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Preface

This guide is intended as a step towards a core method for measuring circularity in the construction sector. Such a method measures the degree of circularity, e.g. of a construction product, a building or a bridge. The intention is that the core measurement method put forward by Platform CB’23 will stimulate the transition to a circular construction economy.

The guide is relevant to anyone engaged in circular construction. The core measurement method can be applied anywhere in the construction sector: in the buildings sector as well as in the civil and hydraulic engineering sector (infrastructure). All parties involved in the construction sector – including clients and contractors – can use the core measurement method. The guide is also of interest for people who work with comparable measurement methods or who work on circular policy, either in the Netherlands or internationally.

The guide was written for readers with different knowledge levels regarding circularity. However, they are all assumed to have a basic knowledge of the construction sector. Specific terms related to circular construction are presented in orange and bold the first time that they are used in the text. The definitions of these terms can be found in the Circular Construction Lexicon (Platform CB’23, 2020a).

This guide 2.0 is an updated version of guide 1.0, which was published last year. The introduction explains which parts are new.

The core measurement method will be updated regularly. The current method can be used to learn more about, and guide decisions on, some aspects of circularity, but is not yet a means to make a full circular appraisal.

Platform CB’23

Platform CB’23 (Circular Construction 2023) has committed to drafting agreements on circularity in the construction sector. The platform brings representatives of stakeholder parties (including market parties, policy makers and scientists) together to talk to each other and achieve generally supported agreements. To do so, they work in different action teams. This document was drafted by the MeasuringCircularity action team. Another action team has published a guide about Passports for the Construction Sector.
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Summary

The Guide for Measuring Circularity in the Construction Sector is the first step towards a broadly supported and harmonised core measurement method for circularity in the Netherlands. The first version of this guide was published in July 2019. This second version adds some elements that the core measurement method was lacking. The guide was published by Platform CB’23.

There is a need for a new method for measuring circularity

Investigations have been carried out to discover whether there is a need for a core measurement method in addition to existing methods such as the Bepalingsmethode milieuprestatie gebouwen en gww-werken (Determination method for the environmental performance of buildings and civil engineering works) (SBK method). This was done by consulting ‘users’ from parties in the circular construction sector. These discussions revealed that a new measurement method was considered desirable.

The parties were asked why they had taken up circular construction and what information they required to base their circularity decisions on. The lion’s share of the information needs for circular construction was found to come from three key goals of circular construction:

- to protect stocks of materials;
- environmental protection;
- value retention.

So far, the existing measurement methods provide insufficient information about the extent to which these goals are being met.

The core measurement method harmonises existing measurement methods

The core measurement method is a further development of existing methods for measuring sustainability and circularity. These methods have now been harmonised and this has created a broadly supported core measurement method.

The core measurement method has a fixed set of indicators. The results for these indicators are always calculated in the same way. The core measurement method leads to results for all the indicators, but, for the time being, they are not ‘weighted’. This means that they are not aggregated into one overall score. There is also room to add further indicators if needed for a specific project. The core indicators can be embedded in existing circularity calculation tools.

Scope and conceptual framework

The core measurement method can be applied broadly. Its potential uses include:

- both the buildings sector and the civil and hydraulic engineering sector (infrastructure);
- any level of scale of a structure: they can be applied to materials, construction products, groups of construction products such as ‘the façade’ or ‘the installations’, and to the entire structure;
- all phases of the construction cycle.

The following conceptual framework applies to the indicators of the core measurement method:
• The core measurement method measures the **impact** on the three goals of circularity. The core measurement method does not assess the actual circular strategies (such as service life extension and efficient reuse), but considers their impacts. The core measurement method enables the impacts of different circular strategies to be compared.

• The core measurement method starts from the **entire life cycle** of the structure (or any other object being measured). The method includes all achieved and/or expected input and output flows in that life cycle as part of the calculations.

• In future, the core measurement method will have to start from **several life cycles**. This enables a better understanding to be achieved of the impacts of circular strategies that are active over several life cycles.

Agreements concerning the scope and the conceptual framework have been formulated based on user stories and the conceptual frameworks of existing, frequently used measurement methods.

**Core indicators for protecting existing stocks of materials**

The core indicators for protecting existing stocks of materials largely match the materials balance used in environmental impact analyses. The method for determining the indicators has been changed for some of them. This has made the indicators suitable for measuring circularity.

1. **The quantity of materials used (input)**
   1.1 The quantity of primary materials (non-renewable, renewable, sustainably produced and renewable, and unsustainably produced and renewable)
   1.2 The quantity of secondary materials (from reuse and from recycling)
   1.3 The quantity of physically scarce materials
   1.4.1 The quantity of socio-economically scarce raw materials
   1.4.2 The quantity of socio-economically abundant raw materials

2. **The quantity of materials available for the next cycle (output)**
   2.1 The quantity of end-of-life materials available for reuse
   2.2 The quantity of end-of-life materials available for recycling

3. **The quantity of materials lost (output)**
   3.1 The quantity of end-of-life materials used for energy production
   3.2 The quantity of end-of-life materials sent to landfill

**Core indicators for protecting the environment**

The indicators for protecting the environment have been copied from the product system impact categories from the SBK method. These categories are based on the European life cycle analysis method (LCA method) for the construction sector, NEN-EN 15804.

4. **Impact on the environment**
   4.1 Climate change – overall
   4.2 Climate change – fossil
   4.3 Climate change – biogenic
   4.4 Climate change – use of land and change in use of land
   4.5 Ozone depletion
   4.6 Acidification
   4.7 Eutrophication - freshwater
   4.8 Eutrophication - seawater
   4.9 Over-fertilisation - soil
   4.10 Occurrence of smog
   4.11 Depletion of abiotic raw materials – minerals and metals
4.12 Depletion of abiotic raw materials – fossil energy carriers  
4.13 Use of water  
4.14 Emission of particulate matter  
4.15 Ionising radiation  
4.16 Ecotoxicity (freshwater)  
4.17 Human toxicity, carcinogenic  
4.18 Human toxicity, non-carcinogenic  
4.19 Impact/Soil quality related to the use of land

Core indicators for value retention

Since no existing methods are available for measuring the indicators for value retention, the action team has started to create its own indicators. They break value down into techno-functional value and economic value.

5. The quantity of initial value (input)  
5.1 Techno-functional value  
5.2 Economic value

6. The quantity of value available for the next cycle (output)  
6.1 Techno-functional value  
6.2 Economic value

7. The quantity of existing value lost (output)  
7.1 Techno-functional value  
7.2 Economic value

Report on adaptive capacity

Besides the indicators, a report on adaptive capacity is also part of the core measurement method. Adaptive capacity is the degree to which a structure or product can satisfy changing needs. The report on adaptive capacity helps to calculate input and output flows of materials during the current life cycle (since adaptive capacity has an effect on maintenance/replacement) and in later life cycles (since adaptive capacity has an effect on transformation to another function/location).

Data

When using the core measurement method, uniform data is needed in order to reach uniform results. This is still a challenge for the core measurement method.

However, when measuring circularity, data that is specific to the structure or object to be measured is preferred. This specific data is often not available during the early phases of a construction project, such as the design phase. The lack of a good data infrastructure makes it difficult to obtain specific data during later phases of a construction project.

The alternative for specific data is generic data, e.g. data that concerns a type of material or product. Generic data is not always easy to obtain either. At present, there are no extensive and freely accessible generic datasets for renewability, secondary materials, or scenarios about what will be done with a material at the end of its life cycle.

The action team has included recommendations in the guide which should improve the availability of data for the core measurement method.
I Introduction

1.1 Transition to a circular construction economy

The Netherlands is on the brink of transitioning to a circular economy. A circular economy is a way to reduce the global consumption of raw materials and reduce waste production. A circular economy thus contributes to the integrated sustainability task we are facing: combating climate change, a loss of biodiversity and the overburdening of our planet. This calls for a change to our current systems which are based on a linear economy.

It is the ambition of the Dutch national government that the Dutch economy should be entirely circular by 2050 and the use of primary raw materials should be halved by 2030. These ambitions were expressed in the Dutch national programme Nederland Circulair in 2050 (The Netherlands circular in 2050, Dutch national government, 2016) and will be gradually expanded.

The construction sector plays an important role in the transition to a circular economy. The objectives for the Dutch construction sector are set out in the Transitieagenda Circulaire Bouweconomie (Transition Agenda for the Circular Construction Economy) (2018) and the associated Uitvoeringsprogramma (Implementation Programme) (De Bouwagenda, 2018).

1.2 Platform CB’23 is supporting the transition through working agreements

The need to achieve a circular construction sector has become clear to many people. However, ideas are still being developed about the exact nature of the transition and the changes it will require. Collating existing ideas and using them to achieve a set of unambiguous agreements is an important step. Such agreements will anchor circular thinking and actions in daily construction practice.

Platform CB’23 has committed to achieving such agreements. Platform CB’23 was set up by Rijkswaterstaat, the Dutch Central Government Real Estate Agency (Rijkswaterstaat), De Bouwcampus and NEN (Netherlands Standardization Institute). The platform brings together stakeholders in the construction cycle (including clients, designers, suppliers, construction companies, recyclers, policy makers and scientists) to work together and reach generally supported agreements.

The agreements reached through Platform CB’23 are essentially working agreements rather than formal standards. However, they are used as input for national and European measurement methods and initiatives (see paragraphs 9.5 and 9.6).

Platform CB’23 has committed to reaching agreements on various topics. This has resulted in four documents:

- Circular Construction Lexicon (Platform CB’23, 2020a): clear language in the circular construction sector
- Guide for Measuring Circularity (this document): core method for measuring circularity in the construction sector
- Guide to Passports for the construction sector (Platform CB’23, 2020b): information storage and data exchange for a circular construction sector

1 This is not only the case in the Netherlands. Construction and demolition have also been given priority in the transition to a circular economy at the European level.

2 More information about the method followed by Platform CB’23 can be found in the section preceding the bibliography in this guide.
A successful transition requires more agreements and actions. Annex A to this guide describes Platform CB’23’s vision of which agreements and actions are needed at specific moments.

1.3 Unambiguous working agreements on measuring circularity

The working agreements in this guide concern the measuring of circularity.3 Measuring circularity is important to many decisions that need to be taken. It may, for example, play a role in tenders or when monitoring circularity performance in a specific geographical region.

In Guide 1.0 (Platform CB’23, 2019b), the Measuring Circularity action team at Platform CB’23 (hereinafter: the action team) established that a core measurement method for circularity offered added value, complementing that already offered by measurement methods for sustainability.4 Interviews with stakeholders brought to light a need for a measurement method for circularity that provides information about three goals5:

- to protect stocks of materials;
- environmental protection;
- value retention.

So far, the existing measurement methods provide insufficient information about the extent to which these goals are being met.

A harmonised measurement method for circularity offers added value because it will create clarity.6 Several measurement methods exist and it cannot be taken for granted that these measurement methods can be compared to each other as the various measurement methods come with different data requirements. Independently of each other, several different parties (including the Netherlands Enterprise Agency (Rijksdienst voor Ondernemend Nederland), Rijkswaterstaat and NEN) have established that more clarity is needed.

The differences between the existing measurement methods have led to:

- Data and measurement specifications differing per construction project resulting in high development costs for suppliers and contractors.
- Claims about the degree of circularity not being clear-cut and not verifiable.
- A limited ability to learn from circular interventions. This not only applies to organisations, but also to the construction sector as a whole.

This led Platform CB’23 to decide that it was going to develop a broadly supported, harmonised core method for measuring circularity in the construction sector which would create unity and

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3 Initiatives to draft such agreements have also been taken at an international level. The relationship between the agreements in this guide and international agreements is discussed in section 9.6.

4 An example of a frequently used method to measure sustainability is Stichting Bouwkwaliteit’s determination method, leading to an MPG score (Dutch score for the environmental performance of buildings, used in the buildings sector) or an ECI score (civil engineering sector) (Stichting Bouwkwaliteit, 2019).

5 Section 3.1 examines these three goals in detail. Section 8.1 gives a detailed justification of why the action team considers that a harmonised core measurement method for circularity would add value now, at this early stage of the transition.

6 Chapter 9 discusses the added value of Platform CB’23’s core measurement method compared to other measurement methods for sustainability and circularity.
consistency in this respect and which would also enable future findings about circular construction to be incorporated.

1.4 Structure of this guide

This paragraph provides a brief description of the topic of each chapter allowing for a better understanding of the structure of the guide. An indication is given of which chapters should preferably be read in conjunction with each other. An indication is also given of which chapters are relevant or are perhaps too detailed for specific groups of readers.

Chapter 2 describes the goals of the guide and the scope of the core measurement method.

Chapter 3 contains the conceptual framework of the core measurement method about which the action team has reached consensus, and which includes the three goals of circular construction: to protect stocks of materials, environmental protection, and value retention. During the first phase of the transition, the conceptual framework might actually be more important than the core measurement method itself.

Chapter 4 contains the indicators and reports that are part of the core measurement method. Chapter 4 is best understood by first reading chapter 3.

Chapter 5 describes the method for determining all the indicators, including calculation rules. This is the most technical part of the guide. Readers who are insufficiently familiar with mathematical models can skip parts of this chapter.

Chapter 6 offers guidance for reporting on adaptive capacity. This report helps readers to understand the degree of circularity that may be expected in the future.

Chapter 7 contains some areas of attention for users of the core measurement method.

Chapter 8 justifies the choices made in chapters 3 to 5.

Chapter 9 compares the core measurement method to other measurement methods for circularity and sustainability and to other initiatives. This chapter is mainly relevant to readers who are familiar with those methods and who want to know what the core measurement method adds and where the core measurement method differs from other methods.

Chapter 10 summarises the current status of the core measurement method and the follow-up steps to further develop the method. This chapter also contains recommendations for other parties such as the Stichting Bouwkwaliteit (SBK) foundation and universities.
Differences compared to guide 1.0

A first version of this guide was published in 2019: guide 1.0 (Platform CB’23, 2019b). This text box shows which content has been added or changed in the new guide. This will enable readers who are familiar with guide 1.0 to quickly find the new content.

Although the content of some parts has not changed, the action team has made textual changes to make the guide easier to read. For example, the chapters have been rearranged. Also, more parts have been moved to appendices and footnotes to make the document more manageable.

The main additions to the content are:

- The texts on social fairness in sections 3.1 and 7.1.4 are new.
- The distinction between achieved and expected circularity and between certain and uncertain data has been emphasised more strongly in section 3.5.
- Determination methods for scarcity indicators have been developed. New texts about this can be found in sections 4.1.2, 5.3.5, 5.3.6 and 8.3.1.
- A start has been made on the indicators for value and value retention. New texts about this can be found in sections 4.2.5, 5.3.10, 5.3.11, 5.3.12 and 8.3.3.
- Section 5.2.2 describes more explicitly how the core measurement method deals with specific and generic data.
- The ideas about adaptive capacity (including detachability) have been worked out in more detail and applied to the civil engineering sector. The new texts are in chapter 6.
- A workflow for those applying the core method has been added in section 7.2.
- The follow-up and recommendations in chapter 10 are new.
2 Goal and scope

2.1 Goal: Taking steps towards the indicators and their determination method

The goal of this guide is to develop a core method for measuring circularity in the construction sector. A core measurement method consists of a set of core indicators and their determination method. Core indicators are the minimum indicators that enable a statement to be made as to the degree of circularity.

