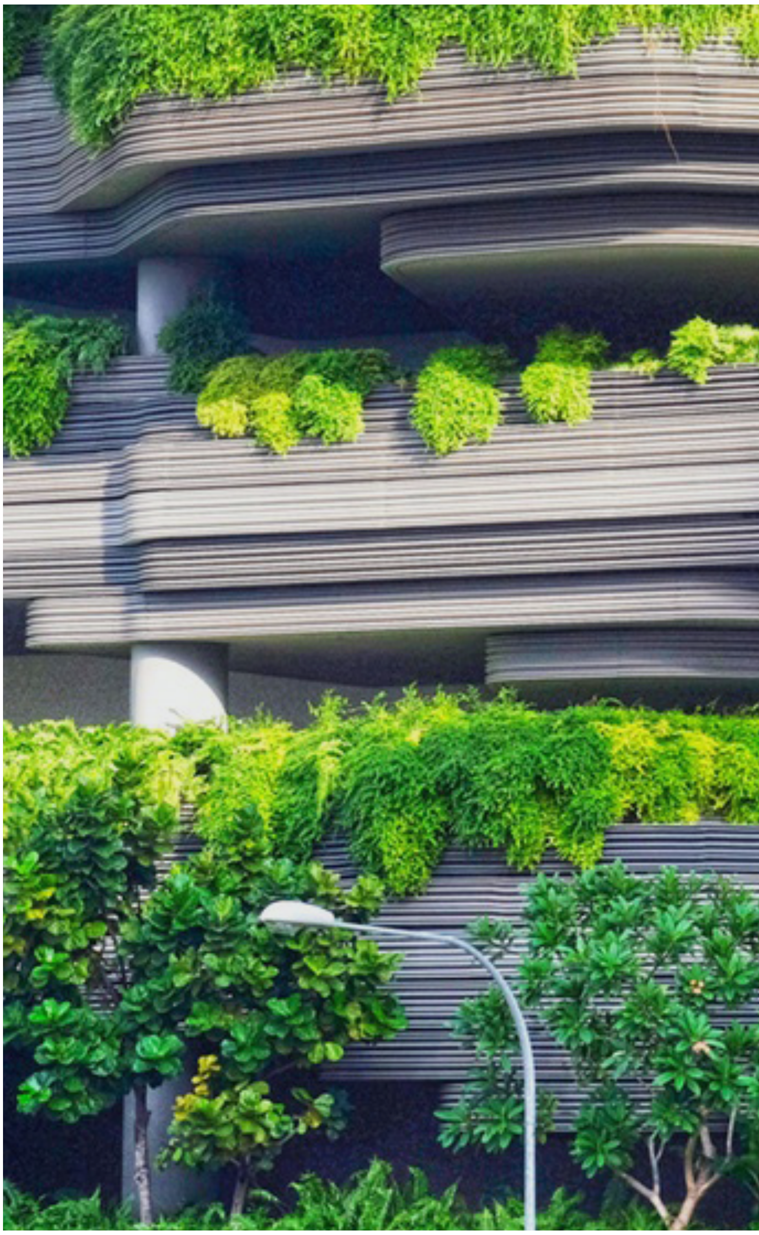
The definition is in line with the EMF's definition of circularity, in that the preservation of value of buildings and their components is ensured by optimising use and reuse cycles with minimal use of virgin resources. In addition, it stresses the importance of both the technical and biological cycles. In line with Gladek's broader definition, it addresses human needs and a healthy biosphere within the planetary boundaries.

It is important to note that a systems perspective is needed to achieve circularity at the building level. Smart integration into the surrounding (built) environment is key to maximising positive impacts, for instance by making sure that (reused) materials are sourced locally to minimise transport, or by efficiently combining renewable energy sources like geothermal heating. Indeed:

> ***During the use-phase impacts are primarily net-positive, and the building contributes to circular flows (of water, energy, and consumer goods) at the level of the building and its surroundings.***

Within the circular built environment, a circular building should take into account its location in the surrounding area and district, and its particular spatial characteristics (see Box 2 for more information on the importance of an integrated approach). A circular building is not an indivisible entity, it consists of different layers that can be distinguished as according to the 6S framework developed by Stewart Brand: site, structure, skin, space plan, services and stuff (furnishing & fittings), that are all part of a circular system of products, components and materials.

Circular buildings ideally contribute to a sustainable built environment in all lifecycle phases: conception, design, planning, construction, use & operation, and deconstruction. These phases are planned and executed with minimum environmental or social impact, optimise high-value material use, are adaptive and future-proof.



Box 2 - The importance of an integrated approach

This paper considers the performance characteristics of a building at its completion. Although this determines many aspects of its circularity, it presents a snapshot of the circular state at a certain moment in time within a specific geographic scope. In order to ensure a fully integrated approach to the development of circular buildings, it is crucial to consider interactions with four closely related processes:

- **Construction of the building**
- **Use phase of the building**
- **End-of-life phase of the building**
- **Development of the area which surrounds the building**

The actual construction process is impacted by the design and intended performance of the building. The choice for certain more circular materials can result in an increase or decrease in the construction costs, time, the amount of required energy and water, or the amount of construction waste that is produced during the construction process. Moreover, when inadequate methods are used during the construction of a perfectly circular design, such as applying certain types of glue or paint, then the resulting building won't live up to its circular performance potential.

The use phase is where the circular performance of a building is determined to a large extent through the resource flows it consumes and produces and how it preserves the state of the resources that are embedded in its stock. Not all of these resource stocks and flows can be fully influenced by the design of the building at its completion. User-related influences have a large effect on resource flows such as energy use for appliances, water use and the furniture that is bought and replaced. Within the more building-related influences, the renovation cycles in a building should ideally be matched to the functional state of the components and materials to prevent the loss of circular potential.

At the end of the functional lifetime the building will release (part of) the material stock that it has built up and preserved over its lifetime as material flows. It is crucial in this fase that these materials, components and elements are prepared for reuse at their highest quality. Next to meeting the initial precondition for eventual reuse, such as design for disassembly, use of renewable materials and securing availability of material information, it is equally important that the methods used at the end of the functional life should be geared to actually disassembly rather than turning the material stock into waste, which is the case for a large part of the current demolition practices.

A building is just a small part of the larger urban metabolism in which resource flows are exchanged, converted and fixed. This spatial dimension determines at what scale different resource cycles can most efficiently be closed. Energy cycles can for example often be closed on a building level, while water and nutiënt flows typically require a larger scale for recovery. The choice for the most efficient degree of decentralisation influences the way we should develop our buildings to benefit from the potential synergies between building and area.

3.2.1 Desired impacts of a circular building

A circular building has positive impacts in each of the seven impact areas or performance characteristics described in 3.1.1. The first three (Materials, Energy and Water) are associated with physical resource flows and represent key impact areas for realising circular buildings. In line with the definition of a circular building given above, cycling these resources will avoid unnecessary resource depletion and environmental pollution. At the same time, a circular building should also ensure the preservation and growth of natural capital (Biodiversity), social capital (Health & Wellbeing, Human culture & society) as well as other value creation (Multiple form of value). Enriching these forms of capital will be beneficial for the wellbeing of people and the biosphere.

Especially when it comes to Health & Wellbeing there are key issues that are often not taken into account. During workshops organised by the Circular Buildings project team in 2017 and 2018, participants stressed the importance of a healthy living and working environment for any building, and for circular buildings in particular. 'Healthy' materials contribute to optimal lifetimes because they don't have to be removed (like asbestos), while a health environment positively impacts the wellbeing and working performance of people. In the following section design strategies are presented that can be applied to each impact area.

3.2.2 Specific circular building strategies

Four practical design strategies for circular buildings can be deduced from the seven general strategies for circularity presented in section 3.1.2. These four design strategies, presented in the Roadmap Circular Land Tendering, have a logical hierarchy (the first strategy needs to be considered first, the second second, etc) and are the following:

REDUCE:

The easiest way to mitigate impact is to avoid producing it in the first place. Rather than trying to figure out how to supply an enormous energy demand in a sustainable way, the best course of action is to design a system that has very low demands for energy to begin with. Recent studies have shown that up to 75% of energy used in the built environment could be eliminated through smarter design. It is important to note that we never aim to "reduce" resource demand beyond a level where it may begin impacting comfort.

Associated general circular strategies:

Prioritise regenerative resources

Design for the future

SYNERGISE:

Once resource demands and their related impacts have been maximally reduced, the next step is to identify local synergies that can satisfy these demands. For example: if waste heat is being produced in a building, it should ideally be cascaded and re-used. Design options that satisfy multiple resource demands (such as a greenhouse that can be used to generate heat, electricity, collect water, provide recreational space, and be used to produce food) are preferable to single-solution choices. Local waste flows (energy, materials) should ideally be used. Contextually available resources (such as rainwater or heat from local bodies of water) should be tapped into to a maximum extent.

Associated general circular strategies:

Preserve & extend what's already made

Use waste as a resource

Collaborate to create joint value

Design for the future

SUPPLY:

Once synergistic supply options have been reasonably exhausted, remaining resource and functional demands should be supplied using clean, renewable, recycled, or otherwise ecologically beneficial sources of supply. Resources that can be harvested locally are preferred here, as it limits the impact of the neighborhood on its direct environment. Moreover, it increases efficiency, because locally harvested resources do not require transport or large infrastructural investments.

Associated general circular strategies:

Prioritise regenerative resources

Use waste as a resource

Design for the future

MANAGE

Creating information and data transparency about how and when resources are being used is essential to operating an efficient and well-functioning system. It is important to maintain feedback about how a system is working once it is operational; even basic informational feedback has been shown to reduce resource demands (e.g., for energy and water) in households by up to 15%. This kind of feedback allows for behavioural and technological adjustment over time. For each impact area that is traditionally associated with the built environment and urban living, we have followed this hierarchy as a guiding principle in eliminating or reducing impact.

Associated general circular strategies:

Rethink the business model

Design for the future

Incorporate digital technology

It is important to note that, although this is a guiding hierarchy that is generally correct, it occasionally makes sense to skip to a step in the process because of contextual factors or costs. For example, if a development is planned near a source of high thermal heat (like a hot spring), it may make more sense to tap into that heat (skip to the "synergise" step) rather than focus undue effort and cost on reducing the demand for heat, which might be more costly.

3.2.3 Strategy framework for circular design and construction

n this section the four building design strategies (Reduce, Synergise, Supply and Manage) are applied to each of the seven impact areas (section 3.2.1). Together with the definition of a circular building and the impact areas, these strategies form the basis of the strategy framework - visualised in figure 4. In some cases, a circular building design strategy (e.g. Synergise for impact area Health & Wellbeing) is not relevant for a particular impact area and therefore omitted from the strategy framework.