2.1.1 Goal of guide 1.0: Formulating a conceptual framework and some initial indicators

An important goal of guide 1.0 (Platform CB'23, 2019b) was to formulate a broadly supported conceptual framework for the core measurement method (see chapter 3). Members of the action team discussed this at length.

The second goal of guide 1.0 was to start developing the core indicators and their determination method (see chapters 4 and 5). A harmonisation effort was required to achieve this which involved bringing together existing instruments, methods and experiences.

2.1.2 Goal of guide 2.0: Developing any missing elements

The goal of guide 2.0 is to develop the elements that were still missing or that were incomplete. For example, in guide 1.0, the action team had not yet been able to address the core indicators for value/upcycling or downcycling and scarcity. The role of adaptive capacity within the method was further developed in 2020, e.g. by adding a detailed discussion of adaptive capacity in the civil engineering sector.

2.1.3 Long-term goal: To develop a fully-fledged core measurement method

It is the action team's long-term goal to develop a fully-fledged core measurement method. New versions that further expand and improve the guide will be published in the future (but not necessarily every year). The basic assumption for this is that the core measurement method will be harmonised with the methods of the Stichting Bouwkwaliteit (SBK) (concerning the national standard for use of LCA methodology in the construction sector) and the Netherlands Environmental Assessment Agency (PBL) (concerning the monitoring of the transition towards a circular economy), whilst also offering additional value in respect of those methods.

2.2 Scope: widely applicable

This paragraph describes what the core measurement method does and does not apply to. Firstly, a demarcation is defined: focus on the measurement process (paragraph 2.2.1). The text then goes on to sketch the range of the application in terms of sector (paragraph 2.2.2), circular activities (paragraph 2.2.3), level of scale (paragraph 2.2.4), moment in the construction process (paragraph 2.2.5), and contexts (paragraph 2.2.6). The underlying idea is to make the core measurement method as widely applicable as possible.

2.2.1 Focus on the measurement process

Incorporating the degree of circularity in the decision-making process requires three steps:

- Step 1: Data collection;
- Step 2: A measurement process with different indicators;
- Step 3: Weighting/assessment of the results (see figure 1).
For now, this core measurement method focuses on the second step: the measurement process.

The measurement process consists of the aforementioned core indicators, their determination method (see paragraph 5.3), and the associated data collection (see paragraph 5.2.1). Establishing the method of determining the indicators (calculating) clearly defines the data to be supplied (input) and the results (output, list of scores for the indicators), regardless of who does the calculations.\(^7\),\(^8\)

![Figure 1 - Steps in circular decision-making that are part of the core measurement method version 2.0](image)

For the time being, the core measurement method does not specify the relative importance of the different indicators. Furthermore, the results are not combined (aggregated) into one overall score.

The action team does not consider it desirable to aggregate results. Firstly, because opinions about the weighting this would require have not yet taken sufficient shape. Secondly, an aggregated overall score would limit the possibilities for joint learning, whereas this is essential in this phase. An aggregated overall score would make it more difficult to see which choices have influenced that score.

The action team hopes to be able to add weighting/assessment to the core measurement method in the future and thus achieve one aggregate overall score (a degree of circularity\(^9\)).

### 2.2.2 The entire construction sector

The core measurement method can be applied to the entire built environment: both in the buildings sector and in the civil engineering sector. If any elements of the method apply to only one sector, this has been indicated.

### 2.2.3 Every circular strategy

There are several different strategies to increase the circularity of an object or sub-object. The effect of these strategies on the core indicators should be clear. The core measurement method should be able to be applied to all those strategies. Examples of circular strategies are

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\(^7\) Information from the measurement method can be used, for example, for a design for new-build or renovation. Each time the design changes, some or all of the data collection, calculation and assessment shall have to be done again to see if the change in the design will have the desired effect.

\(^8\) The agreements made about the data to be used are in section 5.2.1.

\(^9\) The wording 'degree of circularity' is frequently used in the guide. This refers to an aggregated overall score, but it should be remembered that this is not part of the current core measurement method.
constructing demountable structures, minimising the total quantity of material used, maximising the service life, and applying the ‘R principles’10.

2.2.4 Every level of scale

The core measurement method can be applied to any level of scale in the construction sector. In principle, any results from the lower levels of scale can be inherited by higher levels of scale. If a certain element is not applicable to all levels of scale, or if inheriting is not possible, this has been indicated.

There are several subdivisions into levels of scale. The core measurement method is applicable to all these subdivisions at all levels of scale. Two commonly used subdivisions are:

- the division based on the decomposition proposed in Circular Construction Framework version 1.0 (raw material, material, construction product, element, structure, complex, area; see Platform CB’23, 2019a: 10-11);
- Brand's or Schmidt's building layers (including stuff, space plan, services, structure, skin, site and surroundings (see paragraph 6.4.1)).

Brand's layers were originally intended for the buildings sector. The action team has 'translated' these layers so that they can also be applied to the civil engineering sector (see paragraph 6.4.1). These layers can also function as levels of scale.

The term ‘object or sub-object’

Since the core measurement method can be applied to all levels of scale, the term ‘object or sub-object’ is used rather frequently in the guide. ‘Object or sub-object’ refers to the entity to which the measurement results apply. That entity could be a material (e.g. asphalt), a door or window frame, a heating installation, a façade, a load-bearing structure, an entire structure or even a group of structures, i.e. ‘object or sub-object’ is specifically not restricted to a structure.

The rather abstract term ‘object or sub-object’ has also been chosen because it can be applied to both the buildings sector and the civil engineering sector.

2.2.5 At any time during the construction process

The core measurement method can determine the degree of circularity at any time in the construction life cycle. This can be done, for example, at the design stage for new-build, just after completing a construction object or construction sub-object, or while preparing a renovation, maintenance, or disassembly project.

2.2.6 Five contexts

The core measurement method offers guidance in the different construction contexts. The action team differentiates between five relevant contexts11:

- Technical requirements
  The core measurement method can be used to establish criteria or technical requirements as

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10 Examples of the R principles are refuse, rethink and reduce.
11 User stories, based on stakeholders’ experiences, were used to determine these contexts. These user stories/experiences are described in annex E.
part of a tender for design, construction, renovation, disassembly, demolition, etc. For example, the measurement method can already be used prior to tendering, e.g. to decide on the material required to make a guardrail. The invitation to tender that follows can then be limited to the description ‘zinc’ or ‘wood’.

• Comparing options
  The core measurement method enables a comparison between the available options based on their degree of circularity. An example of such a comparison is a comparison between two design options. However, the options for design, construction, renovation, management, maintenance and disassembly can also be compared to each other (asset management). This could be, for example, a comparison between renovation and disassembly.

• Data for circular claims
  The core measurement method must provide clarity about which data suppliers should provide in order to calculate the core indicators. This adds uniformity to the provision of data for tenders and passports for the construction sector.

• Control
  The core measurement method shall provide a control method to assure circular performance during the design and construction processes.

• Monitoring
  The core measurement method shall enable monitoring of the overall circularity performance of the structures in an organisation, a region, or a sector.
3 Conceptual framework

This chapter contains the conceptual starting points for the core measurement method: the conceptual framework. All indicators (see chapter 4) and their determination methods (see chapter 5) stem from this conceptual framework. The conceptual framework was formulated on the basis of user stories from stakeholders and conceptual frameworks from existing measurement methods for sustainability and circularity (see paragraph 8.2).

3.1 Three goals of circular construction

According to the action team, a core measurement method should focus on the following three goals for circular construction (see also paragraph 1.3):

- to protect stocks of materials;¹²
- environmental protection;
- value retention.

To protect stocks of materials means to ensure that stocks of materials are not exhausted, so that they will continue to be available for use. Environmental protection is about ensuring that the living environment for people and animals continues to be of a good quality. Value retention means that construction objects and sub-objects are preserved for as long as possible, that they maintain the highest quality possible, and that they continue to be put to optimum use. This applies to the first life cycle of an object or sub-object, but also to its reuse/recycling in subsequent cycles (see also paragraph 3.4).

These three goals form the basis of the core measurement method. According to the action team members and stakeholders, a core measurement method for circularity has added value if it provides information about all these goals. Existing measurement methods usually focus on one or two of these goals.

The core measurement method helps to clarify the considerations underlying the choice of goals. For instance, it shows how a certain circular strategy retains value and protects stocks of materials and trades this off against a lesser focus on protecting the environment or vice versa.

Circularity experts and stakeholders have differing opinions about which goal(s) are the most important. Some parties see protecting stocks of materials and value retention as goals that should be for the complete benefit of protecting the environment. Others conduct an integrated assessment comparing the three goals. Since the core measurement method does not aggregate results into an overall score (see paragraph 2.2.1), it supports both these perspectives.

¹² The guide attempts to make consistent use of the terms ‘material’ and ‘raw material’. However, in practice these terms are often used interchangeably, given the fact that these two terms are quite similar. ‘To protect stocks of materials’ was chosen here since this is a customary expression when referring to ‘physical substances’.
Protection principles

The core measurement method indicates the degree to which stocks of materials and the environment are protected, and value is retained. Protecting stocks of materials is divided into two basic principles:

- reducing use;
- limiting loss.

Some circular strategies focus on reducing the use of stocks of materials, e.g. in the event of a structure that is constructed using a minimum of materials. Other circular strategies limit loss, e.g. if parts of a structure are detachable and have degraded little during their use then these materials will continue to be available for a next cycle.

Impact indicators

A widely held conviction in the action team is that the core measurement method has to measure the impact on the three key goals and must therefore consist of impact indicators. Impact indicators differ from process indicators which are sometimes also used to measure circularity.

The two types of indicators differ as follows:

- **process indicators** measure the degree to which circular strategies have been applied and complied with;
- **impact indicators** measure the effect of these strategies.

The core measurement method uses impact indicators. This differentiates this method from, for example, the framework of the R principles referred to above (see paragraph 2.2.3). R principles are circular strategies that are often presented in a ladder, suggesting that a strategy which is located higher on the ladder contributes more to circularity. However, the circular impact differs from application to application (an example is given in paragraph 9.4). The advantage of impact indicators is that the impact on the three key goals of circularity can be measured for each specific application.

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**Social fairness**

The action team considered adding social fairness as a goal. Social fairness means preventing social malpractices in the production chain. However, after consideration they decided against adding it. This is because social fairness is not one of the primary reasons why most parties want to go for circular construction. Parties mainly need a core measurement method that focuses on the three aforementioned goals.

Nevertheless, the action team considers social fairness to be an important theme. Since the action team is of the opinion that circular construction efforts should not negatively affect social fairness, section 7.1.4 outlines the methods that can be used to ensure social fairness.

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13 These basic principles are also used in other measurement methods for circularity in construction. The action team has adopted these principles as a conceptual framework.
3.4 Entire life cycle of object or sub-object

The impact of circular strategies can only be determined by looking at the entire life cycle. This is because different circular strategies have an impact on the three key goals at different points in the life cycle. As a result, the entire life cycle (and therefore the entire production chain required to create an object or sub-object) is a conceptual starting point for the core measurement method.\textsuperscript{14,15}

### Definition of life cycle

The term 'life cycle' and related terms such as 'lifespan' or 'service life' are still a subject of discussion in the circular construction sector. For example, should a transformation of function (e.g. from office to living space) be seen as a new life cycle? And when it comes to circularity, is 'cycle of use' then not more appropriate than 'life cycle'?

For example, should a transformation of function (e.g. from office to living space) be seen as a new life cycle? The action team has not come round to formulating broadly supported, harmonised definitions on this subject in guide 2.0. This is an important follow-up step (see section 10.3.1). However, in order to be able to eventually compare results of the core measurement method, it will be important that users use the same definition.

That is why the guide now consistently uses 'life cycle'. For the time being, users of the core measurement method can define the end of the life cycle as 'the moment when an object or a sub-object ceases to be used for its current function and is disposed of, and/or changes location'. Any deviations from this definition should be clearly indicated.

Two examples illustrate how circular strategies can have impacts at different moments during the life cycle. Adaptive construction (example 1) may require a greater investment of materials when a structure is initially constructed, but may actually save the use of additional materials when renovating the structure. In the case of an initiative where a lightweight structure is opted for, materials are saved immediately during its construction (example 2).

The action team is of the opinion that the core measurement method should consider multiple life cycles in the future (see figure 2). This will provide a better understanding of the impacts on the three goals of circular construction in the longer term (see paragraph 3.1). This is done to a limited extent in the current core measurement method. Paragraph 10.3.2 describes this as a follow-up step for the action team.

\textsuperscript{14} This is also a starting point in the LCA method and the Material Circularity Indicator (MCI) method developed by the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015).

\textsuperscript{15} This may change in due course. For some parts of the core measurement method, it is advisable to look at multiple life cycles. The action team has not been able to develop this part yet. Section 10.3 refers to looking at multiple cycles as a follow-up step that should be pursued in guide 3.0.
3.5 Expected and achieved circularity

The core measurement method can also be used before an object or sub-object has been constructed. For example, the core measurement method can also be applied to a design drawing (see paragraph 2.2.5). This means that, apart from measuring achieved circularity, the core measurement method also measures expected circularity. The data for the expected circularity will then be based on estimates rather than facts (see figure 3).

![Figure 3 – The degree of circularity consists of the circularity achieved and expected circularity](image)

Some expected circularity is relatively 'certain' (e.g. maintenance in the first few years can be easy to predict). Some other aspects of expected circularity are 'uncertain' (e.g. processing at the end of a long life cycle can be hard to predict).\(^{16}\)

\(^{16}\) However, it can also be easy to predict, e.g. if there are agreements about the end-of-life treatment.

\(^{17}\) This can be compared to expected profits or losses in a business plan. Some of them are very certain, whereas others are highly uncertain. Expected profits are always more uncertain than profits that have already been achieved.

In the current core measurement method, both certain and uncertain achieved and expected circularity are calculated in the same way. The results are added up for each indicator.

The drawback of this approach is that current problems may not be solved because of an assumed positive effect in the future. Another drawback is that users of the core measurement method may be overly optimistic and overestimate positive expected effects which are actually very uncertain. The action team wants to avoid this. For that reason, it intends to add transparency in subsequent versions of the guide (see paragraph 10.3.3) about which part of the results is expected and which part has been achieved. The action team also intends to provide transparency as to the degree of certainty. These distinctions can then be taken into account in circular decision-making.
In order to keep the core measurement method practically feasible, indicators and determination methods must be the same for all types of data (achieved and expected, certain and uncertain).

### 3.6 Materials balance

Considering material flows is a customary element of measuring circular impact. This is also a starting point for the core measurement method. There are two types of material flows:

- **Input flows:** this includes all the materials used to make, repair, and modify the object or sub-object within its life cycle. They can be both primary and secondary materials.

- **Output flows:** this includes material from an object or sub-object that leaves the object or sub-object during the life cycle, or at the end of the life cycle. These may be materials that can be reused or recycled, but also materials that are lost.

Figure 4 illustrates all flows of an object or sub-object that are relevant for the core measurement method. Paragraph 5.1 explains the system boundaries in more detail.

![Figure 4 – Input and output flows of a sub-object (materials balance)](image)

Information is collected on all these flows (e.g. does an input flow come from recycling or reuse?). This leads to a detailed materials balance.

### 3.7 Core measurement method in a diagram

The main parts of the conceptual framework of the core measurement method have been translated into a visual diagram in figure 5.

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18 This is also the basis of the LCA method and the MCI method, for example.
Figure 5 – Core measurement method in a diagram (1)
4 Indicators and reports

4.1 Elements of the core measurement method

The action team developed the core measurement method on the basis of the conceptual framework from chapter 3. The method consists of at least two, and possibly three, elements:

- a summary of results of core indicators with their sub-indicators;
- a report on adaptive capacity (intended to get a better picture of expected circular impact);
- possibly an extra report containing performance, backgrounds, and a justification.

This chapter outlines what the core indicators and sub-indicators are (paragraph 4.2). It also gives a brief explanation of the reports (paragraphs 4.3 and 4.4).

4.2 Indicators

The indicators of the core measurement method are shown in tables 1 to 5. Indicators 1 to 3 concern the key goal of protecting stocks of materials. Indicator 4 concerns the key goal of protecting the environment. Indicators 5 to 7 concern the key goal of value retention.

When drawing up the indicators, indicators from existing measurement methods were used as much as possible. This has made the core measurement method uniform and suitable for practical use. Why these specific indicators were chosen is explained in more detail in paragraph 8.2. Chapter 5 contains the method of determination for the indicators.

4.2.1 Indicator 1: input materials, dimension 1

Indicator 1 is the indicator of the quantity of input materials used. This indicator has two dimensions:

1) a material that is used is a primary or a secondary material;
2) a material that is used is either scarce or abundant.

This paragraph only deals with dimension 1. Paragraph 4.2.2 deals with dimension 2.

Each flow of materials is assigned to one of the indicators between 1.1 and 1.2.2. Dimension 1 differentiates between primary and secondary materials. As a next step, primary materials are subdivided into renewable materials (with renewable materials being further subdivided into sustainably produced and unsustainably produced materials) and non-renewable materials. Secondary materials are subdivided into reuse and recycling. Figure 6 illustrates this subdivision.

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19 It is possible that a follow-up version of this guide may add a further distinction between upcycling and downcycling (see section 10.3.5).
This leads to the following indicators:

Table 1 – Indicators 1.1 and 1.2

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. THE QUANTITY OF MATERIALS USED (INPUT)</strong></td>
<td></td>
</tr>
<tr>
<td>1.1 The quantity of primary materials</td>
<td>Degree to which materials produced from primary raw materials have been used</td>
</tr>
<tr>
<td>1.1.1 The quantity of non-renewable primary materials</td>
<td>The degree to which primary materials of abiotic or biotic origin are used which are grown, naturally replenished or naturally cleansed, beyond the human time scale</td>
</tr>
<tr>
<td>1.1.2 The quantity of renewable primary materials</td>
<td>The degree to which primary materials of abiotic or biotic origin are used which are grown, naturally replenished or naturally cleansed, on a human time scale</td>
</tr>
<tr>
<td>1.1.2a The quantity of sustainably produced, renewable primary materials</td>
<td>The degree to which materials of abiotic or biotic origin are used that originate from a production unit that is managed sustainably</td>
</tr>
<tr>
<td>1.1.2b The quantity of unsustainably produced, renewable primary materials</td>
<td>The degree to which materials of abiotic or biotic origin are used that do not originate from a production unit that is managed sustainably</td>
</tr>
<tr>
<td>1.2 The quantity of secondary materials</td>
<td>The degree to which materials recovered from previous use, or from residual flows from another product system which substitute primary materials or other secondary materials, are used</td>
</tr>
<tr>
<td>1.2.1 The quantity of secondary materials from reuse</td>
<td>The degree to which reused parts are used</td>
</tr>
<tr>
<td>1.2.2 The quantity of secondary materials from recycling</td>
<td>The degree to which recycled materials are used</td>
</tr>
</tbody>
</table>

---

20 This guide restricts the use of the term 'raw materials' to raw material flows from natural resources.
4.2.2 Indicator 1: input materials, dimension 2

In the second dimension, indicator 1 contains sub-indicators of scarcity. This second dimension is separate from the first dimension (primary/secondary materials). This means that both primary and secondary input flows are also assessed against the properties from this dimension.

The scarcity dimension itself is subdivided into two types of indicators. They are indicators of:

- **physical scarcity**\(^{21}\);
- scarcity in terms of economic relevance and risks to security of supply (**socio-economic scarcity**).

These indicators are also conceptually separated from each other.\(^{22}\) This means that it is possible that a material is both physically scarce and socio-economically scarce, or that only one of the two indicators applies to it.

Figure 7 illustrates the relationship between the indicators in the scarcity dimension.

![Figure 7 - Relationship between indicator 1 and sub-indicators 1.3 and 1.4](image)

The indicator of socio-economic scarcity consists of two sub-indicators that add up to 100%:

- socio-economically scarce raw materials;
- socio-economically abundant raw materials.

This leads to the following indicators in the scarcity dimension (see table 2):

<table>
<thead>
<tr>
<th>Table 2 – Indicators 1.3 to 1.4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicator</strong></td>
</tr>
<tr>
<td><strong>I. THE QUANTITY OF MATERIALS USED (INPUT)</strong></td>
</tr>
<tr>
<td>1.3 The quantity of physically scarce materials</td>
</tr>
</tbody>
</table>

---

\(^{21}\) Physical scarcity means a scarcity of known reserves.

\(^{22}\) In practice, they are connected.
1.4.1 The quantity of socio-economically scarce raw materials used
The degree to which raw materials are used that are scarce as regards their economic relevance and where there are risks to their security of supply

1.4.2 The quantity of socio-economically abundant raw materials used
The degree to which raw materials are used that are abundant as regards their economic relevance and in terms of risks to their security of supply

### 4.2.3 Indicators 2 and 3: output materials

Indicators 2 and 3 are indicators of output. These indicators are more straightforward than indicator 1 and therefore need no further explanation. The indicators are shown in table 3.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2. THE QUANTITY OF MATERIALS AVAILABLE FOR THE NEXT CYCLE (OUTPUT)</strong></td>
<td></td>
</tr>
<tr>
<td>2.1 The quantity of end-of-life materials available for reuse</td>
<td>The degree to which the reuse of the objects or sub-objects is the most realistic end-of-life treatment</td>
</tr>
<tr>
<td>2.2 The quantity of end-of-life materials available for recycling</td>
<td>The degree to which recycling the materials is the most realistic end-of-life treatment</td>
</tr>
<tr>
<td><strong>3. THE QUANTITY OF MATERIALS LOST (OUTPUT)</strong></td>
<td></td>
</tr>
<tr>
<td>3.1 The quantity of end-of-life materials used for energy production</td>
<td>The degree to which processing materials in an incinerator for energy production is the most realistic end-of-life treatment</td>
</tr>
<tr>
<td>3.2 The quantity of end-of-life materials sent to landfill</td>
<td>The degree to which sending materials to landfills is the most realistic end-of-life treatment</td>
</tr>
</tbody>
</table>

Indicators 1 to 3 are mainly based on wishes derived from user stories (see paragraph 8.2). There is also an overlap with the stock-taking phase in environmentally-focused life cycle assessments (LCAs). However, some slight changes have been made to the method of determination (see chapter 5).

### 4.2.4 Indicator 4: environmental impact

For indicator 4, the product system impact categories from the Bepalingsmethode milieuprestatie gebouwen en gww-werken (Determination method for the environmental performance of buildings and civil engineering works - Stichting Bouwkwaliteit, 2019) (hereinafter: the SBK method) were adopted. They are shown in table 4.

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23 The meaning of ‘most realistic end-of-life treatment’ is explained in section 5.3.7.
24 This method is used to calculate MPG and ECI scores.
25 The indicators in the table will enter into force on 1 January 2021. Until then, the 11 old product system impact categories from the SBK method will apply (see section 5.3.9).
## Table 4 – Indicator 4

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. ENVIRONMENTAL IMPACT</strong></td>
<td></td>
</tr>
<tr>
<td>4.1 Climate change – overall</td>
<td>The degree to which objects or sub-objects contribute to climate change</td>
</tr>
<tr>
<td>4.2 Climate change – fossil</td>
<td>The degree to which objects or sub-objects contribute to climate change due to the use of fossil fuels</td>
</tr>
<tr>
<td>4.3 Climate change – biogenic</td>
<td>The degree to which objects or sub-objects contribute to climate change due to the use of plant-based materials</td>
</tr>
<tr>
<td>4.4 Climate change – use of land and changes in use of land</td>
<td>The degree to which objects or sub-objects contribute to climate change due to the use of land</td>
</tr>
<tr>
<td>4.5 Ozone depletion</td>
<td>The degree to which objects or sub-objects contribute to the depletion of the ozone layer</td>
</tr>
<tr>
<td>4.6 Acidification</td>
<td>The degree to which objects or sub-objects contribute to acidification of soil or water</td>
</tr>
<tr>
<td>4.7 Eutrophication - freshwater</td>
<td>The degree to which objects or sub-objects contribute to enriching freshwater with nitrogen and phosphorus</td>
</tr>
<tr>
<td>4.8 Eutrophication - seawater</td>
<td>The degree to which objects or sub-objects contribute to enriching seawater with nitrogen and phosphorus</td>
</tr>
<tr>
<td>4.9 Over-fertilisation - soil</td>
<td>The degree to which objects or sub-objects contribute to enriching soil with nitrogen and phosphorus</td>
</tr>
<tr>
<td>4.10 Occurrence of smog</td>
<td>The degree to which objects or sub-objects contribute to the formation of tropospheric ozone (part of smog)</td>
</tr>
<tr>
<td>4.11 Depletion of abiotic raw materials - minerals and metals(^{26})</td>
<td>The degree to which objects or sub-objects contribute to the depletion of abiotic raw materials, excluding fossil energy carriers</td>
</tr>
<tr>
<td>4.12 Depletion of abiotic raw materials – fossil energy carriers</td>
<td>The degree to which objects or sub-objects contribute to the depletion of fossil energy carriers</td>
</tr>
<tr>
<td>4.13 Use of water</td>
<td>The degree to which objects or sub-objects contribute to the depletion of the sources of water</td>
</tr>
<tr>
<td>4.14 Emission of particulate matter</td>
<td>The degree to which objects or sub-objects contribute to diseases related to particulate matter</td>
</tr>
<tr>
<td>4.15 Ionising radiation</td>
<td>The degree to which objects or sub-objects contribute to humans being exposed to ionising radiation</td>
</tr>
<tr>
<td>4.16 Ecotoxicity (freshwater)</td>
<td>The degree to which objects or sub-objects contribute to adverse toxicological effects for freshwater organisms</td>
</tr>
</tbody>
</table>

\(^{26}\) This indicator may possibly be removed or adjusted in the future to prevent any double counting with indicator 1.3.
4.17 Human toxicity, carcinogenic
Degree to which objects or sub-objects contribute to adverse carcinogenic effects for people

4.18 Human toxicity, non-carcinogenic
The degree to which objects or sub-objects contribute to adverse toxicological effects for people (non-carcinogenic)

4.19 Impact/Soil quality related to the use of land
The degree to which objects or sub-objects contribute to changes to the soil quality due to the use of land

4.2.5 Indicators 5 to 7: value retention

Since few measurement methods were available for the indicators of value retention, a start has been made with a purpose-designed measurement method for these indicators. This measurement method has not yet been fully developed.

A subdivision into two value dimensions that together give a good picture of the degree of value retention was chosen:

- techno-functional value;
- economic value.

The indicators of value retention only apply to objects or sub-objects on the levels of scale of materials, construction product and element.

The indicators of value are shown in table 5.

Table 5 – Indicators 5 to 7

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. THE QUANTITY OF INITIAL VALUE (INPUT)</td>
<td></td>
</tr>
<tr>
<td>5.1 Techno-functional value</td>
<td>The degree to which the object or sub-object functions in its current state (taking its service life, defects and changing performance requirements into account)</td>
</tr>
<tr>
<td>5.2 Economic value</td>
<td>The degree to which the object or sub-object has economic value in its current function</td>
</tr>
<tr>
<td>6. THE QUANTITY OF VALUE AVAILABLE FOR THE NEXT CYCLE (OUTPUT)</td>
<td></td>
</tr>
<tr>
<td>6.1 Techno-functional value</td>
<td>The degree to which the current object or sub-object can be applied and used in a new or subsequent function</td>
</tr>
<tr>
<td>6.2 Economic value</td>
<td>The degree to which the current object or sub-object represents an economic value for a subsequent use or function</td>
</tr>
<tr>
<td>7. THE QUANTITY OF EXISTING VALUE LOST (OUTPUT)</td>
<td></td>
</tr>
<tr>
<td>7.1 Techno-functional value</td>
<td>The degree to which the techno-functional quality and performance have decreased during the life cycle</td>
</tr>
<tr>
<td>7.2 Economic value</td>
<td>The degree to which the economic value has decreased during the life cycle</td>
</tr>
</tbody>
</table>

In practice, determining the extent to which value is retained is particularly relevant during the design phase and at the end of the first or subsequent life cycle.

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27 In practice, determining the extent to which value is retained is particularly relevant during the design phase and at the end of the first or subsequent life cycle.
4.2.6 Indicators in a diagram

The indicators can be added to the diagram illustrating the core measurement method. This gives the following overview (see figure 8):

Figure 8 – Core measurement method in a diagram (2)
4.3 Report on adaptive capacity

Users of the core measurement method must prepare reports in which they quantify their thought processes regarding the adaptive capacity of an object or sub-object. These reports have been included in the core measurement method because the adaptive capacity of an object or sub-object is important in order to estimate the expected degree of circularity (impact on the protection of stocks of materials and the environment, and on value retention) throughout the life cycle.\footnote{This means that adaptive construction itself is not a circular goal, but a circular strategy (see section 2.2.3).}

An object or a sub-object with a high adaptive capacity can easily be changed (without additional material or with a minimum of additional material). Such changes are made by removing, adding, moving or replacing parts. An object or a sub-object with a high adaptive capacity remains valuable for a longer time. There are two reasons for this:

- Its service life is extended because the object or sub-object can fulfil the needs and requirements for a longer period of time, even if they change;
- The majority of the materials and their value are retained after the life cycle.

Several different instruments\footnote{By instruments, we mean adaptive concepts that help forecast the expected circular impact. Examples are future scenarios (see section 6.3.1) and independently adaptable layers (see section 6.4.1).} are available for preparing reports on adaptive capacity. They are described in chapter 6.