For a number of strategies, also sub-strategies are introduced that form the basis for potential indicators. As part of this study, a rough inventory was done based on existing standards and frameworks, to get an idea of what indicators could be used for the sub-strategies. Although this is not the core of the underlying paper, the results of this inventory of indicators can be found in Annex I.

Ultimately the framework is meant to provide guidance to developers and architects on how to design and construct a circular building: it needs to connect the practices on the building site (and at the drawing table) to the desired impacts and characteristics associated with a circular building.

The description of the strategies and sub-strategies for each impact area is given below, starting with Materials.

1. Materials

In the construction, use, and end-of-life phase of a building, the material cycles should be closed as optimally as possible, both through technical (human-designed closure of loops) and biological management (using the purifying power of nature and ecosystem services).

Optimising material use is the first step to close the material cycle. Taking a life-cycle approach, five ways can be identified to optimise the use of building materials: 1) reducing the total amount of materials used for construction and thus the amount that will need to be cycled, 2) designing for flexible use, to allow the building and its elements to serve multiple purposes during its lifetime, thus optimising and often extending the lifetime of a building, 3) designing for resilience, taking into account for instance potential changes in the environment or climate conditions, such as erratic rainfall, flooding or changing temperatures. 4) designing for reassembly, to facilitate the disassembly and reuse of building components and materials, and 5) maximising positive environmental impacts when applying the first four strategies that optimise the use of materials.

Following this, materials should be selected and assembled in a manner that ensures the preservation of material complexity and allows for continuous reuse of materials at high quality. This includes both the use of materials, components and elements with a previous life-cycle, as well as favouring modular construction that allows for these products to be re-used again after the current life cycle while preserving quality and complexity.

Wherever reused products are not sufficient, new materials have to be used in order to achieve the required function. This is done so by selecting the correct materials, keeping renewability, toxicity, scarcity, and impact on both environment and social aspects in mind.

Finally, keeping track of which materials are used where and when in the building process is important in increasing the potential of future reuse. This information can be stored in a so-called material passport. Within the material impact category thirteen circular sub-strategies have been established, divided over the four circular building strategies.

Within the material impact category 12 circular sub-strategies have been established, divided over the four circular building strategies.

M1 - Optimal material use	**M2 - Reutilisation of products**	**M3 - Circular materials**	**M4 - Knowledge development and sharing**
1. Reduce amount of materials used 2. Design for flexibility 3. Design for resilience 4. Design for reassembly 5. Checks and balances on environmental impact (prerequisite)	6. Maximise amount of reused materials 7. Maximise amount of reused components 8. Maximise amount of reused elements 9. Future use	10. Maximise use of renewable materials 11. Minimise use of scarce/critical materials 12. Optimise environmental and social impact of materials	13. Availability/accessibility of material information

2. Energy

The aim should be to achieve 100% energy neutrality in the built environment. Each building is responsible for being conscious of - and applying reasoned deliberation to - the production of the net required energy, taking into account the trade-offs between the efficiency of local production owing to context specific circumstances (avoiding, for example, solar panels in the shade). At a building level it might not always be possible to achieve 100% neutrality, even when possible energy minimisation adjustments are included in the design. In these cases, collaboration with the larger built environment can be used to leverage hotspots for renewable energy production. Further contributions to the aim of neutrality can be made by applying best practices and technologies with the highest efficiency both during the construction and use phase (taking care not to compromise on the quality of services provided). The source of supplied electricity and heat should be fully renewable, where possible locally produced, taking into account the impact of both development of local production capacity, and possible environmental and social aspects. Technological implementations in relation to energy matching would also contribute to this aspect. Finally, information regarding energy consumption during the use phase should be made available for building users and stakeholders, in order to give the possibility of optimising energy consumption during the use phase..

Within this impact category 5 circular sub-strategies have been established, divided over the 4 circular building strategies.

E1 - Minimise energy consumption	**E2 - Optimise energy demand**
1. Building design contains and uses minimal amount of energy	2. Energy matching (space and time)
E3 - Sustainable and local energy	**E4 - Knowledge development and sharing**
3. Minimise environmental impact of energy source	4. Availability of information (energy) for building stakeholders 5. Possibility of optimisation during use phase

3. Water

Water can be made completely circular by matching water use in buildings to the local water cycle and by reclaiming all nutrients and materials from wastewater. Water should be collected, purified and stored as locally as possible. The optimal degree of decentralisation for this depends on the ubiquity of water, the costs and effectiveness of closing the water cycle at a certain spatial and temporal scale, and safety concerns relating to, for instance, water contamination. Water use can be reduced by applying best practices and technologies, focusing on water-saving applications, making use of rainwater and wastewater, and by avoiding the use of any material which has high embedded water use at the location of extraction and production. The quality of water should be matched to its application, meaning that drinking water is ideally not used for irrigation or bathrooms. The recovery of nutrients and materials from wastewater should be done before water is brought back into the hydrological cycle, unless natural processes are better equipped to deal with these flows. In areas that risk heavy rainfall or flooding, an adaptive and resilient design is required to deal with water excess. Through “rainproof” design the negative impacts, such as damage to property and nutrient loss, can be minimised. Finally, and similar to the previous section on Energy, information regarding water consumption during the use phase should be made available for building users and stakeholders, in order to give the possibility of optimising water consumption during the use phase.

Within this impact category 5 circular sub-strategies have been established, divided over the 3 circular building strategies.

W1 - Minimise water consumption	**W2 - Water cascading**
1. Building design contains and uses minimal amount of water	2. Grey water system 3. Rainwater collection system 4. Resource/nutrient recovery
W3 - Knowledge development and sharing	
5. Availability/accessibility of water information	

4. Biodiversity and Ecosystems

Each project should ideally have a positive impact on the surrounding ecosystems and biodiversity, and ensure not to have negative impacts over the course of the life-cycle. Biodiversity is one of the most transgressed planetary boundaries, so this is an important aim. When selecting materials, care should be taken to select those materials which have low ecosystem impacts over their lifetime, taking into account the impacts during the entire life-cycle of the material (extraction, production, transportation). As a general rule, working with nature, rather than against nature, is a deemed a favorable practice. This includes making use of local vegetation for shadow, rainwater storage and ventilation. In addition, the migration patterns of local species should be considered in the design phase. The area should ideally accommodate plenty of greenspace, and biodiversity should be considered when choosing types of vegetation to apply.

Within this impact category 5 circular sub-strategies have been established, divided over the 4 circular building strategies.

BE1 - Avoid the loss of biodiversity	**BE2 - Integration of ecosystem services**
1. Building design causes minimal loss of biodiversity through embodied and use-phase ecosystem impacts	2. Ecosystem elements provide biodiversity and building functions
BE3 - Stimulate local biodiversity	**BE4 - Knowledge development and sharing**
3. Building design strengthens local biodiversity, especially for rare species	4. Long-term preservation of biodiversity and ecology 5. Availability/accessibility of biodiversity information

5. Human culture and society

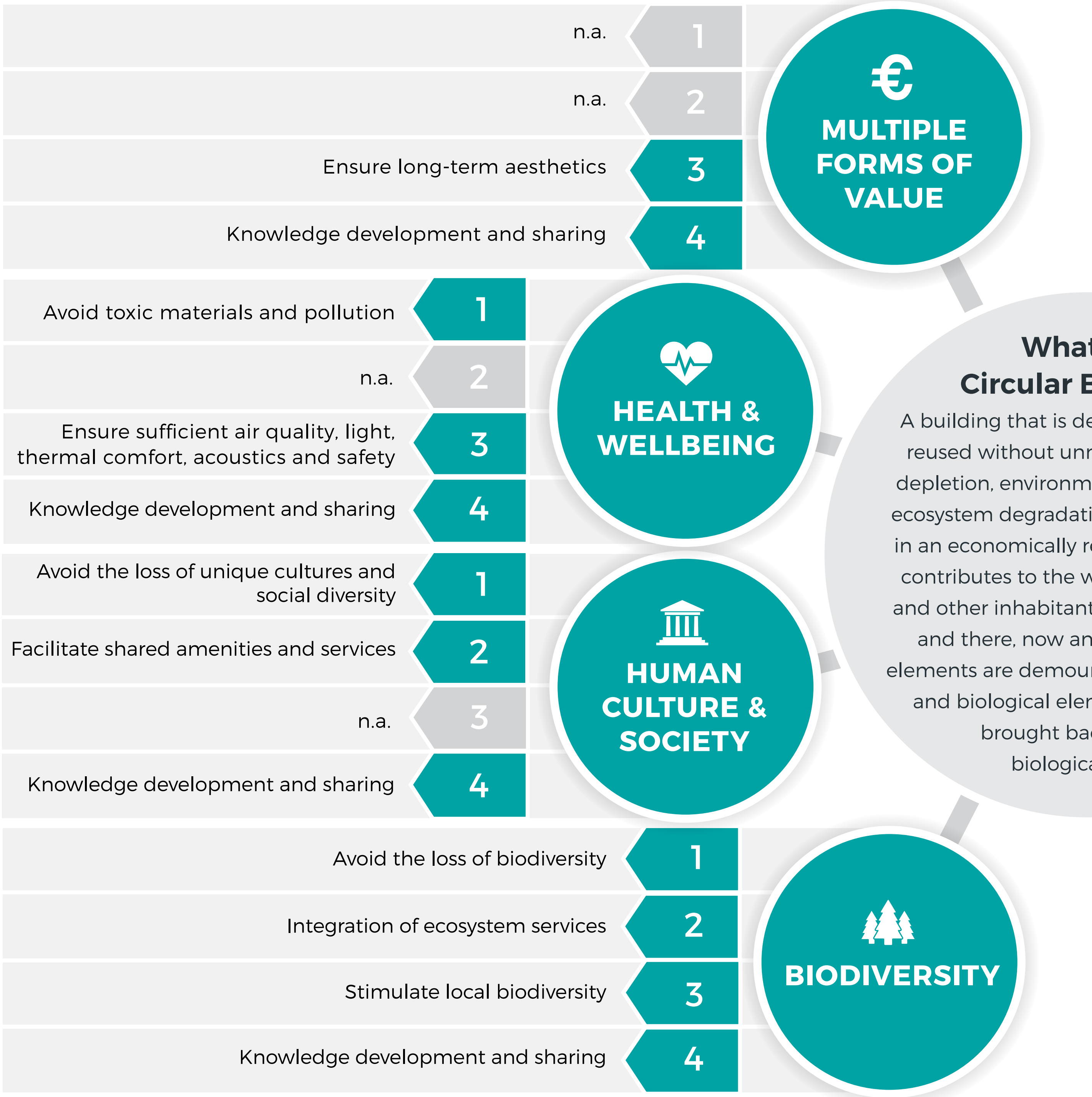
Human cultures and social cohesion are important to maintain, and buildings should contribute to preserving or stimulating this diversity and complexity. During the life-cycle of a building it should be prevented that a shortfall of the social foundation occurs. This applies to the stakeholders involved in the supply of the materials, the construction and the use phase. This also means that the users of the building have access to these needs. A building would therefore ideally have space for meeting and sharing and promote self-organisation for its users.

Within this impact category 3 circular sub-strategies have been established, divided over the 3 circular building strategies.

HS1 - Avoid the loss of unique cultures and social diversity	**HS 2 - Facilitate shared amenities and services**
1. Building design causes minimal social shortfall and loss of cultures through embodied and use-phase impacts	2. Functional shared spaces and amenities provide cohesion and impact reduction
HS 3 - Knowledge development and sharing	
3. Availability/accessibility of social information	

STRATEGY FRAMEWORK

For designing and constructing circular buildings



MULTIPLE FORMS OF VALUE

1. n.a.
2. n.a.
3. Ensure long-term aesthetics
4. Knowledge development and sharing

HEALTH & WELLBEING

1. Avoid toxic materials and pollution
2. n.a.
3. Ensure sufficient air quality, light, thermal comfort, acoustics and safety
4. Knowledge development and sharing

HUMAN CULTURE & SOCIETY

1. Avoid the loss of unique cultures and social diversity
2. Facilitate shared amenities and services
3. n.a.
4. Knowledge development and sharing

BIODIVERSITY

1. Avoid the loss of biodiversity
2. Integration of ecosystem services
3. Stimulate local biodiversity
4. Knowledge development and sharing

What
Circular E

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Figure 4: general strategy framework for designing circular buildings

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MATERIALS

1 Optimise material use
2 Reuse products
3 Use circular materials
4 Knowledge development and sharing

ENERGY

1 Minimise energy consumption
2 Optimise energy demand
3 Sustainable and local energy
4 Knowledge development and sharing

WATER

1 Minimise water consumption
2 Water cascading
3 n.a.
4 Knowledge development and sharing

General circular building strategies:

1 Reduce
2 Synergise
3 Supply
4 Manage

6. Health and Wellbeing

Health and wellbeing are important factors to consider in the built environment, and are relevant to the building level. At a building level, health and wellbeing relate to both the construction, use and demolition phases. For the construction and demolition phases the use and reuse of toxic or polluting materials should be prevented or minimised to avoid health risks, in addition to preserving the broader environmental integrity and biodiversity. Pollution relates to soil erosion, airborne dust, and waterway sedimentation. In the use phase, indoor air quality and access to natural light are important factors to consider.

Within this impact category 6 circular sub-strategies have been established, divided over the 3 circular building strategies.

HW 1 - Avoid toxic materials and pollution	**HW2 - Ensure sufficient quality of life by providing an optimal indoor environment**
1. Building design embodies no or minimal toxicity 2. Prevent pollution during construction, use phase and deconstruction	3. Ensure air quality and thermal comfort 4. Ensure visual comfort 5. Ensure acoustics
HW 3 - Knowledge development and sharing	
6. Availability/accessibility of toxicity information and indoor environment parameters	

7. Multiple forms of value

Materials and energy are not currently available in infinite quantities, so their use should be intentional and meaningful contribution to the creation of societal value. Forms of value beyond financial include: aesthetic, emotional, ecological, etc. Especially aesthetics is important for buildings because it contributes to societal value and largely the functional lifetime of a building.

Within this impact category 2 circular sub-strategies have been established, divided over the 2 circular building strategies.

V1 - Ensure long-term aesthetics	**V2 - Knowledge development and sharing**
1. Aesthetic value of the building doesn't limit its functional lifetime	2. Availability/accessibility of value information

The strategy framework: basis for developing circular indicators

The strategies and sub-strategies for each impact area, as described above, together form the strategy framework for designing and constructing circular buildings. For each of the sub-strategies, one or more indicators can be developed to demonstrate or measure if and how a sub-strategy is put into practice. The table in Annex I shows which indicators could be thought of for the impact areas Materials, Energy and Water. Further research is required to develop such indicators also for the other four impact areas.

4. GAP-ANALYSIS OF BREEAM

Looking through the lense of the strategy framework presented in the previous chapter, a gap-analysis was carried out for BREEAM international New Construction and Refurbishment and Fit-Out (NC and RFO). Figure 5 on page 24-25 shows which strategies are partially or completely covered by the standard and which are not. The underlying analysis that was done at the sub-strategy level is shown in Annex I.

The insights that can be taken from the gap-analysis are the following:

- Impact areas Water and Biodiversity are well covered by BREEAM NC & RFO (dark green in figure 5).
- Energy, Human Culture & Society, and Health & Wellbeing are sufficiently addressed by indicators in the standard (middle green). Although there is room for improving the indicators currently being used or potentially for adding new ones, the analysis shows that many sub-strategies are covered by the current standard.
- Impact areas that are insufficiently taken into account are Materials and Multiple forms of value (light green). Although sustainable material flows are addressed by BREEAM NC & RFO, key sub-strategies for circular buildings are missing, like M1.4 Design for reassembly, or can be significantly improved, like M4.1 Availability of information (element, component, material).

In addition to this overall gap-analysis, a group of experts has been consulted to determine which minimal number of key sub-strategies should be adhered to when designing and constructing a circular building (see Annex I). The corresponding strategies are highlighted in blue (essential strategies, 6 in total) and light-blue (important strategies) in figure 5. The 6 essential sub-strategies are also listed below in Table 1.

All sub-strategies deemed essential by the experts are related to making materials and material flows more circular. The last one, HW1.1, specifically relates to the toxicity of a material and is therefore part of the Health & Wellbeing impact area.

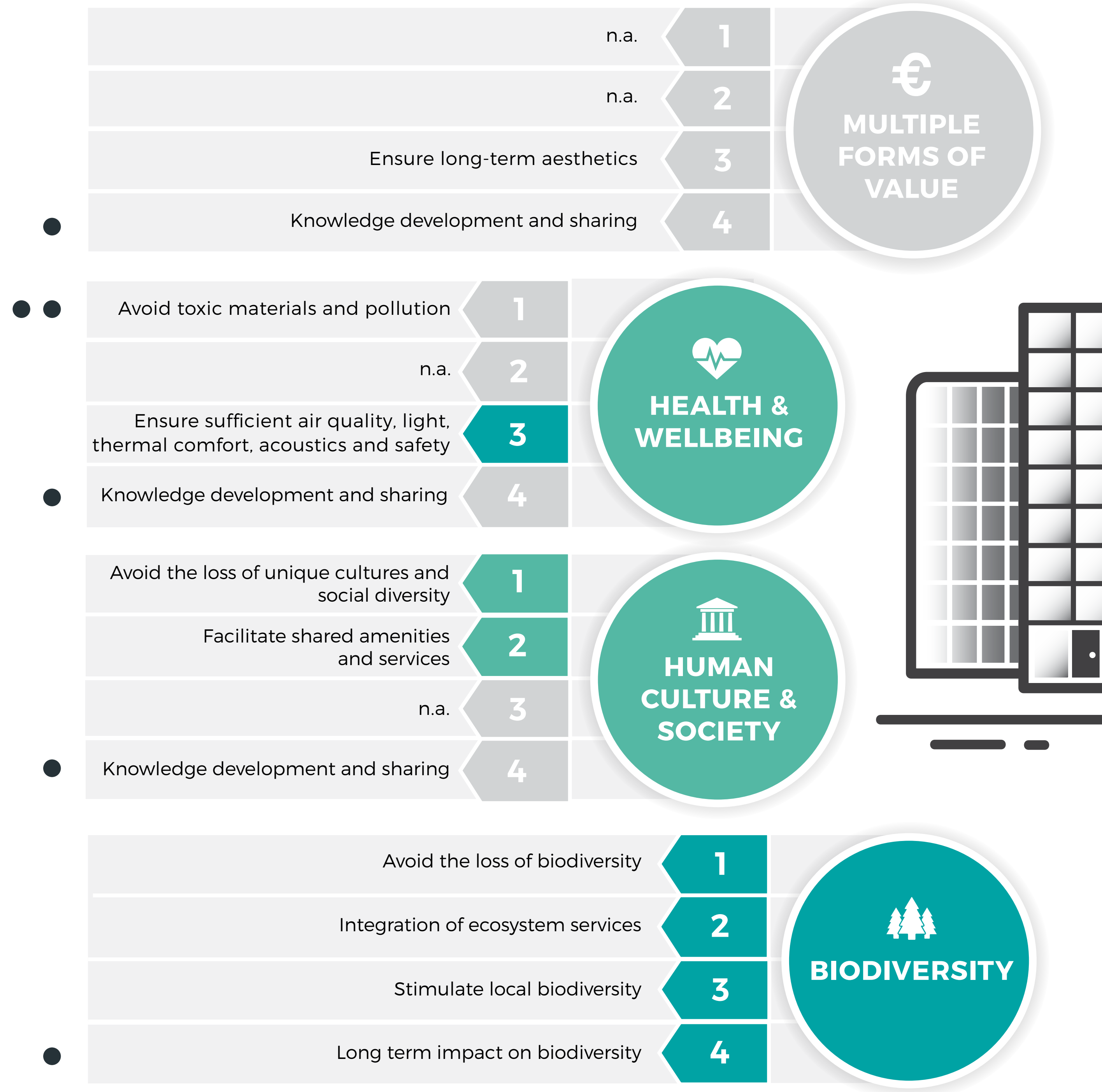
Following the expert recommendations, for each of the six sub-strategies a set of indicators has been developed. These are presented in the next chapter.