4.4 Reporting with justification and further breakdown

It is customary for a report to be drawn up when delivering measurement results. This justification is the third part of the core measurement method. In addition to the justification, the report may contain additional information, such as a further breakdown of performance. The action team has not yet agreed on what that additional information shall be.

However, the action team has identified some elements that might be of interest. These elements are:

- a justification of the choices made and the data used;
- a further breakdown of results, such as by indicator into phases in the life cycle or into building layers (see paragraph 6.4.1);
- the difference between expected performance (in earlier phases) and actual performance; knowledge about this can strengthen the ability to learn;
- past adjustments, including the means used (materials and technology) and the reason for the adjustment; knowledge about this can also strengthen the ability to learn.
5 Method for the determination of indicators

5.1 General determination agreements

The action team has made four general agreements regarding the determination of the indicators:

- **The life cycle of the object is the starting point**
  As indicated in paragraph 3.4, the degree of circularity is calculated over the entire life cycle. Since this is based on the life cycle of the object to be measured, it must first be determined which object's degree of circularity will be measured. Furthermore, if the service life of sub-objects is shorter than that of the object itself, replacements of these sub-objects will be included in the calculation. For example, a door may last as long as 40 years, whereas the hinges and locks need replacing after 20 years.

- **User impact is not taken into account**
  Impact caused by users, but not directly related to the object or sub-object, is not taken into account. Examples of this are the residual flows from a company restaurant or waste paper. The expected impact in the use phase is therefore mainly calculated on the basis of the service life of parts that need to be replaced. If the manner of use affects replacement, this will be taken into account.

- **Materials that do not end up in the object or sub-object are not taken into account for indicators 1 to 3**
  For the time being, materials which are consumed, but which do not end up in the object or sub-object and which are not production waste, do not have to be taken into account as stocks of materials used (indicators 1 to 3 including sub-indicators). However, they are taken into account as an environmental impact of the production process (indicator 4 including sub-indicators). Examples of this are fossil fuels or other energy carriers, water and packaging materials.

- **Mass is expressed in kilogrammes for calculation purposes, unless otherwise specified.**

5.2 Agreements on data

Data collection is not part of the core measurement method (see paragraph 2.2.1). The user is allowed to search for the necessary data in the available sources. The action team might set stricter requirements on data in the future. Insufficient data is available for this at present.31

Paragraph 5.2.1 gives a summary of the data needed to use the core measurement method. Paragraph 5.2.2 addresses the level of detail of data in different phases and gives a summary of useful data sources.

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30 The action team opted for this in order to make the core measurement method easily accessible. For the time being, this data can only be retrieved for parties which produce LCAs. This is very labour-intensive without access to an LCA database and it involves a relatively small mass compared to the total. It is highly desirable that these materials can be included in indicators 1 to 3 in the future as well, for instance if producers supply this data with their products, and/or if a list of flat-rate values that can be used is made available.

31 If results for an object or sub-object are also produced for the SBK method, the same data requirements that apply to the SBK method should also apply to indicator 4 (the environment) of the core measurement method.
5.2.1 Data map

In order to use the core measurement method to measure the degree of circularity, all incoming and outgoing flows of materials (achieved and expected) must be mapped. All these flows are assigned properties: they are given 'labels'. This will create a detailed materials balance (see paragraph 3.6).

The following information is collected during the mapping phase of the core measurement method:

- materials used (including in sub-objects) in all life cycle stages, together with the following details for each material;
  - quantity in kilograms;
  - scarce/abundant\(^{32}\) in the list of Critical Raw Materials (CRM, see European Commission, 2017);
  - physically scarce/physically abundant determined according to NEN-EN 15804:2012+A2:2019 (abiotic depletion potential, ADP);
  - primary/secondary;
    - if secondary: reuse/recycling;
    - if primary: sustainably renewable\(^{33}\)/non-sustainably renewable;
  - most probable end-of-life treatment: available for the next cycle/not available for the next cycle;
    - if available for the next cycle: reuse\(^{34}\)/recycling;
    - if not available for the next cycle: energy production/landfill.
- Materials which are consumed but do not end up in the object or sub-object and which are not production waste (see paragraph 5.1) for calculating the environmental impacts\(^{35}\);
- emissions into the soil, air and water for calculating the environmental impacts;
- costs and benefits per life cycle phase, according to Standaard Systematiek voor Kostenramingen (Standard Cost Estimation System - SKK) for civil engineering objects or sub-objects and according to NEN 2699 or NEN-ISO 15686-5 for objects or sub-objects in the building sector;
- information on the adaptive capacity of the structure, including information on the detachability of sub-objects (see paragraph 6.4.2 for the details);
- estimated service life of objects or sub-objects (per sub-object). The SBK method (Stichting Bouwkwaliteit, 2019: 37) can be used for structures. A substantiated design service life can also be used. For lower levels of scale the estimation method in Levensduur van bouwproducten:

\(^{32}\) Slashes (/) indicate that the user must choose one of the labels.

\(^{33}\) In the case of sustainably renewable materials, information must be added to demonstrate that the conditions for renewability have been complied with. Further information can be found in section 5.3.2.

\(^{34}\) In the case of objects and sub-objects for which reuse is the most likely end of life treatment, information shall be added to show that the conditions for reuse have been complied with. Further information can be found in section 5.3.7.

\(^{35}\) In practice, an LCA for an object or sub-object will already exist or will have been begun. Section 7.2 outlines the workflow that can be used in that case.
Paragraph 5.3 indicates when the specific labels are assigned to materials.

Wherever possible, data and data collections that are already available have been chosen. The Dutch national environmental database \((NMD)\)\(^{36}\) can be used for most of the data needed to measure expected end-of-life circularity.\(^{37}\) Data on the type of secondary input and on sustainably produced renewable raw materials is currently not available in the NMD. This means that users of the core measurement method will have to retrieve (or estimate) this data themselves. The action team makes a recommendation to change this in paragraph 10.3.

5.2.2 Level of detail of data

The core measurement method can be used at any time during the construction process (see paragraph 2.2.6) and also measures the expected degree of circularity (see paragraph 3.5). This is possible because the method allows data with a different level of detail to be used in different phases. For example, which specific materials or products will be used is not always known during the exploration or design phases. General, representative data is therefore used for calculations in these phases.

The more information that is known about the design, the more detailed the data can become. In order to make the type of data used unambiguously transparent, the core measurement method differentiates between four levels of detail\(^{38}\) for data:

- **Level of detail 1**: The material is known (for example: wood);
- **Level of detail 2**: The broad outlines of the product are known (e.g.: beam / deciduous wood, oak);
- **Level of detail 3**: The detailed information of the product is known (e.g.: beam/dimensions/deciduous wood+ oak/fire resistance/recycling information);
- **Level of detail 4**: The product is known, including producer and supplier data\(^{39}\) (specific data).

Of course, more specific data (a higher rating in the list) is preferred.

**Availability of specific data**

Specific data can be obtained as follows:

- **The Environmental Product Declarations**\(^{40}\) (EPDs) based on NEN-EN 15804 can be consulted. Producers state some of the specific data required for the core measurement method in these EPDs. EPDs can be found as follows:
  - For the Netherlands: through the website of the Stichting MRPI foundation.\(^{41}\)

\(^{36}\) See SBK, 2019: 45-47.

\(^{37}\) As soon as an object or sub-object has a passport based on the formats of Platform CB’23 (Platform CB’23, 2020b), a large part of the data will also be able to be found there.

\(^{38}\) These levels of detail differ from the Levels of Detail (LOD) identified in Building information Modeling (BIM).

\(^{39}\) This data can be about a specific producer or about a specific group of producers.

\(^{40}\) EPDs are based on the European LCA method.

\(^{41}\) See www.mrpi.nl.
There are several different EPD databases for Europe. Most of them are freely accessible but some require a license. Commonly used databases are Okobaudat, Global EPD and INIES.42

- If the EPDs are not available, or do not provide sufficient information, specific data can be requested from the producer or supplier.

**Availability of generic data**

Generic data (level 1 to 3) is also often hard to find at present. This particularly goes for input data.43 Sometimes datasets or lists are unavailable and sometimes data is 'hidden' in larger datasets. Which datasets are available for specific geographical areas is listed below.

**Generic data on input flows**

Generic data on input flows can be obtained in the following ways:

- For the Netherlands, a generic dataset is available in the NMD in the form of category 3 product cards;
- Generic data at the raw materials level and at the materials level can be searched for in the database of processes kept by NMD and Ecoinvent44;
- The generic dataset from the *Product Environmental Footprint Pilot Guidance* (PEF) (European Commission, 2020: annex C) can be used for Europe;
- Generic datasets are being developed for many other countries. If no dataset is available, generic, representative data will have to be found.

**Generic data on output flows**

Generic data (levels 1 to 3) on output flows can be obtained as follows:

- Annex V of the SBK method can be used for the Netherlands;
- The generic dataset from the *Product Environmental Footprint Pilot Guidance* (PEF) (European Commission, 2020: annex C) can be used for Europe;
- A generic dataset is also available for Belgium (table 6 in NBN-EN 15804:2017);
- Generic datasets are being developed for many other countries. If no dataset is available, generic, representative data will have to be found.

**From data to results**

The core measurement method specifies how to map all the materials during the entire life cycle (see paragraph 5.2.1). All this data is then taken into account in order to arrive at results for the indicators. Figure 9 illustrates this process.

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43 Secondary Material Content is part of a product card in the Dutch National Environmental Database (NMD). In practice, this part is often not filled in properly, because little attention was paid to it in the past. This is expected to change soon, but it will take time to improve the dataset after that.
44 See ecoinvent.org.
5.3 Determination method and calculation rules for the indicators

Paragraphs 5.3.1 to 5.3.12 contain the calculation rules for the indicators and sub-indicators (see paragraph 4.2) of the core measurement method. They provide the exact mapping requirements and the rules for using the results in calculations. These paragraphs only describe what the method of determination and the calculation rules are. Chapter 8 explains how and why these methods were chosen.

The first steps of the environmental LCA form the basis for the indicators for the protection of material stocks (indicators 1 to 3). Here and there, additions have been made to the 'labels' of the flows. The paragraphs on these indicators (see paragraphs 5.3.1 to 5.3.8) are mainly a set of instructions on unambiguous labelling.

5.3.1 Calculation rules for primary/secondary input material (indicators 1.1 and 1.2)

All input flows are labelled as ‘primary materials’ or as ‘secondary materials’. Materials are labelled as primary and secondary based on the following definitions\textsuperscript{45}:

- **primary input materials**: materials produced by the earth and used by humans for the production of products and other materials;

\textsuperscript{45} These definitions can be found in Platform CB'23 Circular Construction Lexicon version 2.0 and correspond to the definitions in the SBK method and the MCI method (Ellen MacArthur Foundation, 2015).
• **secondary input materials**: materials recovered from previous use or from residual flows from another product system which substitute for primary materials or other secondary materials.

**Calculation rules for indicator 1.1 - The quantity of primary materials used**

The proportion of primary input materials is calculated for every object or sub-object:

\[
V_x = \frac{\sum_i (m_i \cdot m_{vi})}{\sum_i m_i}
\]

- \(V_x\): primary input materials as a percentage of a total object or sub-object
- \(m_i\): mass of an object or sub-object (i)
- \(m_{vi}\): proportion, by mass, of primary (virgin) materials in an object or sub-object

The proportion of primary materials must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

**Calculation rules for indicator 1.2 - The quantity of secondary materials used**

The recycled content is calculated for every object or sub-object:

\[
S_x = \frac{\sum_i (m_i \cdot m_{si})}{\sum_i m_i}
\]

- \(S_x\): secondary input materials as a percentage of a total object or sub-object
- \(m_i\): mass of an object or sub-object (i)
- \(m_{si}\): proportion, by mass, of secondary materials in an object or sub-object

The recycled content must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

5.3.2 **Calculation rules for primary materials which are renewable/non-renewable (indicators 1.1.1 and 1.1.2)**

Primary materials are labelled 'renewable' or 'non-renewable'. This is based on the following definitions:

- **non-renewable**: not from a renewable source;
- **renewable**: from a renewable source which is grown, naturally replenished or naturally cleansed, on a human time scale. A renewable raw material can be of abiotic or biotic origin.
Calculation rules for indicator 1.1.1 - The quantity of primary materials used that are non-renewable

The proportion of non-renewable materials is calculated for every object or sub-object:

\[ NH_x = \frac{\sum_i (m_i \times m_{nh})}{\sum_i m_i} \]

- \( NH_x \): non-renewable materials as a percentage of a total object or sub-object
- \( m_i \): mass of an object or sub-object (i)
- \( m_{nh} \): proportion, by mass, of non-renewable materials in an object or sub-object

The proportion of non-renewable primary materials must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

Calculation rules for indicator 1.1.2 - The quantity of primary materials used that are renewable

The proportion of renewable materials is calculated for every object or sub:

\[ H_x = \frac{\sum_i (m_i \times m_h)}{\sum_i m_i} \]

- \( H_x \): renewable materials as a percentage of a total object or sub-object
- \( m_i \): mass of an object or sub-object (i)
- \( m_h \): proportion, by mass, of renewable materials in an object or sub-object

The proportion of renewable primary materials must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

5.3.3 Calculation rules for primary materials that are renewable and are sustainably produced/not sustainably produced (indicators 1.1.2a and 1.1.2b)

All primary renewable input flows are given labels indicating whether they are ‘sustainably produced renewable’ or ‘unsustainably produced renewable’ (susceptible to becoming depleted) materials.

There are two ways to demonstrate that a raw material is extracted, grown or managed sustainably:

1) The raw material complies to an internationally or nationally recognised administrative marking for sustainable production (including chain of custody);

2) There is another way of showing that the raw material is extracted, cultivated or managed sustainably.
The following basic principles apply to method 2:

- The raw material must be naturally replenished on a human time scale\(^{46}\). The raw material is not depleted. This can be demonstrated by the relationship between growth and extraction. In the case of a biotic raw material, three more basic principles apply:
  
  - Information about the carbon balance of the production unit must be included.
  - Extraction/cultivation may not cause any loss of biodiversity.
  - The use of any fertilisers and crop protection products must be in accordance with the guidelines for organic cultivation.

- Crops suitable for consumption must not be used in order to produce the raw material.

**Calculation rules for indicator 1.1.2a – The quantity of primary materials used that are renewable and are sustainably produced**

The proportion of sustainably produced renewable materials is calculated for every object or sub-object:

\[
N_x = \frac{\sum_i (m_i \cdot m_{ni})}{\sum_i m_i}
\]

\(N_x\) = sustainably produced renewable materials as a percentage of a total object or sub-object

\(m_i\) = mass of an object or sub-object (i)

\(m_{ni}\) = proportion, by mass, of primary, sustainably produced renewable materials in an object or sub-object

The proportion of sustainably produced renewable primary materials must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

**Calculation rules for indicator 1.1.2b – The quantity of primary materials used that are renewable and are not sustainably produced**

The proportion of unsustainably produced renewable materials is calculated for every object or sub-object:

\[
VN_x = \frac{\sum_i (m_i \cdot (m_{vi} - m_{ni}))}{\sum_i m_i}
\]

\(VN_x\) = non-renewable or unsustainably produced renewable raw materials as a percentage of a total object or sub-object

\(m_i\) = mass of an object or sub-object (i)

\(m_{vi}\) = proportion, by mass, of primary (virgin) materials in an object or sub-object

\(m_{ni}\) = proportion, by mass, of sustainably produced renewable materials in an object or sub-object

The proportion of unsustainably produced renewable primary materials must not only be represented as a percentage of the whole, but also as absolute kilos.

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\(^{46}\) The action team intends to give a precise definition of this term in a follow-up version of the guide (see section 10.3.1).
5.3.4 Calculation rules for input materials from recycling/reuse (indicators 1.2.1 and 1.2.2)

Secondary materials are labelled as reuse and recycling based on the following definitions:

- secondary material from reuse: material that is part of a composite object that is reused as a whole for the same function after previous use (possibly after being processed);

- secondary material from recycling: material that has undergone a recycling process and is now reused in an object or sub-object.

As these definitions have not yet been fully developed to conclusively classify all conceivable input flows,\(^{47}\) users of the core measurement method must indicate clearly which choices were made while labelling.

### Calculation rules for indicator 1.2.1 – The quantity of secondary materials used from reuse

The recycled content from reuse is calculated for every object or sub-object:

\[ H_x = \frac{\sum_i (m_i \times m_{s,hi})}{\sum_i m_i} \]

- \( H_x \) = reused materials as a percentage of a total object or sub-object
- \( m_{s,hi} \) = proportion, by mass, of reused materials in an object or sub-object
- \( m_i \) = mass of an object or sub-object (i)

The proportion of materials from reuse must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

### Calculation rules for indicator 1.2.2 – The quantity of secondary materials used from recycling

The recycled content is calculated for every object or sub-object:

\[ R_x = \frac{\sum_i (m_i \times m_{s,ri})}{\sum_i m_i} \]

- \( R_x \) = recycled materials as a percentage of a total object or sub-object
- \( m_{s,ri} \) = proportion, by mass, of recycled materials in an object or sub-object
- \( m_i \) = mass of an object or sub-object (i)

The proportion of materials from recycling must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

---

\(^{47}\) The definitions will be reviewed in the near future (see section 10.3.1).
5.3.5 **Calculation rules for physical scarcity (indicator 1.3)**

Physical scarcity is determined using the product system impact category of *abiotic depletion potential* (ADP). The ADP method reflects the ratio between the rate at which raw materials are used and the amount of stocks of those raw materials in the earth’s crust that are technically accessible and economically feasible. This is based on the ‘reserve base’, i.e. estimates of the available minerals in the earth’s crust. A raw material which is used a lot and whose reserves are low is a scarce raw material.

The ADP method is part of both the *Product Environmental Footprint Guidance* (PEF) and NEN-EN 15804:2012+A2:2019. Determination is done according to the impact assessment method which is also part of NEN-EN 15804:2012+A2:2019.

**Calculation rules for indicator 1.3 - The quantity of physically scarce materials used**

The quantity of physically scarce materials is expressed in *abiotic depletion potential* (ADP).

5.3.6 **Calculation rules for socio-economic scarcity (indicators 1.4.1 and 1.4.2)**

The calculation rules for socio-economic scarcity are based on the EU list of scarce materials. This list is known as the CRM list (*Critical Raw Materials*, see European Commission, 2017). Many aspects of security of supply were considered when preparing this list. The list is updated every three years.

The EU has set thresholds in the CRM list for risks relating to economic importance and security of supply. This divides raw materials into four quadrants. Figure 10 illustrates this.

---

48 The action team will probably discuss the concept of ADP in more detail in a future version of the guide. They may then also examine the characterisation factors in the PEF method. Characterisation indicates the extent to which a raw material influences a particular environmental impact. The PEF method is about the characterisation factors for biotic raw materials and non-natural stocks. Neither of them is part of the ADP method.


50 This list also takes into account end-of-life treatment (possible recycling and possible substitution of raw materials).


52 The CRM list is also used as a basis for a study into the extent to which the Dutch economy depends on abiotic materials and their availability (TNO, 2015). However, some adjustments were made to the CRM list for this study. This study resulted in a raw materials scanner, a tool which allows companies to investigate the extent to which dependence on raw materials poses a risk to them (www.grondstoffenscanner.nl).
In the core measurement method (and also in the CRM list), raw materials are classified as follows:

- **Socio-economically scarce**: raw materials in the upper right quadrant. These are high-risk raw materials as regards their economic importance and security of supply.
- **Socio-economically abundant**: all other raw materials (including raw materials that are not on the list).

According to this method, many materials used in bulk in the construction sector, such as sand and gypsum, are considered to be abundant raw materials. Some metals used in installations, such as solar panels, are actually scarce raw materials.

Tables 6 and 7 classify the raw materials (based on the 2017 CRM list) into quadrants.
Table 6 - Scarce raw materials (27)

<table>
<thead>
<tr>
<th>Scarce raw materials (27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
</tr>
<tr>
<td>Fluorspar</td>
</tr>
<tr>
<td>Helium</td>
</tr>
<tr>
<td>Silicon Metal</td>
</tr>
<tr>
<td>Tantalum</td>
</tr>
<tr>
<td>Baryte</td>
</tr>
<tr>
<td>Phosphate Rock</td>
</tr>
<tr>
<td>HREEs53</td>
</tr>
<tr>
<td>Natural Graphite</td>
</tr>
<tr>
<td>Vanadium</td>
</tr>
<tr>
<td>Beryllium</td>
</tr>
<tr>
<td>Phosphorus</td>
</tr>
<tr>
<td>Indium</td>
</tr>
<tr>
<td>Natural Rubber</td>
</tr>
<tr>
<td>Tungsten</td>
</tr>
<tr>
<td>Bismuth</td>
</tr>
<tr>
<td>Gallium</td>
</tr>
<tr>
<td>Cobalt</td>
</tr>
<tr>
<td>Niobium</td>
</tr>
<tr>
<td>Borates</td>
</tr>
<tr>
<td>Germanium</td>
</tr>
<tr>
<td>LREEs54</td>
</tr>
<tr>
<td>PGMs55</td>
</tr>
<tr>
<td>Coking Coal56</td>
</tr>
<tr>
<td>Hafnium</td>
</tr>
<tr>
<td>Magnesium</td>
</tr>
<tr>
<td>Scandium</td>
</tr>
</tbody>
</table>

Table 7 – Abundant raw materials (34)

<table>
<thead>
<tr>
<th>Abundant raw materials with a security of supply risk (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bauxite</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abundant raw materials with a risk as regards their economic importance (19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
</tr>
<tr>
<td>Chromium</td>
</tr>
<tr>
<td>Diatomite</td>
</tr>
<tr>
<td>Iron Ore</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Abundant raw materials (10)57</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bentonite</td>
</tr>
<tr>
<td>Gypsum</td>
</tr>
</tbody>
</table>

---

53 HREEs are heavy rare earth metals.  
54 LREEs are light rare earth metals.  
55 PGMs are platinum group metals.  
56 Although coking coal is in the abundant raw materials quadrant with a risk as regards its security of supply, it is on the EU list of scarce raw materials. The EU list states that coking coal may well disappear from the list when it is next updated (2020). The action team will await this update before definitively recording the position of coking coal.  
57 Again: all candidate raw materials that are not on the CRM list are also in the abundant category. This means that they can be added to table 7.
44

Calculation rules for output material available for the next cycle (indicators 2, 2.1 and 2.2)

The output flow of materials is divided into two categories:

- materials available for the next cycle;
- materials that are lost.

Materials that are available for the next cycle are given one of the following labels:\(^{58}\):

---

5.3.7 Calculation rules for output material available for the next cycle (indicators 2, 2.1 and 2.2)

The output flow of materials is divided into two categories:

- materials available for the next cycle;
- materials that are lost.

Materials that are available for the next cycle are given one of the following labels:\(^{58}\):

---

\(^{58}\) Indicator 2 only concerns the quantity of materials that are expected to be suitable for reuse and recycling, i.e. this indicator does not refer to upcycling or downcycling. Upcycling/Downcycling is covered by indicators 5 to 7.
• End-of-life materials available for **reuse**: These are materials that are part of a composite object with a realistic prospect of being reused as a composite object in the same function (possibly after having been processed).

• End-of-life materials available for **recycling**: These are materials that are part of a composite object with a realistic prospect of being reused as materials after having been removed from the composite object.

Materials are labelled based on a **realistic** end-of-life treatment, i.e. not based on theoretical possibilities.

Three criteria are applied to determine which end-of-life treatment is realistic. These criteria are based on the *Circulair sturen op hoogwaardig hergebruik van toepasbare en toe te passen materialen (Circular promotion of upcycling materials that have been or will be used)* report (Royal Haskoning DHV, 2018). The three criteria are:

• the proportion of the object or sub-object that is technically reusable; this depends on several aspects, including detachability;

• the proportion of the technically reusable output flow for which there is demand when it becomes available;

• negative effects of reusing the object or sub-object on the reuse possibilities of other materials from the envisaged application; these effects must be as low as possible.

The action team has not yet prepared any guidance or instruments that help to make any statements about these criteria. This means that, for the time being, users of the core measurement method must do this themselves.

In practice, it will be necessary to take responsibility for, and/or control of, the end-of-life treatment in order to obtain any certainty as to a realistic end-of-life treatment. Examples are using a return system or contractual arrangement. This element has not been detailed further in the core measurement method.

---

**Calculation rules for indicator 2.1 - The quantity of end-of-life materials available for reuse**

The proportion of realistic reuse is calculated for every object or sub-object:

\[
H_g = \frac{\sum_i (m_i \times m_{he})}{\sum_i m_i}
\]

- \( H_g \): percentage of realistic reuse of an object or sub-object
- \( m_i \): mass of an object or sub-object (i)
- \( m_{he} \): proportion, by mass, for which reuse of a composite object is the most realistic

The proportion of end-of-life materials available for reuse must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

---

59 Therefore, deviating from flat-rate (market average) scenarios for reuse and recycling potential can only be done in LCAs if sufficient proof is provided that a functioning return system will be available at the end of the life cycle.
Calculation rules lost output materials (indicators 3, 3.1 and 3.2)

Output flows which cannot realistically be assumed to be available for the next cycle are subdivided using the following two labels:

- materials which can realistically be assumed to end up in an incinerator for energy production;
- materials which can realistically be assumed to be deposited in a landfill site.

An assessment of which scenario is realistic is made using a table from the SBK method with flat-rate values (Stichting Bouwkwaliteit, 2019: 30). This may only be departed from if good arguments are given. In that case, the following shall be taken into account:

- **Toxic substances**
  Toxic substances which are released during use and in future reuse or recycling attempts may result in an object or sub-object having to be disposed of.

- **Adaptive capacity**
  Adaptive capacity (see chapter 6) influences the extent to which materials are lost if the object or sub-object changes function at the end of its service life.

The proportion of end-of-life materials available for recycling must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

### Calculation rules for indicator 2.2 - The quantity of end-of-life materials available for recycling

The proportion of realistic recycling is calculated for every object or sub-object:

\[
R_e = \frac{\sum_i (m_i \times m_{re})}{\sum_i m_i}
\]

- \(R_e\) = realistic recycling percentage of an object or sub-object
- \(m_i\) = mass of an object or sub-object (i)
- \(m_{re}\) = proportion, by mass, for which recycling is the most realistic

For example, the sum of landfill and energy recovery equals the 'unrecoverable waste' indicator from the MCI method. LCA calculations carried out in accordance with the SBK method use the output flows of landfill (waste [kg]) and energy recovery (materials for energy [kg]) in a similar fashion, whilst calculating both flows separately.

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60 This table indicates what can be expected to happen to the most commonly used materials in the Netherlands.

61 The definition of this indicator is comparable to many other commonly used methods.
The action team has not reached a consensus on whether materials with a realistic prospect of ending up in an incinerator for energy production should be further subdivided. A subdivision into biotic and abiotic materials would accommodate parties who feel that burning biotic materials is less problematic for the purposes of circularity.

Calculation rules for indicator 3.1 - The quantity of materials used for energy production

The proportion of lost materials used for energy production is calculated for every object or sub-object:

\[ R_e = \frac{\sum_i (m_i \times m_{ew})}{\sum_i m_i} \]

- \( R_e \) = percentage of materials of an object or sub-object used for energy production
- \( m_i \) = mass of a disassembled object or sub-object (i)
- \( m_{ew} \) = proportion, by mass, for which energy production is the most realistic end-of-life treatment

Calculation rules for indicator 3.2 - The quantity of end-of-life materials sent to landfill

The proportion of lost materials that are sent to landfill is calculated for every object or sub-object:

\[ R_s = \frac{\sum_i (m_i \times m_{st})}{\sum_i m_i} \]

- \( R_s \) = percentage of materials of an object or sub-object sent to landfill
- \( m_i \) = mass of a disassembled object or sub-object (i)
- \( m_{st} \) = proportion, by mass, for which landfill is the most realistic end-of-life treatment

The proportion of end-of-life materials sent to landfill must not only be represented as a percentage of the whole, but also as absolute kilograms in the list of results.

5.3.9 Calculation rules for the environment (indicators 4 and 4.1 to 4.19)

The product system impact categories from the SBK method (Stichting Bouwkwaliteit, 2019: 30) are used for main indicator 4 and its sub-indicators. The following 11 product system impact categories apply until January 2021:

- 4.1a Depletion of abiotic raw materials
- 4.2a Depletion of fossil energy carriers
- 4.3a Climate change
- 4.4a Ozone depletion

\[62\] The argument for this is that incineration restores biotic materials to ‘their origins’: the CO₂ and organic materials they absorbed during their lives. Incineration can thus be seen as a form of recycling of biotic materials.
4.5a Photochemical oxidation
4.6a Acidification
4.7a Over-fertilisation/Eutrophication
4.8a Toxicological effects for humans
4.9a Ecotoxicological effects (freshwater)
4.10 Ecotoxicological effects (seawater)
4.11 Ecotoxicological effects (terrestrial)

The SBK method will be using 19 new product system impact categories from 1 January 2021. The core measurement method has adopted these. The 19 new product system impact categories are:

4.1 Climate change – overall
4.2 Climate change – fossil
4.3 Climate change – biogenic
4.4 Climate change – use of land and changes in use of land
4.5 Ozone depletion
4.6 Acidification
4.7 Eutrophication - freshwater
4.8 Eutrophication - seawater
4.9 Over-fertilisation - soil
4.10 Occurrence of smog
4.11 Depletion of abiotic raw materials – minerals and metals
4.12 Depletion of abiotic raw materials – fossil energy carriers
4.13 Use of water
4.14 Emission of particulate matter
4.15 Ionising radiation
4.16 Ecotoxicity (freshwater)
4.17 Human toxicity, carcinogenic
4.18 Human toxicity, non-carcinogenic
4.19 Impact/Soil quality related to the use of land

Due to the complexity of determining performance for the product system impact categories, the rules for calculating this are not summarised in this guide. The current version of the document containing them can be found on https://milieudatabase.nl/milieuprestatie/bepalingsmethode/.