Essential sub-strategy	**Building design strategy**
M1.1 - Reduce amount of materials	M1 - Optimise material use
M1.4 - Design for reassembly	M1 - Optimise material use
M2.1 - Maximise amount of reused materials	M2 - Reutilisation
M3.1 - Maximise amount of renewable materials	M3 - Circular materials
M4.1 - Availability of information (element, component, material)	M4 - Knowledge development and sharing
HW1.1 - Building design embodies no or minimal toxicity	HW1 - Avoid toxic materials and pollution

Table 1: Sub-strategies prioritised by experts

CIRCULARITY GAPS IN BREEAM NC & RFO

& essential circular building design strategies



MULTIPLE FORMS OF VALUE

	n.a.	1
	n.a.	2
	Ensure long-term aesthetics	3
●	Knowledge development and sharing	4

HEALTH & WELLBEING

● ●	Avoid toxic materials and pollution	1
	n.a.	2
	Ensure sufficient air quality, light, thermal comfort, acoustics and safety	3
●	Knowledge development and sharing	4

HUMAN CULTURE & SOCIETY

	Avoid the loss of unique cultures and social diversity	1
	Facilitate shared amenities and services	2
	n.a.	3
●	Knowledge development and sharing	4

BIODIVERSITY

	Avoid the loss of biodiversity	1
	Integration of ecosystem services	2
	Stimulate local biodiversity	3
●	Long term impact on biodiversity	4

Figure 5: circularity gaps in BREEAM NC & RFO and essential circular building design strategies

CIRCLE ECONOMY | METABOLIC | DGBC Dutch Green Building Council | SGS SEARCH

MATERIALS

🟩 1	Optimise material use	● ●
⬜ 2	Reutilisation	● ●
⬜ 3	Circular materials	● ●
⬜ 4	Knowledge development and sharing	● ●

ENERGY

🟦 1	Minimise energy consumption	●
⬜ 2	Energy matching	
⬜ 3	Sustainable and local energy	
⬜ 4	Knowledge development and sharing	●

WATER

🟦 1	Minimise water consumption	
🟩 2	Water cascading	
⬜ 3	n.a.	
🟩 4	Knowledge development and sharing	●

Level of coverage by BREEAM NC & RFO of impact areas and design strategies:

- 🟦 **Good**
- 🟩 **Sufficient**
- ⬜ **Insufficient**

Priority given by experts to circular building design strategies:

- ● ● **High (essential)**
- ● **Medium**

5. CIRCULAR SUB-STRATEGIES AND INDICATORS FOR POSSIBLE INCLUSION IN BREEAM

This chapter presents the indicators that were developed for the six sub-strategies selected in the previous chapter (table 1). For each of these sub-strategies, 2 or 3 indicators are proposed that make it possible to assess whether a sub-strategy has been applied. These indicators are listed in table 2. This table also highlights which indicators are already included in BREEAM NC & RFO ('CONSIDER IMPROVEMENT') and which new indicators could be added to make the standard more circular ('INTRODUCE NEW').

A number of existing standards, frameworks and other sources have been studied to better understand what indicators could be suitable for a particular sub-strategy. Besides looking at BREEAM itself, a quick scan was done of frameworks and assessment methodologies used by organisations like the German Sustainable Building Council (DGNB), Cradle to Cradle Product Innovation Institute and the European Commission, of standards like LEED and WELL, and of tools like AQSI, GPR and FLEX 4.0.

M.1.1 - Reduce amount of materials

M.1.1.1 - A feasibility study is performed on the possibilities of building refurbishment, possibly excluding the option of new development. INTRODUCE NEW

M.1.1.2 - A feasibility study is performed on the possibilities of minimising the square meters of development (both new construction and renovation), within the specified requirements. CONSIDER IMPROVEMENT

M.1.1.3 - A feasibility study is performed on the possibilities of minimising the total material mass used within the specified requirements and square meter surface of development. CONSIDER IMPROVEMENT

M.1.4 - Design for reassembly

M.1.4.1 - De-/remountable connections are used when placing/installing the product in its direct surroundings, of which the preservation of similar quality can be guaranteed. INTRODUCE NEW

M.1.4.2 - The product is assembled through de-/remountable connections, of which the preservation of similar quality can be guaranteed. INTRODUCE NEW

M.1.4.3 - The connections used for placing/installing the product in its (direct) environment are accessible. INTRODUCE NEW

M.2.1 - Maximise amount of reused materials

M.2.1.1 - The score calculated by the tool MCI (Material Circularity Indicator) is equal or higher than X. CONSIDER IMPROVEMENT

M.2.1.2 - When determining the materialisation, search for local supply of reusable/second hand materials CONSIDER IMPROVEMENT

M.3.1 - Maximise amount of renewable materials

M.3.1.1 - Recyclable materials are used in the technical cycle CONSIDER IMPROVEMENT

M.3.1.2 - Biobased materials are used in the biological cycle CONSIDER IMPROVEMENT

M.4.1 - Knowledge development and sharing

M.4.1.1 - A building material passport is composed and maintained during the use cycle of the building regarding material cycles. CONSIDER IMPROVEMENT

M.4.1.2 - The building material passport is available for every building stakeholder. INTRODUCE NEW

M.4.1.3 - Upon completion, the building is delivered with demolition specification or disassembly guidelines. INTRODUCE NEW

HW.1.1- Building design embodies no or minimal toxicity

HW.1.1.1- No materials from the C2C Banned List of Chemical Materials are used CONSIDER IMPROVEMENT

HW.1.1.2- Building products have no or minimal VOC emissions CONSIDER IMPROVEMENT

Table 2: Suggested indicators for each of the 6 essential sub-strategies.

6. NEXT STEPS

This report represents a first step in developing a general strategy framework for circular buildings. It builds on definitions and frameworks that are already out there, and aspires to provide a good basis for further discussion and improvement. Part of this discussion regards the possibilities for incorporating new circular strategies and indicators in BREEAM NC & RFO. The overall aim of writing this report was to contribute to further standardisation - an essential element of accelerating the transition towards a circular built environment.

Next steps for the strategy framework
To take the strategy framework to the next level, the following steps are envisioned:

- Discuss the possible applications by the Dutch government in policy (Transition Agenda) and policy instruments (MIA-Vamil)
- Further refine and elaborate the strategy framework - on the one hand to fill the gaps regarding sub-strategies and potential indicators for all impact areas, on the other to see how the broader built environment and construction processes can be included as well.

Next steps for BREEAM-NL
The DGBC is currently working on the next version of BREEAM-NL New Construction and BREEAM-NL Refurbishment and Fit-Out based on the International versions of both schemes. In order to strengthen the BREEAM scheme with circularity indicators the following steps are advised to be undertaken by the DGBC following this report:

1. Discuss the report and the concept circularity indicators with the appropriate technical consultants at the BRE.
2. Discuss the report and the concept circularity indicators with the DGBC advisory board Nieuwbouw & Renovatie.
3. Test and improve the robustness of the circular indicators through pilot projects.
4. Elaborate the most promising indicators into full BREEAM credits and discuss the inclusion of the indicators in BREEAM-NL with BRE.

Parallel to above steps, DGBC can start to test the uptake of circularity indicators and its robustness by stimulating BREEAM-NL building projects to apply for innovation credits.

ACKNOWLEDGEMENTS

The Circular Buildings project team is grateful for the support provided by Redevco Foundation and would like to thank the following people and organisations for their valuable inputs during the preparation of the report:

- Participants of a workshop during the National BREEAM Congress 2018 held on the 20th of March in Rotterdam to discuss the envisioned framework.
- Experts who provided further suggestions on improving the framework and selecting essential strategies in a separate workshop held on the 24th of May 2018: Thijs Maartens, C2C PII, Andre Dröge - DGMR, Guido den Teuling - Redevco, Harry van Ewijk - SGS Search.

GLOSSARY

Impact area	7 pillars of a circular economy (Metabolic) https://www.metabolic.nl/the-seven-pillars-of-the-circular-economy
General strategy	7 elements of a circular economy (Circle Economy) https://www.circle-economy.com/the-7-key-elements-of-the-circular-economy
General building design strategy	4 general strategies presented in Roadmap Circular Land Tendering https://amsterdamsmartcity.com/projects/roadmap-circular-land-tendering
Building design strategy	Translation of general building design strategies into specific building design strategies for each impact area
Sub-strategy	Lower strategy level: each building design strategy is split into up to four sub-strategies
Strategy framework	Combined framework of: • definition of a circular building • impact areas (7) • building design strategies • sub-strategies
Indicator	Way of assessing the level to which a sub-strategy is implemented or adhered to; each sub-strategy can be divided into one or more indicators

Annex I

Strategy framework for circular buildings & potential indicators for BREEAM

What to measure	Impact Area	Strategy	Sub-Strategy	Indicator		Designated credit in BREEAM-NL NB&R 2014 v2.0	Degree of relation	Designated credit International RFO 2015 & NC 2016	Degree of relation
Circular building	**M** Material cycle	**M1** Optimise material use	**M1.1** Accountability and substantiation of building volume	**M1.1.1**	A feasibility study is performed on the possibilities of building refurbishment, possibly excluding the option of new development.	**MAN 6**	-	**MAN 01**	-
				M1.1.2	A feasibility study is performed on the possibilities of minimising the square meters of development (both new construction and renovation), within the specified requirements.	**MAT 1 / MAN 6**	**1**	**MAN 01**	**1**
				M1.1.3	A feasibility study is performed on the possibilities of minimising the total material mass used within the specified requirements and square meter surface of development.	**MAT 1**	**1**	**MAT 06**	**2**
			M1.2 Design for flexibility	**M1.2.1**	The score calculated by the tool Building Flexibility is equal or higher than X.	**MAT 8**	**3**	**WST 06**	**2**
			M1.3 Design for resilience	**M1.3.1**	A good to excellent thermal comfort is ensured.	**HEA 10**	**2**	**HEA 04**	**3**
				M1.3.2	Crucial functions are not situated in vulnerable locations of the building.	-	-	**POL 03**	**3**
				M1.3.3	Parts of the building with a high risk of damages are supplied with extra protection measures.	**MAT 7**	**3**	**MAT 05**	**3**
			M1.4 Design reassembly	**M1.4.1**	De-/remountable connections are used when placing /installing the product in its direct surrounding, of which the preservation of similar quality can be guaranteed.	-	-	-	-
				M1.4.2	The product is assembled through de-/remountable connections, of which the preservation of similar quality can be guaranteed.	-	-	-	-
				M1.4.3	The connections used for placing/installing the product in its (direct) environment are accessible.	-	-	-	-
			M1.5 Checks and balances on environmental impact (prerequisite)	**M1.5.1**	A Life Cycle Assessment calculation is made both during design stage and post-construction stage. The resulting environmental impact is compared with best practice results of similar buildings.	**MAT 1**	**3**	**MAT 1**	**2**
				M1.5.2	Based on the LCA calculation of the total building the construction materials chosen are evaluated on evnironmental impact and the material option(s) with the lowest or net-positive environmental impact are considered.	**MAT 1**	**3**	**MAT 1**	**2**
		M2 Reutilisation	**M2.1** Maximise amount of reused materials	**M2.1.1**	The score calculated by the tool MCI (Material Circularity Indicator) is equal or higher than X.	**MAT 1 / WST 2**	**1**	**WST 02 /MAT 03**	**1**
				M2.1.2	When determining the materialisation, search for local supply of reusable/secondhand materials	**WST 2**	**1**	**WST 02 /MAT 03**	**1**
			M2.2 Maximise amount of reused components	**M2.2.1**	When choosing components, search for renewable components.	**MAT 1**	**2**	-	-
				M2.2.2	When choosing components, search for local supply of reusable components	-	-	-	-
			M2.3 Maximise amount of reused elements	**M2.3.1**	The use of recycled products is mentioned in the tender procedure to stimulate reutilization during the design phase.	-	-	-	-
				M2.3.2	When choosing elements, search for renewable elements, preferably with a significant share in the total material consumption	**MAT 1**	**2**	-	-
				M2.3.3	When choosing elements, search for local supply of reusable elements.	-	-	-	-
			M2.4 Future use	**M2.4.1**	Circular business models are used which could possibly encourage the return and reutilization of products	-	-	-	-
				M2.4.2	Elements that are chosen have already been proven to be able for reutilization / recycling in the material cycle for future (similar) products	**MAT 1**	**1**	-	-
				M2.4.3	Managed service contracting with building suppliers in order to guarantee building product performance	-	-	-	-
				M2.4.4	A feasibility study is performed on the possibilities of reusing a product after	-	-	-	-