The results for indicators 4.1 to 4.19 lead to a weighted single final score for indicator 4. The SBK method (Stichting Bouwqualiteit, 2019: 39) is also used for this.

5.3.10 General frameworks for value indicators

Levels of scale

In order to keep the core measurement method practical to work with, value indicators have been chosen that cannot be applied to all levels of scale. The indicators only apply to the raw materials, materials, construction product, and element levels (see figure 11). Furthermore, any results for the value indicators cannot automatically be inherited by higher levels of scale.

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63 When used with respect to value indicators, the term ‘object or sub-object’ only refers to objects or sub-objects at the lower four levels of scale.

64 The action team would like to provide a better understanding of the relationships between the levels of scale, but it thinks this can be quite challenging since value depends on function.
Measuring moments in the construction process

The scope of the core measurement method requires that the value indicators shall be applicable at all times in the construction process (see paragraph 2.2.5). However, in practice, there will be two main moments when measuring the value of an object or a sub-object is interesting. The action team has specified these two moments here, because the method of determining the indicators may require different information for the different moments.

The two moments when value will usually be measured in practice are:

- the beginning (development/design) of a life cycle; it is then mainly relevant to have information on the service life of a structure, on degradation, and on the possibilities for reuse/recycling in a subsequent cycle;  

- during the life cycle of an object or a sub-object to obtain information about application possibilities in the next cycle; it is then mainly relevant to know whether degradation has been prevented and technical quality has been retained, and also whether the object or sub-object can be used in the same function in the next life cycle.

If value is determined at moment 2, which information is required will depend on the technical quality and use in the next cycle. Figure 12 illustrates which information is needed in specific cases.

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65 In practice, this information is mostly used to achieve a higher degree of circularity by extending the service life, reducing degradation, and increasing the possibilities for reuse, for example through adaptive measures.
5.3.11 Calculation rules for techno-functional value (indicators 5.1, 6.1 and 7.1)

Indicators still under development

The indicators for techno-functional value (5.1, 6.1 and 7.1) are still being developed. Section 5.3.11 sketches the first frameworks for these indicators. These indicators cannot be used yet.

Two types of information are required in order to determine techno-functional value:

- information about the current value of the object or sub-object (e.g. information about traces of use in the current cycle);
- information that helps to forecast the future value of the object or sub-object.
Table 8 gives a summary of parts of the indicator of techno-functional value which can provide that information. The table is not complete yet.

**Table 8 – Parts of indicators of techno-functional value**

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Type of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional quality</td>
<td>The degree to which the object or sub-object satisfies the requirements for the current function, determined by a set of technical performance requirements</td>
<td>Current value</td>
</tr>
<tr>
<td>Technical quality</td>
<td>The degree to which an object or sub-object satisfies the performance requirement</td>
<td>Current value</td>
</tr>
<tr>
<td>Degradation</td>
<td>The degree to which the object or sub-object has defects</td>
<td>Current value</td>
</tr>
<tr>
<td>Spatio-functional adaptive capacity at time x</td>
<td>Capacity of the object or sub-object to cope with changes in functions and space requirements</td>
<td>Future value</td>
</tr>
<tr>
<td>Technical adaptive capacity (detachability) at time x</td>
<td>Degree to which connections in and of the object or sub-object can be detached and parts are accessible and physically independent of each other</td>
<td>Future value</td>
</tr>
</tbody>
</table>

In order to arrive at an indicator, the relationship between these components shall become clear. It shall also be decided how to measure the parts and which data may be used for that purpose. Existing methods in the buildings and civil engineering sectors offer input for this. Annex B contains a summary of methods that may be useful for this purpose.

**Function and performance requirements in multiple cycles**

Table 8 shows that the function of a structure plays an important role for its techno-functional value, since the function determines the performance requirements for materials and construction products. For example, different requirements are set on the façade of an office than on the façade of a house. Only if the function is known can it be determined whether the object or sub-object satisfies these requirements and how long it will be able to satisfy them (service life).

If the function of a structure changes, its performance requirements change as well. Spatio-functional adaptive capacity helps to predict the degree to which a structure can satisfy these new performance requirements.

The function shall be clear in the current cycle, but also in the next cycle(s). This is because the function in the next cycle determines the performance requirements for reuse or recycling. The

---

66 A discussion of function requirements and performance requirements follows after Table 8.

67 For the distinction between spatio-functional and technical adaptive capacity, see section 6.2.1.
function of an object or sub-object and the associated performance requirements can differ for different cycles.

Only if an object or sub-object can satisfy the same or comparable requirements will the techno-functional value be retained. Figure 13 illustrates this.

**Figure 13 – Value creation and value retention in successive cycles**

*Note:* Figure 13 is slightly updated in comparison with Figure 13 in the Dutch version of the guide Measuring circularity version 2.0.

**Determination method for indicator 5.1 - The quantity of initial techno-functional value**

The quantity of initial techno-functional value ($TFW_i$) is determined for each object or sub-object. This result is the 100% reference point using which the lost techno-functional value (indicator 7.1) can be determined.

$$TFW_i = 100\%$$

$TFW_i$ = percentage of initial techno-functional value
5.3.12 Calculation rules for economic value (indicators 5.2, 6.2 and 7.2)

The economic value is determined after determining the techno-functional value. The principle of Total Cost of Ownership (TCO) is the point of departure for this. TCO is the total cost incurred during the service life of a structure.

Positive and negative cash flows

Cash flows can be both negative (costs) and positive (benefits) during the life cycle. Examples of positive cash flows are income from residual value of land, objects or sub-objects. Both types of cash flow are considered when calculating economic value. This corresponds to the Whole-Life Costing (WLC) method, formalised in NEN-ISO 15686-5.

All life cycle phases

The cash flows in all life cycle phases of a structure are mapped when calculating the TCO. This not only concerns the cash flows at the time of the investment, but also cash flows during the life cycle and at the end of the life cycle. This means that the economic value can both increase and decrease during the entire life cycle. Table 9 summarises all the phases whose costs must be taken into consideration.

---

Annex C contains an example for calculating the economic value.

Since the commonly used Life Cycle Costing (LCC) method only considers outgoing cash flows, the WLC method provides a broader picture of the economic value of an object or sub-object by including the benefits at the end of its service life.

These phases match European standards NEN-EN 15978 and NEN-EN 15804. They are also used in the SBK method (see Stichting Bouwkwaliteit, 2019): 45).
Table 9 – Life cycle phases of an object or sub-object

<table>
<thead>
<tr>
<th>Code</th>
<th>Life cycle phase</th>
<th>Code</th>
<th>Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1-A3</td>
<td>Production phase</td>
<td>A1</td>
<td>Extraction of raw materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A2</td>
<td>Transportation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A3</td>
<td>Production</td>
</tr>
<tr>
<td>A4-A5</td>
<td>Construction phase</td>
<td>A4</td>
<td>Transportation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A5</td>
<td>Construction and installation process, construction</td>
</tr>
<tr>
<td>B1-B7</td>
<td>Use phase</td>
<td>B1</td>
<td>Use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B2</td>
<td>Maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B3</td>
<td>Repairs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B4</td>
<td>Replacements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B5</td>
<td>Renewal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B6</td>
<td>Operational energy use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B7</td>
<td>Operational water use</td>
</tr>
<tr>
<td>C1-C4</td>
<td>Demolition and processing phase</td>
<td>C1</td>
<td>Demolition</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2</td>
<td>Transportation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3</td>
<td>Waste processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C4</td>
<td>Final waste processing</td>
</tr>
<tr>
<td>D</td>
<td>Benefits beyond the system boundary of</td>
<td>D</td>
<td>Reuse, reclamation and recycling</td>
</tr>
<tr>
<td></td>
<td>the object or sub-object</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data for life cycle phases C and D

Since it is still difficult to obtain data for the later life cycle phases (C and D) in practice, it is not always possible to fully determine the indicators of economic value.

Calculation of cash flows in life cycle phase A

Two types of construction costs must be taken into account during the production phase (A1-A3) and the construction phase (A4-A5):

- **direct costs**: costs directly attributable to a service or product, such as wages and prices of materials and equipment;

- **indirect costs**: costs not directly attributable to a service or product. Examples are Preliminaries (Prelims), Profit and Risk (P&R), and General Contractor Costs (GCC), expressed as a percentage.

Calculation of cash flows in life cycle phase B
Costs in the use phase are operating costs. This includes insurance costs, energy costs, ground rents, maintenance and management costs, amortisation and rent. These costs tend to be budgeted and recorded on a yearly basis.

**Calculation of cash flows in life cycle phase C**

Two types of cash flow must be taken into account during the demolition and processing phase (C1-C4):

- **end-of-life cost**: cost of various activities, including decommissioning, demolition, decontamination, recycling and reclaiming and disposing of elements or materials, as well as transport costs and costs to comply with regulations;

- **upgrade costs**: costs to enable upcycling and to increase the residual value of objects or sub-objects.

**Calculation of cash flows in life cycle phase D**

The residual value is calculated in phase D. The residual value is the market value of an object or a sub-object for reuse at the end of its service life.

**Differences in calculations for the buildings sector and for the civil engineering sector**

The calculation of costs in the different life cycle phases varies from situation to situation:

- NEN 2699 or NEN-ISO 15686-5 are the standards applied for calculating costs at the 'building' level of scale in the buildings sector. Costs are expressed in euros per m² of gross floor area [€/m² of GFA]. The following methods are used for the life cycle phases:
  - A: Construction cost estimate
  - B: Operating budget
  - C: End-of-life budget
  - D: Residual value calculation

- The Standaard Systematiek voor Kostenramingen (Standard Cost Estimation System - SKK) (Kennisplatform CROW, 2018) is applied to calculate costs at other levels of scale than 'building' in the buildings sector and to calculate cost in the civil engineering sector. No standard unit for the surface area, such as m² of GFA, applies here. However, the principles of the indicators can also be applied at other levels of scale in the buildings sector and in the civil engineering sector, but it will be up to the actual user of the core measurement method to choose a logical unit of measurement for the situation in question.

Costs in life cycle phases B, C and D are discounted to the current date.

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An example of how the residual value can be calculated is by using TNO’s residual value model.
**Determination method for indicator 5.2 – The quantity of initial economic value**

The quantity of initial economic value is determined for each object or sub-object. This result is the 100% reference point which can be used to determine the lost economic value (indicator 7.2).

\[ EW_i = 100\% \]

\[ EW_b = \text{percentage of initial economic value} \]

**Determination method for indicator 6.2 – The quantity of economic value available for the next cycle**

The quantity of economic value available for the next cycle is calculated for every object or sub-object:

\[ EW_b = \frac{B_D}{K_A + K_B + K_C} \times 100\% \]

\[ EW_b = \text{the quantity of economic value available for the next cycle of use as a percentage} \]

\[ B_D = \text{benefits arising from life cycle phase D, expressed as an appropriate unit and discounted to the current date} \]

\[ K_A = \text{costs arising from life cycle phase A, expressed as an appropriate unit} \]

\[ K_B = \text{costs arising from life cycle phase B, expressed as an appropriate unit and discounted to the current date} \]

\[ K_C = \text{costs arising from life cycle phase C, expressed as an appropriate unit and discounted to the current date} \]

**Determination method for indicator 7.2 – The quantity of economic value lost in the buildings sector**

The quantity of techno-functional value lost is calculated for each object or sub-object.

\[ EW_v = EW_i - EW_b \]

\[ EW_v = \text{the quantity of economic value lost as a percentage} \]

\[ EW_i = \text{the quantity of initial economic value as a percentage} \]

\[ EW_b = \text{the quantity of economic value available for the next cycle as a percentage} \]
6 Instruments for reporting on adaptive capacity

This chapter offers instruments to map adaptive capacity in terms of quality. For the time being, they can be used to prepare the report on adaptive capacity (see paragraph 4.3). Where possible, the action team used and harmonised existing tools. Where necessary, new instruments were developed as well.

The chapter first shows the status of adaptive capacity as part of the core measurement method (paragraph 6.1). It then suggests three general instruments for adaptive capacity (paragraph 6.2). This is followed by a discussion of the role of future scenarios (paragraph 6.3) and how those future scenarios can be translated into appropriate adaptive measures\(^2\) (paragraph 6.4). The last paragraph (paragraph 6.5) addresses the safeguarding of these measures.

### Focus on buildings/structures

Where this chapter refers to an object or sub-object, this always concerns the 'structure/building' level of scale. The chapter also considers other levels of scale, but they are never discussed separately from the object or sub-object structure/building.

Determining the adaptive capacity at lower levels of scale is possible, but the action team has not yet got round to this.

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### 6.1 Status of instruments of adaptive capacity in the core measurement method

#### 6.1.1 Current status

Currently, users of the core measurement method can use the instruments to map adaptive capacity for the report on adaptive capacity (see paragraph 4.3). The report on adaptive capacity consists of the following elements:

- an analysis and way of decision-making for future scenarios;
- adaptive measures and their justification;
- ways in which the adaptive measures are safeguarded.

For example, when it comes to the buildings sector, the report on adaptive capacity identifies the extent to which an object or sub-object is easy to maintain or can transform within the scope of its existing function and/or into another function, such as living (enabling residents to continue to live in a house as they grow older), working (offices, companies), healthcare and/or education.

The report can play a role in decision making. Examples of possible uses of the report are:

- to choose between alternative designs;
- to optimise an existing design;
- to evaluate the long-term impact of adaptive interventions.

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\(^2\) Adaptive measures are interventions that increase the adaptive capacity of an object or a sub-object by making it suitable for other uses. Examples are movable walls or a detachable façade.
6.1.2 Future status

The impact of adaptive measures will also be reflected in the results of the indicators (see paragraph 10.3.6) in a future version of the guide. To be able to do so, the quality instruments must be translated into quantified consequences for the materials balance established during the stock-taking phase (see paragraph 5.2.1).73

The report on adaptive capacity will then help to make the materials balance more realistic. This is relevant because adaptive capacity has a major influence on the impact on flows of materials, not only at the end of life74 (transformation to another function and/or location), but also during the service life (maintenance, replacement, etc.).

The pink elements in figure 14 indicate the moments in the life cycle of a structure where adaptive capacity influences the materials balance.

Figure 14 - Adaptive capacity influences the materials balance at different moments in the life cycle (pink markings)

6.2 General instruments for adaptive capacity

6.2.1 Types of adaptive capacity

When it comes to adaptive capacity, a distinction is made between spatio-functional and technical adaptive capacity.

- An object or sub-object has **spatio-functional adaptive capacity** if it can cope with changes in functions and space requirements.75

- An object or a sub-object is **technically adaptive** if connections can be detached and components (elements such as installations and construction products) are accessible and physically independent of each other.

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73 For example, the scenario of changing the floor plan would require, among other things, determining how many internal walls will be damaged during the dismantling and re-installation activities and which quantities of additional materials will be needed to replace these broken walls.

74 To enable a proper analysis to be made of the consequences of adaptive capacity, life cycle should be defined more broadly than is currently done in the core measurement method. Several life cycles should actually be considered (see section 3.4). These follow-up steps will probably be addressed in a future version of the guide (see section 10.3.2).

75 Spatio-functional adaptive capacity is applicable in the buildings sector, but can also play a role in the civil engineering sector, for example a bridge which can be expanded (broadened).
Another distinction is also common in the scientific literature. Durmisevic (2015) divides transformations into three dimensions (see figure 15):

- **Structural transformation**: a structure and/or its components are *demountable* and therefore replaceable, reusable and/or repairable. According to Durmisevic, structural transformation is the main dimension for circular construction because it avoids demolition.

- **Spatial transformation**: a building is *adaptive* (Durmisevic’s definition), which means it can also be used in the event of new requirements.

- **Element and materials transformation**: parts of a structure are reusable or recyclable at the end of its life cycle.

![Figure 15 - Adapted subdivision of transformation capacity, adopted from Durmisevic](image)

Durmisevic uses a narrow definition of ‘adaptive capacity’. This guide uses the term ‘adaptive capacity’ in a broader sense: it is used both for structural transformation (demountable) and for spatial transformation (the narrow definition of adaptive). Both types of transformation are also dealt with in the tables in paragraph 6.4.2.

### 6.2.2 Adaptive capacity in different phases

An adaptive measure is usually included in a plan of requirements for, or a design of, an object or sub-object in the initial or design phase. The report on adaptive capacity is usually also drawn up during these phases. Client/owners and a design team can *influence* adaptive capacity during these phases. Adaptive measures are *implemented* during the use phase and the end of the life cycle of an object or sub-object.
Figure 16 explains when, i.e. in which phase, stakeholders are involved with adaptive capacity and how (e.g. influencing or utilising). An interesting rule of thumb in this respect is that 80% of the operational costs are determined during the design phase.
6.2.3 Adaptive capacity as an investment

Including adaptive measures in the initial or design phases may involve additional investments\textsuperscript{77}, expressed in terms of negative consequences for the three circular objectives. If such investments lead to savings (fewer negative consequences, or positive consequences for the three circular objectives) later on in the life cycle, they will lead to a higher degree of circularity for the object or sub-object during its entire life cycle. In that case, the total loss of raw materials and value, and detriment to the environment, will be reduced.

Obviously, an investment in an adaptive measure is recouped more easily if the investment is low (has few negative consequences for the three circular goals).\textsuperscript{78} Smart solutions can sometimes help to increase adaptive capacity without additional investments (without negative consequences for the three circular goals). However, a smart solution of this type often requires extra engineering or design time.

6.3 Adaptive capacity and future scenarios

6.3.1 The role of future scenarios

In the case of adaptive measures, it is important to first consider whether they meaningfully affect the materials balance and, if so, which measure is preferred. Four steps are needed to determine the degree to which adaptive measures affect the materials balance. They are:

- **Step 1:** Define future scenarios (paragraph 6.3.2) and determine how probable they are (paragraph 6.3.3).
- **Step 2:** Determine how the requirements for the object or sub-object change in the scenarios (paragraph 6.3.2).
- **Step 3:** Translate the changing needs into appropriate adaptive measures (paragraph 6.4) and consolidate these measures (paragraph 6.5).
- **Step 4:** Quantify the consequences of adaptive measures for the materials balance.

The rest of this chapter deals with the first three qualitative steps. As mentioned above, the fourth step will be defined in a future version of the guide.

Figure 17 illustrates the four steps.

---

\textsuperscript{77} Financial terms are used to explain how adaptive measures contribute to the three goals of circularity during the entire life cycle. Where the text refers to investments and savings, this always refers to their circular impact (impact on the three circular goals) and not to money.

\textsuperscript{78} Russell and Moffatt (2001) make recommendations for ways to keep adaptive investments low.
If a scenario shows that no future changes to the object or sub-object will be needed, adaptive measures will not meaningfully affect the materials balance either.

The future of some aspects is so unpredictable that it is futile to work with defined scenarios. In that case ‘broadening’ the adaptive capacity may be an option.

6.3.2 Defining future scenarios

The following two questions may help when defining future scenarios:

- Which developments can be expected? This includes demographic, economic, politico-legal, ecological, socio-cultural and technological developments. Examples of such (general) developments are self-driving cars, a high CO₂ burden, smaller families, the desire for smaller homes, shifting healthcare to people’s home environments, and remote working and/or studying.

- How do these developments affect supply and demand, usage requirements, space requirements or the function of the object or sub-object in the specific location concerned?

6.3.3 Evaluating future scenarios

How probable is it that a scenario will become reality? How extensive will any negative consequences for the three circular goals be if that happens? Which adaptive measures can reduce these consequences and what is the investment impact of taking those measures? These are the types of questions that need to be considered for future scenarios.

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79 These are the elements of the DEPEST analysis which is used to map the macro-environment.

80 At present, dealing with uncertainty in the event of expected circularity has not yet been further detailed in the core measurement method (see section 3.5). It has however been mentioned as a follow-up step for a future version of the guide (see section 10.3.3).
Methods for economic considerations can serve as inspiration for such evaluations. Examples are Total Cost of Ownership (TCO) and the social costs and benefits analysis (SCBA). Both methods consider investments during the entire life cycle (or several life cycles), including innovation. If the TCO and SCBA methods are used for the purpose of the core measurement method, they concern circular investments (impact on the three circular goals).

These considerations can help to determine whether circular investments in adaptive measures are desirable. Examples of such considerations are:

- If an adaptive measure with little or no negative impact on the three circular goals can be taken, this is not problematic, regardless of whether future scenarios can be outlined and what their probability is.

- If a future scenario is fairly certain (high probability), an investment in adaptive measures is justified if it would enable adjustments with a minor impact to be made at a later stage. This will lower the total impact during the life cycle.

- If a future scenario is rather uncertain (low probability), a circular investment in adaptive measures will be uncertain. In that case, a circular investment could be deferred until a later stage in which there is more certainty (see the decision tree in figure 18).

**Decision tree**

An article on dealing with uncertainty in SCBAs for infrastructure projects (Bos et al., 2016) offers interesting instruments for dealing with certain and uncertain scenarios. The article differentiates between far-reaching adjustments and less far-reaching adjustments (referred to in the article as 'non-flexible' and 'flexible' adjustments). These are linked to high probability of scenarios (in which a far-reaching measure pays off) and low probability of scenarios (in which a less far-reaching measure would have been better).

The decision tree can only be used if multiple decision moments are possible. At a later stage, when there is more clarity about the scenario, it should still be possible to invest circularly in the far-reaching measure.

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81 The SCBA is a tool that can be used when taking decisions on major spatial projects. It is used to make carefully considered and substantiated policy choices.

82 If such a decision is taken, consideration can already be given to how this later measure can be implemented with the lowest possible impact.

83 The article gives the example of a lock. It is possible that more ships will use this lock in the future, but this is uncertain. In such a case, a less far-reaching measure can be chosen, allowing water to flow in and out of the lock more quickly. This will allow slightly more boats to use the lock. A far-reaching measure would be to add an extra lock.
Figure 18 is an example of a simple decision tree with two decision moments. In a more complex decision tree, multiple moments can be taken into account and probability ratings can be assigned to scenarios. This will allow calculations to be made for each branch. What the probability has to be for a scenario to become a reality can also be calculated in order to ensure that an investment in an adaptive measure will be recouped.

### 6.4 Appropriate adaptive capacity

Based on the scenario analysis, consideration can be given to which type of adaptive measure will influence the expected impact and in which part of the object or sub-object the impact will be felt.\(^{84}\)\(^{85}\) This paragraph contains tables (paragraph 6.4.2) with aspects of adaptive capacity for the buildings sector and the civil engineering sector that can help with this.

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\(^{84}\) In practice, scenario analysis and the selection of adaptive measures are not strictly separate phases.

\(^{85}\) The action team studied one type of future scenario in more detail: the scenario in which a building undergoes a change of function from non-residential to residential construction. This study showed that the future scenario determines which adaptive measures will influence the impact. In addition, this differs for each part/characteristic of the building (such as the main load-bearing structure, sound insulation, fire resistance, sanitary facilities and installations) because the requirements differ for each function group. For example, a possible measure is to install installations (detachably) in or above the floor so that they will be in the legal zone of the future user. If installations are integrated into the floor, the floor height can also be lowered, which will also save material.
The contractor who prepares an adaptive capacity report can use the table to determine which aspects are important in a specific scenario. The client can use the table to formulate a set of adaptive requirements.

The table of aspects is based on Brand’s building layers. A brief explanation of these layers is given first (paragraph 6.4.1).

6.4.1 Building layers

Stewart Brand (1994) divided buildings into ‘layers’ (shearing layers, here referred to as ‘building layers’) with comparable life cycles: stuff, space plan, services, structure, skin and site. Robert Schmidt III later added two more layers: social and surroundings. These layers were added on the basis of the idea that an object or a sub-object should always be considered in its social and environmental context.

Figures 19 and 20 show Brand’s layers for the buildings and civil engineering sectors, including the layers added by Schmidt. Table 10 explains what these layers mean in the buildings and civil engineering sectors.

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86 The social layer consists of the people in and around the building, such as users, owners and residents in the local area. The surroundings layer concerns the physical network/system of which the building is part. Examples are other buildings in the area, public spaces (such as a park) or the network of roads of which a bridge is a part.
Figure 20 – Building layers for the civil engineering sector

Table 10 – Building layers in the buildings and civil engineering sectors

<table>
<thead>
<tr>
<th>Brand/Schmidt layer (English)</th>
<th>Brand/Schmidt layer (Dutch)</th>
<th>Meaning in the buildings sector</th>
<th>Meaning in the civil engineering sector(^\text{87})</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surroundings</strong></td>
<td>Omgeving</td>
<td>Facilities, public space and the natural environment surrounding the ‘site’</td>
<td>Network/system, also referred to as the ecosystem/town and country planning of which the object or sub-object is a part</td>
</tr>
<tr>
<td><strong>Site</strong></td>
<td>Terrein</td>
<td>Location, land</td>
<td>Location, land</td>
</tr>
<tr>
<td><strong>Skin</strong></td>
<td>Afwerking/schil</td>
<td>Outer wall, roof and lower floor</td>
<td>Top layer, guide rail, edge boards</td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td>Constructie</td>
<td>Foundation and load-bearing structure</td>
<td>Structures (engineering structures, locks, etc.), foundation under roads incl. centre layer</td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>Installatie</td>
<td>Installations</td>
<td>Technical facilities (electrical and mechanical engineering) such as piping, pipes, pumping stations and pumps</td>
</tr>
<tr>
<td><strong>Space plan</strong></td>
<td>Ruimte-indeling</td>
<td>Spatial plan of the interior</td>
<td>Public space planning such as streets, squares and green spaces</td>
</tr>
</tbody>
</table>

\(^{87}\) The listing of meanings in the civil engineering sector gives a general picture, but is not exhaustive.
Relevance of the network in the civil engineering sector

The layers were originally intended to analyse adaptive capacity in the buildings sector. The action team has ‘translated’ the layers into the civil engineering sector. The *surroundings* layer is a particularly important addition for this sector. Whereas the function of the object or sub-object in the civil engineering sector is at the network level, it is at the structure level in the buildings sector.

In the civil engineering sector, the interplay between the network and the objects or sub-objects that are part of the network is considerable. The situation is different in the buildings sector. An example is bridges in a network of roads. If the structures in a network cannot be adapted, the network itself will be unable to be adapted, or only with great difficulty. In the civil engineering sector, it is also the network that determines whether adding adaptive measures to an object or sub-object makes any difference. If so, the network also largely determines the requirements (including adaptive requirements) for the object or sub-object.

Service lives of building layers

The philosophy underlying Brand’s model is that the different layers of an object or sub-object have different expected service lives and functions. The adaptive capacity will be greater if layers are separate and detachable. This enables value to be retained in a layer when other layers need adapting.

The upper layers (*surroundings*, *site*, etc.) have the longest service life and are the most important for the continued existence of an object or sub-object. If such a layer is not adaptable, this can terminate the life cycle of the entire structure.

6.4.2 Tables with aspects of adaptive capacity

Tables 11 and 12 contain the aspects of adaptive capacity referred to above.88,89 As indicated, the tables have been divided into the building layers. The *social* layer is not featured since adaptive capacity does not play any role in that layer.

Each layer contains different aspects that influence adaptive capacity. The meaning of each aspect and how the aspect affects adaptive capacity is shown.

The aspects have been classified based on the following criteria:

- **Uniformity**
  Parts are uniform if they have the same shape or form a unit in terms of dimensions, facilities, properties or capacity. The user can indicate this in the table.

- **Flexibility**
  Flexibility is the degree to which the system can be adapted to new developments and needs. This includes horizontal expandability, over-dimensioning and detachability.

- **Building layer**

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88 The action team has drawn up the tables on a scientific basis as much as possible. An explanation of this is given in section 8.4.

89 The tables can also be downloaded separately from www.platformcb23.nl.
Any interlinkage with other construction layers, and whether the service life of the layer corresponds to the service life that can be expected, can be indicated under the building layer (the layer in Brand's layer model). The table contains an expected service life, but this should be considered a rough general indication. The expected service life differs from project to project. There are also differences between the buildings sector and the civil engineering sector.

- **Schmidt scale**
  Robert Schmidt III developed a scale with six different types of adaptive measures. These types are *adjustable* (1), *versatile* (2), *refitable* (3), *convertible* (4), *scalable* (5) and *movable* (6). Annex D gives a further explanation of the Schmidt scale. The table shows which type of adaptive measure from the Schmidt scale is applicable to each building layer in the table.

The tables with aspects are a good starting point for reporting on the adaptive capacity that is part of the core measurement method. Preparing exhaustive tables is impossible and so the tables are intended to be a guide. Mapping the adaptive capacity of a building requires the entire table to be gone through and all aspects to be assessed.