Circular building		**M3** Circular materials	**M3.1** Maximise amount of renewable materials	**M3.1.1**	Recyclable materials are used in the technical cycle	**MAT 1**	1	-	-
				M3.1.2	Biobased materials are used in the biological cycle	**MAT 1**	1	-	-
			M3.2 Minimise use of scarce/critical materials	**M3.2.1**	The building is not made of critical materials.	**MAT 1**	1	-	-
				M3.2.2	In case critical materials are being used, they are documented.	**MAT 1**	1	-	-
			M3.3 Minimise use of scarce/critical materials	**M3.3.1**	The environmental impact of the used materials is lower than the reference value.	**MAT 1**	3	**MAT 01**	1
				M3.3.2	Minimum of X volume % of the used materials has a substantiated/responsible origin. The amount of points calculated by the MAT 5-calculator, tab isolation and 100% of the used wood is produced sustainable.	**MAT 5**	3	**MAT 03 /MAT 04**	2
		M4 Knowldge development and sharing	**M4.1** Availability of information (element, component, material)	**M4.1.1**	A building material passport is composed and maintained during the use cycle of the building regarding material cycles	**MAT 1**	1	**MAT 01**	1
				M4.1.2	The building material passport is available for every building stakeholder.	**MAT 1**	1	-	-
				M4.1.3	Upon completion, the building is deliverd with demolition specifications / disassembly guidelines.	**MAT 1**	1	-	-
	E Energy cycle	**E1** Minimise energy consumption	**E1.1** Building design contains and uses minimal amount of energy	**E1.1.1**	The building consumes during the use phase a minimal amount of energy.	**ENE 1**	3	**ENE 01 / ENE 04**	3
				E1.1.2	The energy consumption of the building during both the construction and the use phase meets at least the requirements of the Climate Change targets (?)	**ENE 1**	2	**ENE 01**	2
				E1.1.3	The building is included with information sharing systems in order to increase the knowledge of building users in regard of energy consumption, with the desired effect of energy reduction.	**ENE 2**	2	**ENE 02**	2
				E1.1.4	During the design phase, elements, components and/or materials are selected by the least amount of embodied energy.	**MAT 1**	2	-	-
		E2 Optimise energy demand	**E2.1** Energy matching (space and time)	**E2.1.1**	The building is included with storage and/or management systems as part of energy matching.	**ENE 2**	1	**ENE 02**	1
		E3 Sustainable and local energy	**E3.1** Minimise environment impact on energy source	**E3.1.1**	Energy required for the construction and use of the building originates from energy sources with a minimal environmental impact.	**ENE 5**	1	**ENE 04**	1
		E4 Sustainable and local energy	**E4.1** Availability of information (energy) for building stakeholders	**E4.1.1**	All data regarding energy consumption to, in and out of the building is measured.	**ENE 2**	2	**ENE 02**	2
				E4.1.2	All data regarding energy consumption to, in and out of the building is publicly available.	**ENE 2**	2	**ENE 02**	2
			E4.2 Possibility of optimization during use phase	**E4.2.1**	Energy systems are installed with performance based contracting	-	-	-	-
	W Water cycle	**W1** Minimise water consumption	**W1.1** Building design contains and uses minimal amount of water	**W1.1.1**	Water saving or water free facilities are included in the building.	**WAT 1 / WAT 2**	3	**WAT 01 / WAT 04**	3
				W1.1.2	The building is included with information sharing systems in order to increase the knowledge of building users in regard of water consumption, with the desired effect of water reduction.	**WAT 1**	1	**WAT 01 / WAT 04**	3
		W2 Water cascading	**W2.1** Grey water system	**W2.1.1**	The building has a grey water system in order to cascade grey water produced by the building.	**WAT 5**	3	**WAT 01**	3
			W2.2 Rainwater collection system	**W2.2.1**	The building has a rainwater collection system in order to cascade rainwater.	**WAT 5**	1	**WAT 01**	1
			W2.3 Resource / nutrient recovery	**W2.3.1**	The grey water system and/or rainwater collection system have the possibility of recovering resources and nutrients during the cascading process.	-	-	-	-
		W3 Knowledge development and sharing	**W3.1** availability of information (water) for building stakeholders	**W3.1.1**	The building has a water management system for monitoring and giving feedback on water consumption	**WAT 2**	2	**WAT 02**	2

What to measure	Impact Area	Strategy	Sub-Strategy	Indicator		Designated credit in BREEAM-NL NB&R 2014 v2.0	Degree of relation	Designated credit International RFO 2015 & NC 2016	Degree of relation
Circular building	**BE** Biodiversity and ecology	**BE1** Avoid the loss of biodiversity	**BE1.1** Building design causes minimal loss of biodiversity through embodied and use-phase ecosystem impacts	-	see BREEAM	LE1 / LE2	3	LE 01 / LE 02	3
		BE2 Integration of ecosystem services	**BE2.1** Ecosystem elements provide biodiversity and building functions	-	see BREEAM	LE2 / LE3 / LE4	3	LE 02 / LE 03 / LE 04	3
		BE3 Integration of ecosystem services	**BE3.1** Building design strengthens local biodiversity, especially for rare species	-	see BREEAM	LE2 / LE3 / LE4	3	LE 02 / LE 03 / LE 04	3
		BE4 Knowledge development and sharing	**BE4.1** Long-term preservation of biodiversity and ecology	-	see BREEAM	LE6	3	LE 05	3
			BE4.2 Availability/accessibility of biodiversity information	-	see BREEAM	LE6	3	LE 05	3
	HS Human Culture & Society	**HS1** Integration of ecosystem services	**HS1.1** Building design causes minimal social shortfall and loss of cultures through embodied and use-phase impacts	-	not eleborated	LE1 / MAT 5	2	LE 01 / MAT 03	2
		HS2 Facilitate shared amenities and services	**HS2.1** Functional shared spaces and amenities provide cohesion and impact reduction	-	not eleborated	MAN 6	2	MAN 01	2
		HS3 Knowledge development and sharing	**HS3.1** Availability/accessibility of social information	-	not eleborated	MAN 9 / CASE STUDY	1	MAN 04 / CASE STUDY	1
	HW Health & Wellbeing	**HW1** Avoid toxic materials and pollution	**HW1.1** Building design embodies no or minimal toxicity	HW1.1.1	No materials from the C2C Banned List of Chemical Materials are used	MAT 1	1	HEA 02	1
				HW1.12	Building products have no or minimal VOC emissions	HEA 9 / MAT 1	3	HEA 02	1
			HW1.2 Prevent pollution during the construction, use-phase and deconstruction	-	not eleborated	HEA 9 / MAT1	1	HEA 02	1
		HW2 Ensure sufficient quality of life by providing an optimal indoor environment	**HW2.1** Ensure air quality and thermal comfort	-	see BREEAM	HEA 8 / HEA 9 / HEA 10	3	HEA 01 / HEA 02 / Hea 03 / HEA 04 / HEA 05	3
			HW2.2 Ensure light and visual comfort	-	see BREEAM	HEA 1 / HEA 2 / HEA 3 / HEA 4 / HEA 5 / HEA 6	3	HEA 01 / HEA 02 / Hea 03 / HEA 04 / HEA 05	3
			HW2.3 Ensure optimal acoustics	-	see BREEAM	HEA 13	3	HEA 01 / HEA 02 / Hea 03 / HEA 04 / HEA 05	3

What to measure	Impact Area	Strategy	Sub-Strategy	Indicator		Designated credit in BREEAM-NL NB&R 2014 v2.0	Degree of relation	Designated credit International RFO 2015 & NC 2016	Degree of relation
Circular building		**HW3** Knowledge development and sharing	**HW3.1** Availability/accessibility of toxicity information and indoor environment parameters	-	not eleborated	**HEA 8 / HEA 9 /**	**1**	**MAN 04 / HEA 02 / CASE STUDY**	**1**
	V Multiple forms of values	**V1** Ensure long-term aesthetics	**V1.1** Aesthetic value of the building doesn't limit its functional lifetime	-	not eleborated	-	-	-	-
		V2 Knowledge development and sharing	**V2.1** Availability/accessibility of value information	-	not eleborated	**MAN 9 / CASE STUDY**	**1**	**MAN 04 / CASE STUDY**	**1**

Annex II

Detailed descriptions of six building strategies and suggested indicators

The following sub-strategies are described in detail below:

M1.1 - Accountability and substantiation of building volume

M1.4 - Design for reassembly

M2.1 - Maximise amount of reused materials

M3.1 - Maximise amount of renewable materials

M4.1 - Availability of information (element, component, material)

HW1.1 - Building design embodies no or minimal toxicity

M1.1

Accountability and substantiation of building volume

Assessing the need to construct an entirely new building and making well-considered decisions about the need to use construction materials, in order to prevent the unnecessary use of materials.

This is a concept credit proposal as part of the project: A Framework for Circular Buildings

No. of credits available	Exemplary Performance
3	Yes/No

Assessment criteria

This issue is split into three parts:

M.1.1.1	1 point	A feasibility study has been carried out into the possibilities of renovating existing buildings and thus refraining from new construction.
M.1.1.2	1 point	A feasibility study has been conducted into the possibilities of minimising the construction/ renovation surface within the set requirements.
M.1.1.3	1 point	A feasibility study has been carried out into the possibilities of minimising the total amount of materials within the set requirements.

M 1.1.1 - One credit – The necessity need for new construction

The following is required to demonstrate compliance:

1. Research has been carried out into the various options for the realisation of the intended building volume, in which criteria such as location, public transport accessibility, social aspects, impact on or the importance to the environment, functional aspects, financial and commercial aspects have been included, next to the demonstrable examination to environmental aspects, such as reuse / renovation of existing real estate instead of new construction.
2. It is demonstrated that environmental aspects were taken into account in decision-making, either because the most environmentally-friendly option has been chosen, or by justifying and explaining the choice made and the weighed interests, if the most environmentally-friendly option is not chosen.

M1.1.2 - One credit – Minimise the building volume

3. In an early phase (definition phase, concept design stage) the minimisation of the building volume, both gross floor area and gross content of the building, has been pursued. The following aspects were included in the drafting of the space program and starting points for the design:
    a. Rooms / functions to be realised in the building. Do all rooms need to be in their own building, or can facilities from nearby facilities be used?
    b. Multifunctional and / or shared use of spaces, for example meeting rooms / kitchens-pantries
    c. Organisational optimisations, workplace concepts, flexible work spaces
    d. Functional optimisations, aim for optimal Gross-Net and Gross Content-GFA factors
    e. Other measures, for example the prevention of "excessiveness", smart and efficient building
4. Prior to completion of the concept design work stage, all relevant third party stakeholders have been consulted by the

design team and this covers the minimum consultation content in criteria 3.

5. The project must demonstrate how the stakeholder contributions and outcomes of the consultation exercise have influenced or changed the initial project brief and concept design.
6. Prior to completion of the detailed design, consultation feedback has been given to, and received by, all relevant parties.

M1.1.3 - One credit - Reduction of material use within minimum required m2 GFA

7. The required amount of material per square meter of gross floor area to be realised is minimised. The quantity is expressed in m3 of solid material belonging to all main components as stated in table 25 (current BRL 2014v.2.0, page 226/227). This should correspond to the entry in the MAT 5 calculator (if applicable), the input of the MPG calculation (MAT 1, if applicable) and the Materials Passport (see below). A volume calculation is made in which these quantities of solid material per element, per main component and as a total are included.
8. For at least 3 building elements, alternatives have been sought for a construction that is as slim / thin / light as possible to reduce the amount of material to be used. This research must be recorded in a memorandum, which shows which elements this concerns, how much volume it involves per element type, which optimisations were possible, which choices were made and why.

Methodology

M.1.1.1: no specific methodology. Often these considerations are (also) made from a financial perspective. If renovation costs >70% of new construction costs, then new construction is the preferred option (for example in Education, Healthcare). The funding models in those sectors address this.

M.1.1.2. Stakeholder consultation on Spatial Programme and Sketch Design. Ladder of participation - clarifying roles, tasks, powers, responsibilities of stakeholders - can be used to select and involve stakeholders.

M.1.1.2. Stakeholder consultation on Spatial Programme and Sketch Design. Ladder of participation - clarifying roles, tasks, powers, responsibilities of stakeholders - can be used to select and involve stakeholders.

References to other methods

- Regarding M.1.2 .: GPR building 4.3: criterion 4.2.3. (net gross floor area ratio)
- Regarding M.1.2 .: Consultation stakeholders: see BREEAM international MAN 01 Project Brief and Design.
- Regarding M.1.3 .: GPR building 4.3: criterion 2.2.5. (construction method, aimed at efficient use of materials) and criterion 2.2.6. (construction method, focused on multiple cycles)
- Regarding M.1.3 .: Reference to the Materials Passport, to MAT 5, to MAT 1 and to NL-sfb-element coding.

M1.1

Accountability and substantiation of building

Notes of working group for further elaboration

I. Location choice (M.1.1.) - Considerations for the choice of location and the choice for renovation or new construction have been made at an earlier stage, often in the feasibility phase, prior to the design brief and in many cases even before choosing to pursue BREEAM certification. It must therefore be made possible to introduce considerations of choice of location in the course of the design process with retroactive effect as evidence. This can be done in the form of a new declaration with reference to "older" notes, minutes, calculations, etc. that can be attached to the declaration as an attachment.

Remark: The disadvantage of this criterion is possible that one can't get any credits if the relevant considerations have not been made at an early stage.

II. Criterion 2 (M1.1.1) NB. Renovation does not necessarily have to be the most environmentally friendly option. This is almost always the case when it comes to the amount of material and its associated environmental impact, but perhaps not (always) when it comes to, for example, energy consumption (renovation often has a restrictive effect). On the other hand, as it is now described, a choice for new construction can also be justified, including from the point of view of energy performance. That must then be demonstrated.

III. Minimising construction volume (M.1.2.) - The aforementioned aspects can (partly) conflict with other criteria, such as future value, flexibility and so on. The point is that the best optimisations and considerations are made when taking into account those qualities / necessary measures. That has to be shown and argued. A higher floor height results in more volume to be built, but this can be justified if this increases flexibility and future value.

IV. Minimising Building Volume (M.1.2.) - Optimisation Programme of Rooms and (sketch) design results in less use of materials (less volume to be built). This can / must not be at the expense of requirements and wishes of building users. Consultation during the Definition Phase and / or the Preliminary Design Phase should involve stakeholders, which should result in a verification that the starting points meet the requirements and wishes of the stakeholders.

V. Criterion 7 (M1.1.3) - There is still no reference here, as with MPG. What is the "normal" volume of an average building (and that also varies considerably per type of building ...). Perhaps making a volume calculation is good enough for a point in itself. It may be asked to show that leaner constructions / solutions are considered (in the form of a research report (from the architect / constructor / contractor)

M1.4
Design for reassembly

Assessing the need to construct an entirely new building and making well-considered decisions about the need to use construction materials, in order to prevent the unnecessary use of materials.

This is a concept credit proposal as part of the project: A Framework for Circular Buildings

No. of credits available	Exemplary Performance
4	Yes/No

Assessment criteria

This issue is split into three parts:

M.1.1.1	1 point	A feasibility study has been carried out into the possibilities of renovating existing buildings and thus refraining from new construction.
M.1.1.2	1 point	A feasibility study has been conducted into the possibilities of minimising the construction/ renovation surface within the set requirements.
M.1.1.3	1 point	A feasibility study has been carried out into the possibilities of minimising the total amount of materials within the set requirements.

M 1.4.1 – One credit – Remountable connections between product and environment

1. (See also M.1.1.1.) An element overview is drafted, based on the NL-sfb-coding and the main building parts as described in table 25 (current BRL 2014v2.0, page 226/227). This is to be compliant with the input in the MAT5 calculation (if applicable), the input in the MPG-calculation (MAT1, if applicable) and the material passport (see after). Quantities are determined of all elements.
2. The elements as described above (point 1), will be divided based on the different building layers:
   - Stuff (loose interior): element codes: …..
   - Space plan (non-constructive elements and fitout): element codes: …...
   - Services (installations): element codes: …..
   - Skin (facade): element codes: …..
   - Structure (main construction): element codes: …..
3. For the elements part of the layer "Stuff" is assumed they are NOT connected to other building elements, making them automatically demountable and movable. These elements are NOT part of the assessment of this indicator. For the remaining elements, the following applies.
   - The functional lifecycle of elements increases:
   - "space plan": 7 to 15 years
   - "services": 5 to 20 years
   - "skin": 25 to 40 years
   - "structure": 50 to 75 years

- Demountability is essential for all layers to simplify future reuse of elements, components and materials, therefore speaking of remountability. However, the impact is bigger for elements with a shorter life cycle, because disassembly and reassembly of these elements will occur more frequently during the life cycle of the building.

M1.4

Design for reassembly

- The quantities of elements per layer are defined at point 1 and point 2. For at least X % of the total amount of elements, as decided at point 1, per layer is determined what the connection method of the element is, based on table YY:
- Total amount of elements in the layer: 100%
- Considered amount of elements in the layer: xx %
- Average score connections method of considered elements:

A is calculated as follows (per layer):

- Element 1 r % of the total amount of elements in the layer score: 0,5 (example)
- Element 2 s % of the total amount of elements in the layer score: 1,0 (example)
- Element 3 t % of the total amount of elements in the layer score: 0,6 (example)

TOTAL

r % + s % + t % =zz % considered in this layer. This number should be higher than xx%

The average score per layer is calculated based on the ratio per amount. Outcome for example 0.67

For one credit the following minimum scores need to be achieved for each layer:

- “space plan”: average minimum of 0,7
- “services”: average minimum of 0,7
- “skin”: average minimum of 0,6
- “structure”: average minimum of 0,4

Type of connections	accessory external connection or connection system	1.0
	direct connection with additional fixing devices	0.8
	direct intergral connection with inserts (pin)	0.6
	direct integral connection	0.5
	accessory internal connection	0.4
	filled soft chemical connection	0.2
	filled hard chemical connection	0.1
	direct chemical connection	0.1

TABEL 1 (source: Fuzzy variables for DDF (E. Durmisevic et al. 2006))

M 1.4.2 – One credit – Remountable connections at product level

4. The product is assembled from XYX.

M 1.4.3 – One credit – Accessible connections

5. The first credit “Remountable connections between product and environment” is obtained.
6. The connections are easily accessible. Based on the overview as depicted under M.1.4.1 point 3, in which the considered elements per layer and the scores regarding demountability of elements are mentioned, each element/connection is assessed for its accessibility. This is done for all elements considered. Based on table 1, for each element is

decided what the accessibility is of the connection point/assembly components.

- Total amount of elements in the layer: 100% (see M.1.4.1)
- Considered amount of elements in the layer: xx % (zie M.1.4.1)
- Average score accessibility connection points of considered elements: B

B is calculated as follows (per layer):

Element 1	r % of the total amount of elements in the layer (see 1.4.1.)	score: 0,4 (example)
Element 2	s % of the total amount of elements in the layer (zie 1.4.1.)	score: 1,0 (example)
Element 3	t % of the total amount of elements in the layer (zie 1.4.1.)	score: 0,6 (example)

TOTAL

r % + s % + t % =zz % considered in this layer. This number should be higher than xx% (see M.1.4.1) The average score per layer is calculated based on the ratio per amount. Outcome for example 0.78. For one credit the following minimum scores need to be achieved for each layer:

- “space plan”: average minimum of 0,8
- “services”: average minimum of 0,8
- “skin”: average minimum of 0,6
- “structure”: average minimum of 0,6

Methodology

As described above, partly based on BCI.

References

Building Circularity Index (BCI) / Verberne, see table below:

Accessibility to fixings and intermediary	accessible	1.0
	accesible with additional operation with causes no damage	0.8
	accessible with addition operation whcih is reparable damage	0.6
	accessible with additional operation which causes damage	0.4
	non accessible - total damage of elements	0.1

TABLE 2 (source: Fuzzy variables for DDF (E. Durmisevic et al. 2006))

M2.1
Reused materials

Reduce the environmental impact, including the depletion of natural resources, by opting for reused materials.

This is a concept credit proposal as part of the project: A Framework for Circular Buildings

No. of credits available	Exemplary Performance
2	Yes/No

Assessment criteria

This issue is split into three parts:

M.2.1.1	1 point	The aim is to use as many reused materials as possible, which is expressed in a score. De score is calculated by the formula from the Material Input (part of Material Circularity Indicator).
M.2.1.2	1 point	Collect locally reusable materials and apply them in the building.

The following is required to demonstrate compliance:

M 2.1.1 – One credit – Material Circularity Indicator

1. All elements, consisting of components and materials are specified, quantified and qualified (see M.4.1.1. Material passport). Part of the used MATERIALS are reused and/or recycled. This issue is aimed at the level of "Materials", meaning only the reused (= recycled) materials that are not yet part of the reused components (see M.2.2) and/or reused elements (see M.2.3). The total mass or volume of the materials is determined as follows:

a. Total mass of all elements (including the components and materials these elements are made of) = building mass = M-total

b. Total mass of all reused elements (including the components and materials these elements are made of) = M-element reuse

c. Total mass of all reused components that were not included in the reused elements (including all materials these components are made of) = M-component reuse

d. Mass considered materialen = M-total -/- M-element reuse -/- M-component reuse = M-material reference.

This mass forms a reference for determining the amount of reused materials. For that to happen, the mass or volume of the reused or recycled materials needs to be defined = M-recycle. Recycled materials that are part of reused components and/or elements are not taken into account.

The score for "reused materials" is calculated as follows:

M-recycle / M-material reference = q %

One credit is awarded when q > 25%

M 2.1.2 – One credit – Locally reused materials are applie

2. The mass of the materials that belong to the "M-material reference" has been determined during the previous point. This relates to the materials that partially (>25%) contain reused materials. If "a large part of the mass" of the reused materials is sourced "locally", and the average weighted cumulative distance of transportation from the source, possibly through a processor, producer and supplier to the location of the project ("average km") is less than "T km", one point is awarded.

M2.1
Reused materials

This is calculated as follows:

M-material reference = X kg / ton
Made up from: material 1: X1 ton a1 km X1 * a1 = tonkm 1
material 2: X2 ton a2 km X2 * a2 = tonkm 2
material 3: X3 ton a3 km X3 * a3 = tonkm 3
material 4: X4 ton a4 km X4 * a4 = tonkm 4
Weighted average: X ton average km total tonkm

If “average km” < T km, then 1 credit is awarded.

Where “km” refers to cumulative distance from source, via processor, manufacturer and supplier to the construction location

Methodology

In the methodology of the Building Circularity Index (BCI / Verberne) this is calculated as follows (for this issue only “Material INPUT” and its subcategory “RECYCLED materials” have been considered):

V(x) – M (x) * (1 – NVrc (x))

- Virgin feedstock (V)
- Non-virgin feedstock (NV)
- *Fraction recycled materials (Frc)*
- *Remanufactured materials (Frm)*
- *Fraction refurbished materials (Frf)*
- *Fraction reused materials (Fru)*

The Material Circularity Indicator (MCI) focuses on material input, life cycle and material output. For the present issue, the focus is on a section of these aspects, which is “material input”. This implies the MCI cannot be applied without a doubt.

The section “determination of the material input” includes relevant aspects of this issue. These can and will be used for this issue.

The GPR methodology describes this issue (2.1.2.) as follows:

- The application of renewable (biobased) or secondary (obtained by recycling) resources within many materials is already widely accepted (e.g. wood and scrap). That is why the extra percentage is important. A ‘relevant’ or ‘high’ proportion means a percentage that is higher than normally observed. This implies an intentional choice and request. For recycling a distinction is made by material type, as the customary amount of secondary resources differs per material type.

M2.1
Reused materials

- Information regarding sustainable production of renewable resources can be found on www.biobasedeconomy.nl
- A distinction is made based on the percentage of biobased or recycled material (the share in total volume of the total building element:
  - Biobased, including wood (material share based on renewable resources in total material use per element):
    - relevant share: >= 75%
    - high share: >= 90%
    - Extra condition is resources are obtained by sustainable cultivation.
  - Recycling (share of secondary resources in total resources use per element):
    - Metals, relevant share: >= 50%
    - Metals, high share: >= 75%
    - Plastics, relevant share: >= 25%
    - Plastics, high share: >= 50%
    - Organic (including wood), relevant share >= 25%
    - Organic (including wood), high share >= 50%
    - Mineral, relevant share: >= 20%
    - Mineral, high share: >= 50%
  - Valuation of this credit:
    - With multiple building elements; high share 21
    - With one building element; high share 10
    - With multiple building elements; relevant share 7
    - With one building element; relevant share 3
    - No circular materials 0

References to other methodologies

- GPR gebouw 4.3, credit Milieu 2.2.3. Circulaire materialen
- Verberne, BCI -> MCI
- BREEAM nieuwbouw en renovatie, credit WST 2 (secundair materiaal)
- Roadmap Circulaire Gronduitgifte, materialen 5 (gebruik van secundaire materialen voor de bouw)

M3.1
Use reusable and/or renewable materials

Recycling during the design phase of as many products as possible that are applied in the building, to optimise value preservation of the products or the application of renewable materials.

This is a concept credit proposal as part of the project: A Framework for Circular Buildings

No. of credits available	Exemplary Performance
3	Yes/No

Assessment criteria

This issue is split into three parts:

M.3.1.1	1 point	Guarantee the use of reusable and/or recyclable materials (technical cycle)
M.3.1.2	1 point	Guarantee the use of biobased materials (biological cycle)

The following is required to demonstrate compliance:

M 3.1.1 – One credit – application of technical reusable and/or recyclable materials

1. All elements, consisting of components and materials are specified, quantified and qualified (see M.4.1.1 Material passport). The applied MATERIALS are assigned to one of the following categories:
   a. The material has a technical origin and could be reused in the technical cycle in the future on at least equal level of value.
   b. The material has a biological origin (biobased) and could be either reused and/or composted and/or used as fuel in the future.
   c. Remaining materials, non specified and/or to be specified and/or not belonging to previous categories ad a. en ad b.

The total mass of all materials categorised under a., b., and c. is determined. In total this accounts for the total mass of all applied materials (= total building mass). This needs to be coherent to the material (building) passport (see M.4.1.1)

The mass of a. en c. combined forms the basis for further calculating the score of this issue.

= M-basis

The future technological reusability of part of the materials need to be demonstrated. Before this can be done, the materials (M-basis) need to be divided into the following categories, of which the mass need to be established each time:

1. Metals
2. Plastics
3. Organic matter (including wood)
4. Minerals
5. Other

For categories 1-4 the minimal portion (mass) that must be technologically reusable should be defined.

= M-reusability reference per category (metals, plastics, organics, minerals, other)

The mass per category regards the amount of the material that can be reused in a technological loop that retains the material value.

= M-reusable per category (metal, plastics, organic matter, minerals)

The score for "technological reusability of materials" is being calculated as follows (per category):

M-reusability / M-reusibility reference = w%

1. Metals minimum percentage: 50%
2. Plastics minimum percentage: 25%
3. Organic matter (including wood) minimum percentage: 25%
4. Minerals minimum percentage: 20%

One credit is awarded in case (for every category): w > minimum percentage per category

Demonstrating the future technological reusability could for instance be done by providing:

- examples of similar materials that become available from 'mining' and reprocessing building materials
- certification
- proof of origin of waste materials

For reference, see GPR methodology (subject 2.2.2).

M 3.1.2 – One credit – application of biological renewable materials

2. All elements, consisting of components and materials are specified, quantified and qualified (see M.4.1.1. Material passport)
The applied MATERIALS are assigned to one of the following categories:

- a) The material has a technical origin and can be reused in the technical cycle in the future on at least equal level of value.

- b) The material has a biological origin (biobased) and could be either reused and/or composted and/or used as fuel in the future.

- c) Remaining materials, non specified and/or to be specified and/or not belonging to previous categories a. and b.

The total mass of all materials under a., b. and c. is determined. In total this accounts for the total mass of all applied materials (= building mass). This needs to be coherent with the building passport (see M.4.1.1)

= M-total

The mass of b. regarding the mass of which is demonstrated that it has a biological origin (biobased) and in the future can be reused and/or composted and/or used as fuel. Wood products can only be applied when it is certified by a certification methodology, approved by the Timber Procurement Assessment Committee (FSC, PEFC).

= M-biobased

The score for "biobased materials" is being calculated as follows:

M-biobased / M-total = v %

One point is awarded when v > … %

Demonstrate that biobased materials have been used by way of

- certification, like for instance FSC, PEFC,
- substantiate the responsible sourcing, product specifications

M 3.1.3 – One credit – Circular procurement

3. Mining certain types of building materials, both non-renewable materials and renewable materials (in particular wood), can have large social and environmental impacts. In a circular economy, these negative impacts need to be minimised throughout the production chain.\

An environmental costs calculation (MPG) needs to be presented along with the design. This MPG shows the environmental costs in euro per m2 GFA per year of the project, based on an overview of the materials and building elements that will be applied. The calculation needs to be done by an expert, using data available in the Nationale Milieu Database (NMD) and existing software available through BREEAM and/or GPR gebouw.

In addition, a calculation can be provided showing the quantity of reused materials of which the origin and responsible sourcing can be substantiated.

For this calculation, MAT5 tool of BREEAM-NL-2014 can be used (http://www.breeam.nl/hulp/credit/mat_5)

Score: through MAT5 tool up to 5 credits can be obtained.

This score is multiplied by 20 credit, i.e. a maximum of 5x20=100 credits can be obtained.

QUALITATIVE SCORING

In addition to the MPG calculation a Working Method for circular procurement can be requested that includes the approach for responsible sourcing and optimal sustainability performance of materials.

Score: qualitative; up to 10 credits can be obtained; the score is multiplied by 10, i.e. a maximum of 10x10=100 credits can be obtained.

Methodologies

Design from the ambition to allow for high-quality reuse in the future, or to apply biobased materials. Take future circular application into account early during the process.

References to other methods

Described in BREEAM, GPR and ROADMAP.

M4.1
Availability of information

Information of the materials that are applied in the building is available for relevant involved parties and stakeholders in such a way, the information can be kept up to date after building completion and during the use phase regarding maintenance, mutations, replacements, etc. by the building owner and/or manager and/or the parties assigned for construction works by one of these parties in the building, or are otherwise responsible for keeping building material information up to date.

This is a concept credit proposal as part of the project: A Framework for Circular Buildings

No. of credits available	Exemplary Performance
3	Yes/No

Assessment criteria

This issue is split into three parts:

M.4.1.1	1 point	A building material passport is made and updated (material streams are mapped during the life cycle of the building).
M.4.1.2	1 point	The material passport is available for everybody that is/will be authorised.
M.4.1.3	1 point	A demolition specification is / disassembly guidelines are present and provided upon completion of the building

The following is required to demonstrate compliance:

M4.1.1 – One credit – Material passport

1. If currently existing constructional or architectural elements are present at the location which is to be developed in the current situation (including renovation/refurbishment), the current situation need to inventoried, specified, quantified and qualified, for the purpose of establishing which elements and components are present at the current situation and which of these elements and components will be preserved, reused or disposed. The conditions that apply for the inventory are described in the section "additions to the criteria", part of "requirements inventory existing real estate".
2. In addition to the previous point, all elements and components that are supplied and applied on location are specified, quantified and qualified. All elements and components with corresponding specifications, qualifications and amounts as described here, together with the information from the previous point, form the foundation of the material passport of the new building. The material passport needs to contain all elements and components ("as built") upon building completion that belong to the delivered situation, including both existing and newly developed elements. The material passport needs to comply with the conditions as described under "additions to the criteria", part of "requirements material passport".

M4.1.2 - One credit – Availability of the material passport

3. The material passport and related products (see M.4.1.1.) need to be delivered upon completion of the building in digital a form, preferably linked to a BIM model. The passport needs to be set-up, completed and adjusted during the development process. The material passport is developed and delivered in a digital form, both understandable and user-friendly for the building owner and/or manager. The required software for opening, controlling, modifying and maintaining the passport and related products is provided. The developing party is obliged to instruct the building owner and/or manager regarding the passport and the correct use of it by written and verbal explanation. In addition, the developing party needs to be available for further explanation and/or answering of questions during two years after completion of the building.

M4.1.3 – One credit – Disassembly guidelines (demolition specifications)

4. Both M.1.4.1 and M.4.1.1. have been awarded with one credit

5. The potential for disassembly and reassembly of a large number of products has been addressed in previous (sub)issues. This provides insights in the way disassembly could or should happen in the future for a large portion of the building. Guidelines/specifications are drafted for these elements and components, and for the elements and components that have not yet been considered during previous (sub)credits, describing the way in which the building could be disassembled and/or demolished in the future. These guidelines are provided upon completion of the building in combination with the material passport.

Methodologies

To be developed

References

For reference, see for instance:

- NL-sfb-elementencodering
- BREEAM Credits MAN 11, MAT 1, MAT 5, WST 1, WST 2
- NEN 2767 Conditiemetingen
- BREEAM-NL Demolition and disassembly

ADDITIONS TO THE CRITERIA

Requirements inventory existing real estate

An inventory is made of the available construction materials (varying from nearly any materials to an entire building) at location that is to be developed. The inventory has to be done based on the NL-SfB coding system for building elements.

1. The following information needs to be provided for each element:

Identififcation and volume of element in current situation

- A. NL-SfB-coding
- B. naming (e.g. *45.1 lowered suspended ceilings, mineral)
- C. location in building
- D. volume
- 1. m / m2 / m3
- 2. in m3, kg and % total volume

2. State of the element

a. score 1 (new), class 1: excellent quality, new built quality
b. score 2, class 2: good quality, new built impression is gone
c. score 3, class 3: fairly good quality, aging starts being visible
d. score 4, class 4: mediocre quality, aging clearly visible, correct functioning of element is doubtful
e. score 5, class 5: low quality, element does not function as it should
f. score 6, class 5: low quality, element does not function as it should
g. hazardous (asbestos etc): contains dangerous substances, needs to be removed as hazardous waste

3. Indication of (envisioned) reuse and purpose / application (in same location or elsewhere)
   A. First, the age of the building is requested (construction year) ,
   B. Indication of elements / components that will be reused in the same location
      1. Maintained: % of existing element that is kept. Elements (quantity) can be directly reused in the new construction and are thus part of the material passport.
      2. Dismantling and reuse of element after remounting at the location (e.g. movable partition walls / modular ceilings (22.1): % reuse of existing element. Elements (quantity) can be directly reused in the new construction and are thus part of the material passport.
      3. Dismantling and reuse of components at the location after treatment. A description of the component for the purpose of reuse at the location and of new function / of the new element for which it will be used (indicate sfb-code) (e.g. module from modular wall that can be reused as a module in a new wall): the total volume / weight of these components has to be equal to the total volume / weight of reused components in the new situation: % of existing element that will be used in same/different purpose in the new construction. These components (quantity) are thus part of the material passport.

4. Indication of elements / materials that need to be discarded somewhere else:
   A. high value reuse: % of volume that is reused in such a way that the elements / materials require little to no treatment to be reused for a similar or equal purpose (as listed on the NL-SfB element list), thus keeping the originally embodied value. In addition, the volume / weight needs to be calculated.
   B. recycling: % of volume that is recycled. In addition, the volume / weight needs to be calculated.
   C. incineration: % of volume that is incinerated. In addition, the volume / weight needs to be calculated.
   D. landfill / unknown: % of volume that goes to landfill or of which the destination is unknown, including corresponding volume / weight.

Requirements Material Passport

A material passport needs to be created in accordance to the conditions stipulated below. The material passport needs to be set up and updated during the design process up until the completion and commissioning of the building. The material passport has to be established and function (preferably combined with BIM) such that updates can be readily made regarding maintenance, mutations, replacements etc.

The material passport is set up based on the materials and elements that are required for the completion of the building and the area belonging to the building, and needs to contain all building elements (i.e. existing elements to be maintained, elements to be reused and new elements to be supplied). In case BIM is used, this equals the total overview of elements and products that are part of the BIM-model.

The complete overview needs to be set up in accordance to the NL-SfB coding system.

In creating the material passport, the following information needs to be provided for each elements:

1. identification and volume of elements in the new situation
   A. NL-SfB-coding
   B. naming (e.g. *45.1 lowered suspended ceilings, mineral)
   C. location in building (e.g. “ground floor, axis … until axis …”) and identification of ‘layer’ (in accordance to 6S-model, see also M.1.4.1.)

- Site
- Structure (bearing structure)
- Skin (facades)
- Services (installations)
- Space Plan (non-bearing elements and fixed interior)
- Stuff (other interior).

D. volume
  - quantity of the element using relevant unit (e.g. in m, m2, m3)
  - quantity of the element in m3, kg and % relative to the total volume

2. Origin of the element

A. Maintained: data can possibly be retrieved from inventory existing real estate

B. Reused element (at location): data can possibly be retrieved from inventory existing real estate

C. Reused component (at location): data can possibly be retrieved from inventory existing real estate. Components of existing elements / real estate can also be applied in a different element in the new situation. NB. the total quantity of the components, needs to correspond to the quantity of components for reuse indicated as such in the inventory existing real estate.

D. New (including recycled content of element)

3. Specification of elements, both existing reused and new.

A. Supplier data, maintenance requirements, warranties, ownership / lease agreements

B. (Envisioned) lifetime, replacement frequency en / or demolition methodology (see also demolition guidelines)

C. Bill of Materials: from a circularity perspective there is a need to understand and optimise the composition of elements, components and materials. Such information and insights show the real level of circularity of a building and the circular potential (or attention points) of elements, components and materials. The Bill of Materials per element needs to fulfill the requirements as specified under 'additions to the criteria' under 'Bill of Materials'.

D. Certifications. The level of application of materials and elements with a sustainability trademark or certificate. An overview of certified products, including a substantiation of the level of certification.

E. For each element, or otherwise at the component or material level, information needs to be provided regarding:

1. Material health: Volatile Organic Compounds
2. Applied materials that are listed on the EU-list of Critical Materials
3. Applied materials that are toxic and/or on the Banned List of Cradle to Cradle.
4. Reused and or recycled content
5. Reusability, recyclability in the future; possible future applications
6. Possibility to separate, dismantle at the elements and/or component and/or material level.

M4.1
Availability of information

Requirements Bill of Materials (BoM)

The BoM needs to be provided when this information is available, at the latest upon completion of the building. For each element in the material passport a BoM has to be supplied. Ideally, the BoM is linked to the BIM-model.

In the BoM, the following information is collected:

2. Material information
   - A. Part number, serial number
   - B. Material description (e.g. aluminum, nylon 6.6, beeach wood etc.)
   - C. List of parts (e.g. cover including sizes, screws including type, connectors etc.)
   - D. Precise material specification / trade name / product number
   - E. Weight of part in kg per piece * number of parts = total weight in kg
   - F. indication of materials that are on the EU-list of critical materials
   - G. Indication of materials on Cradle to Cradle Banned List
   - H. Indications related to closing the material cycle:
   - 1. The extent to which a material has been recycled
   - 2. The extent to which a material is renewabel
   - 3. The extent to which a material can be recycled
   - 4. The extent to which a material can be composted
     - Possibility of dismantling / disconnecting a material in the component it is used
     - Information about the supplier / producer of the materials (contact details, address etc)

Explanation Building Information Modelling

The material information as described for this credit is preferably linked to the BIM-model. Elements are classified based on the SfB-coding system and components and materials are linked to the elements.

Upon project completion the BIM-model needs to contain (if applicable) the as-built information, so that it can be updated during the use phase regarding maintenance activities, mutations etc.

This way, the materials passports and BoM-reports are also updated and it known at all times which elements and components with which characteristics and properties are present in the building.

If a BIM-model is not applied, the information as described for this credit needs to be saved in a different format such as Word, Excel or Exact etc, and linked to the digital design files. Together, these files should show which elements, components and materials have been used in which place in the building. The digital information needs to be shared with the owner / manager in such a way that it can easily be accessed, used and updated during the use phase.

HW1.1
Toxic Materials

Minimise and possibly eliminate the use of toxic materials to reduce negative impacts on human health and ensure that materials can be reused.

This is a concept credit proposal as part of the project: A Framework for Circular Buildings

No. of credits available	Exemplary Performance
2	Yes/No

Assessment criteria

This issue is split into three parts:

HW.1.1.1	1 point	Materials mentioned on the C2C banned list of chemical materials are not used
HW.1.1.2	1 point	Products have no or only minimal amount of VOC emissions

The following is required to demonstrate compliance:

HW 1.1.1 – One credit – banned list

1. No materials mentioned on the Banned List of Cradle to Cradle are used in the building, and if so, they have been used in quantities lower than the relevant threshold (source: C2C certified Product Standard version 3.1 16012017)\

HW 1.1.2 – One credit – VOC emissions

2. This should be aligned with the BREEAM credits related to VOC emissions in the issue Indoor Air Quality (HEA 02), that consider:
   - Emissions from building products
   - Post construction indoor air quality measurement

Methodology

Methodology applied for current BREEAM credit.

References to other methods

- C2C certified Product Standard version 3.1 16012017
- BREEAM NC & RFO - HEA 02 VOC emissions

A FRAMEWORK FOR CIRCULAR BUILDINGS

Indicators for possible inclusion in BREEAM