The client can use the table during the initial phase (see paragraph 6.2.2) in order to indicate which aspects are relevant. The contractor can specify whether and how each part has been designed in an adaptive manner and how it will be assessed. This can be done by filling in the orange boxes in the table.
### Table 11 – Aspects of adaptive capacity for structures in the buildings sector\(^{90}\)

<table>
<thead>
<tr>
<th>Assessment of aspects for every Brand building layer</th>
<th>0 Surroundings</th>
<th>1 Site</th>
<th>2 Structure</th>
<th>3 Skin</th>
<th>4 Services</th>
<th>5 Space plan</th>
<th>6 Stuff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uniformity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The type, quality, diversity, proximity and accessibility of facilities in the vicinity of the site determine the extent to which the site is suitable for various functions of the structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determines whether different functions are possible on the site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The surface area for the main structures in the zoning plan limits horizontal expandability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sizing system or modularity; a large grid offers more possibilities of parcelling out a plot than a small grid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A specific shape is more difficult to expand and connect to the existing structure than a rectangular standard size - the same applies to its ability to be disassembled and reused elsewhere</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modular stuff makes it versatile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{90}\) In the second half of 2020, the aspects in table 11 and table 12 will be harmonised with the indicators of future value presented by Brinkgroep.
<table>
<thead>
<tr>
<th>Network</th>
<th>The position of the object or sub-object in the logistics network determines the relevance of the adaptive capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flexibility</strong></td>
<td></td>
</tr>
<tr>
<td>Horizontal expandability</td>
<td>Site expandability</td>
</tr>
<tr>
<td>Suitability for multiple functions</td>
<td>Load-bearing capacity of floor suitable for multiple functions</td>
</tr>
<tr>
<td>Potential for internal movement (unrestricted floor plan possibilities), absence of obstacles.</td>
<td>Column structure and/or load-bearing walls/floors with possibilities for openings</td>
</tr>
<tr>
<td>Over-dimensioning and expandability</td>
<td>Overcapacity due to surrounding brownfield area</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disassembly: detachability</strong></td>
<td><strong>Load-bearing capacity of construction</strong></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Detachable connection between horizontal and vertical parts of the load-bearing structure</td>
</tr>
<tr>
<td></td>
<td>Disassembly sequence, possible damage during disassembly, type and number of connections</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Building layer</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relationship with other building layers</strong></td>
</tr>
<tr>
<td>Layer in accordance with its expected service life</td>
</tr>
<tr>
<td>Robustness of the layer and its components</td>
</tr>
<tr>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>Assessment per building layer according to Schmidt’s scale</td>
</tr>
<tr>
<td>Scale 6: movable (location)</td>
</tr>
<tr>
<td>Scales 3/4/5: refitable (performance), convertible (function), scalable (size)</td>
</tr>
<tr>
<td>Scales 2/3/4/5: versatile (space), refitable (space), convertible (function), scalable (size)</td>
</tr>
<tr>
<td>Movability to another location</td>
</tr>
<tr>
<td>Refitable, convertible, scalable due to horizontal and vertical expandability</td>
</tr>
<tr>
<td>Multifunctional due to movability, refitable, convertible, scalable due to horizontal and vertical expandability</td>
</tr>
<tr>
<td>Total assessment per building layer⁹¹</td>
</tr>
</tbody>
</table>

⁹¹ The core measurement method does not specify how users of this table of aspects can arrive at an overall assessment.
Table 12 – Aspects of adaptive capacity for buildings in the civil engineering sector

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniformity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sizing system or modularity; a large grid offers more possibilities of parcelling out a plot than a small grid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A specific shape makes expansion of and connection to the existing structure more difficult than a rectangular standard size - the same applies to its ability to be disassembled and reused elsewhere</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The network is an ecosystem that is constantly subject to change; every adaptation at a site has an effect in the network, which in turn determines changing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional requirements for a location are directly related to the network's adaptivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The position of the object or sub-object in the network, i.e. logistics network, determines the relevance of the adaptive capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requirements for an Object</td>
<td>Flexibility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Horizontal expandability</strong></td>
<td>Accommodating changes in the ecosystem enables expandability</td>
<td>Ownership of surrounding land determines horizontal expandability, purchasing creates opportunities for future expansion</td>
<td>Modular construction makes it easier to scale up and down</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Suitability for multiple functions</strong></td>
<td>Number and shape/position of support points</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Possibility of internal movement (unrestricted floor plan possibilities), absence of obstacles</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Over-dimensioning and expandability</strong></td>
<td>Overcapacity due to surrounding brownfield area</td>
<td>Structural interlinkage with intersecting network part; more integrated often means less flexible</td>
<td>Size and position of plant room (central/decentral), position of cores for vertical transport, position of piping shafts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Load-bearing capacity of construction</td>
<td>Modular / detachable / open source construction allows for expansion / upgrades</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disassembly: detachability</td>
<td>Detachable connection between horizontal and vertical parts of the load-bearing structure</td>
<td>Accessibility for maintenance and replacement</td>
<td>Accessibility of pipelines and connection points for maintenance, replacement and expandability</td>
<td>Room partitions and finishes detachable from load-bearing structure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disassembly sequence, possible damage during disassembly, type and number of connections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relationship with other building layer</th>
<th>Isolating installations and load-bearing structure</th>
<th>Separation of room partitioning elements and load-bearing structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer corresponds to its expected service life</td>
<td>&gt; 15 years to infinitely</td>
<td>Infinitely</td>
</tr>
<tr>
<td></td>
<td>30-300 years</td>
<td>20 years</td>
</tr>
<tr>
<td></td>
<td>7-15 years</td>
<td>3-30 years</td>
</tr>
<tr>
<td></td>
<td>&gt; 0 years</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Robustness of the layer and its components</th>
<th>The materials used can withstand and/or are protected against mechanical damage for the expected service life</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Assessment per building layer according to Schmidt's scale</th>
<th>Unknown</th>
<th>Scale 6: movable (location)</th>
<th>Scales 5/6: scalable (size), movable (location)</th>
<th>Scales 3/4/5: refitable (performance), convertible (function), scalable (size)</th>
<th>Scales 3/4/5: refitable (performance), convertible (function), scalable (size)</th>
<th>Scales 2/3/4/5: versatile (space), refitable (performance), convertible (function), scalable (size)</th>
<th>Scales 1/2: adjustable (task), versatile (space)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movability to another location</td>
<td>Scalable due to horizontal and vertical</td>
<td>Refitable, convertible, scalable due to horizontal</td>
<td>Refitable, convertible, scalable due to horizontal</td>
<td>Multifunctional due to movability, refitable, multifunctional</td>
<td>Can be rearranged due to detachability, multifunctional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assessment per building layer</td>
<td>expandability, movability inside and outside the location (modules)</td>
<td>and vertical expandability</td>
<td>and vertical expandability</td>
<td>convertible, scalable due to horizontal and vertical expandability</td>
<td>multifunctional due to movability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------------------------------</td>
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<td></td>
</tr>
</tbody>
</table>
6.5 Assuring adaptive capacity

Once adaptive measures have been added, it is important to ensure that they will, or can actually be, used at a later stage. Process and contractual aspects play an important role in this. Contracts that include maintenance or have product-as-a-service could be an incentive for contractors to opt for adaptive solutions. Parts, for instance, would then be easily replaceable, interchangeable and removable.

Adaptive preparatory stage

Scope for adding adaptive measures can also be ensured in the decision-making stage that precedes the construction of an object or sub-object. This is particularly relevant in the civil engineering sector, where such a decision-making stage can take years. There will be more scope for adaptive measures based on different views if ‘open’ decisions and contracts are drawn up at an early stage.

An open decision or contract only establishes the minimum requirements. Anything established is described as broadly as possible, preferably at the level of ambitions or functional specifications. Those specifications will not be detailed any further until the design process. The Systems Engineering method can be used for this. This is already quite common in the civil engineering sector.

92 Since they are responsible for the Total Cost of Ownership, TCO.
7 Areas of attention and agreements for use

7.1 Limitations of the method

The current core measurement method can be used to gain an understanding of, and base decisions on, elements of circularity. However, the method is not yet suitable for making a fully circular assessment.

Paragraphs 7.1.1 to 7.1.3 deal briefly with specific areas of attention arising from limitations of the method. The areas of attention that need to be resolved in due course are addressed first (paragraphs 7.1.1 and 7.1.2). After this, paragraphs 7.1.3 to 7.1.6 go into the areas of attention arising from the choices made.

7.1.1 Certain and uncertain data

The current core measurement method does not yet make any distinction between certain and uncertain data (see paragraph 3.5). Both types of data are used in the same way when calculating indicators. When using the data, it is important to consider whether any impact in the present outweighs uncertain benefits in the future.

7.1.2 Value

Since the indicators for value (indicators 5 to 7) have not yet been defined and tested sufficiently, they should be used with some caution.

7.1.3 Service life

The expected service life of the object or sub-object needs to be known before the core measurement method can be applied. When comparing options with different service lives, users shall themselves consider how a difference in service life relates to a difference in impact. For instance, they can then opt for an object or a sub-object with a service life which is twice as long, and with that object or sub-object having a slightly higher environmental impact.

7.1.4 Social fairness

Paragraph 3.1 states that social fairness is not part of the core measurement method, but that it is important to ensure that the transition to circular construction will proceed smoothly. However the action team has made recommendations in order to safeguard social fairness.

The action team advises parties to assess their own production for social fairness, using the following methods\(^93\):

- Amfori BSCI (Amfori, 2020);
- Global Compact Self Assessment Tool (Global Compact Self Assessment Tool, 2020);
- CSR Risk Check (MVO Nederland, 2020).

7.1.5 Considerations

The core measurement method can only be used to measure the degree of circularity. In practice, this quality aspect will have to be seen in conjunction with other performance goals, such as safety,

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\(^93\) Since the action team does not want to specify a preferred method, the methods are listed in alphabetical order.
health, quality, and social fairness. Lending credence to such considerations is not part of the scope of this guide. Of course, in practice it is important to ensure that any problems are not simply shifted elsewhere.

7.1.6 Tools

The core measurement method does not include tools that perform calculations and present the results. This means that the core measurement method is not an instrument. However, the core measurement method can be integrated into existing instruments.

7.2 Workflow

Most users of the core measurement method will not start with indicator 1.1.1, then go on to indicator 1.1.2, etc. In practice, the core measurement method will often be used in combination with the LCA method. The action team has therefore added a workflow that shows how indicators can be calculated for the core measurement method, starting from an LCA calculation.

An LCA has four phases. They are explained briefly below for the sake of clarity. However, the workflow is particularly easy to use for people who are already familiar with the LCA method (Guinee, 2002). The four phases in the LCA are:

- **Goal and scope**
  This phase determines the exact issue being analysed by the LCA, who the target group is, and the object or sub-object to which the LCA is applied.

- **Mapping**
  During the mapping phase, data is collected on all flows of materials that are associated with the object or sub-object.

- **Impact assessment**
  This phase translates the data into environmental effects (impact) and social preferences.

- **Interpretation**
  Verification that the results are consistent and complete is done in the last phase. If they are, conclusions will be drawn.

The workflow of the core measurement method in combination with the LCA method is shown in figure 21.

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94 If you are not interested in results for indicator 4 (degree of protection of the environment) of the core measurement method, you can apply the method separately from the LCA method. In that case, you can immediately start on the inventory phase from section 5.2.
Figure 21 - Workflow of the core measurement method in combination with the LCA method

The action team has the following comments on this workflow:

- It is not customary for the target and scope to have to be adjusted if there is already an LCA.
- Any data not identified during the mapping phase is usually data on the recycled material content of input flows. Data on end-of-life, maintenance and replacement scenarios should be available.
- The mapping should be done in accordance with the LCA method and the corresponding standards (ISO 14040 and ISO 14044, possibly in combination with NEN-EN 15804 and the SBK method).

7.3 Presentation of results

It is important that the data from the core measurement method is presented uniformly. This makes data comparisons easier.
The presentation should at least show the following results:

- **Degree of protection of stocks of materials**
  All the indicators of the input and output flows (indicators 1 to 3) in kilograms including their percentage of the total input or output.

- **Degree of protection of the environment**
  All product system impact categories from the SBK method (sub-indicators of indicator 4).

- **Degree of protection of value**
  Percentage of techno-functional and economic value that is retained/lost (sub-indicators 6.2, 6.3, 7.2 and 7.3).

- **Degree of adaptive capacity**
  An indication of, or the report on, adaptive capacity.

- **Expected service life**
  The service life of the main object in the calculation.

- **Life cycle phase**
  Life cycle phase at the time of calculation and detail level(s) of the data used.

Figure 22 contains an example of a communication format for the results. The format contains the minimum results. Additional information can obviously be included (see examples in paragraph 7.4).
Figure 2.2 - Example of a format to communicate the results of the core measurement method

95 This format can also be downloaded from platformcb23.nl.
7.4 Additional information

Parties who use the core measurement method can, of course, make their own additions to the core measurement method. For example, they can add another indicator or split the results of the core indicators into underlying levels of detail. Such an intervention will often arise from a specific information need in a region, an organisation, or a project organisation.

This possibility enables market parties who develop measuring methods and measuring instruments to continue to be distinguishable. By starting from the core measurement method, they do so on an unambiguous, verifiable, and broadly supported basis.
8 Justification

8.1 Added value of the core measurement method early in the transition

As indicated in paragraph 1.3, several parties have independently identified the need for a harmonised core measurement method for circularity. Such a harmonised methodology will ensure that all parties use the same indicators, data, and determination method. This enables statements about the degree of circularity to be verified and compared.

In guide 1.0 (Platform CB’23, 2019b), the action team examined whether there is actually any added value in using such a core measurement method. The conclusion was that there is. Most existing measurement methods for sustainability and circularity focus on one or two of the three goals of circular construction (see paragraph 3.1). This is also demonstrated in chapter 9 which compares the core measurement method to other measurement methods.

The action team is aware that we are at the beginning of the transition to a circular construction economy and that the time may not yet seem ripe for a harmonised core measurement method. The reason for starting on such a method as early as this is that the beginning of a transition is mainly characterised by experimentation: radical new thoughts and actions (more information on transition phases can be found in annex A). The action team also sees working on the core measurement method as a way of experimenting and learning together.

8.2 Scope and conceptual framework

Decisions about the scope (see chapter 2) and conceptual framework (see chapter 3), including the three goals of circular construction (see paragraph 3.1) are based on the shared needs of the stakeholders. These needs were derived from six user stories and were tested in all the organisations which participated in the development of guide 1.0. The user stories are from Rijkswaterstaat, Heijmans, Dutch Central Government Real Estate Agency (Rijksvastgoedbedrijf), Branchevereniging Nederlandse Architectenbureaus, Waternet and The Metropoolregio Amsterdam(MRA). Further details of the user stories can be found in annex E.

Some topics from the user stories have not been incorporated into the core measurement method. These are:

- **Toxic substances in input and output flows**
  Toxic substances have an indirect impact on the three goals of circular construction. However, toxic substances are identified as an area for attention when determining the expected end-of-life scenario (see paragraph 5.3.8). This is because toxic substances can affect reusability and recyclability.

- **Service life extension and R principles**
  **Service life extension** and R principles are circular strategies (see paragraph 2.2.3). Since it has been decided to work with impact indicators, these strategies have not been included in the conceptual framework. In principle, the core measurement method is capable of measuring the effects of these strategies.

- **Maintainability and reparability**
  Maintainability and reparability are not included as indicators in the measurement method either because they are circular strategies. However, because it is important to have an understanding of these aspects in order to be able to make an estimate of future material flows, these themes have been included in chapter 6.
In addition to the user stories, conceptual frameworks have been adopted from the LCA and MCI methods. These include life cycle thinking (see paragraph 3.4) and a materials balance (see paragraph 3.6). According to the action team, these are good ways of systems thinking that prevent problems from being moved elsewhere.

When preparing guide 2.0, the action team explicitly double-checked whether social fairness was a reason for stakeholders to want to take up circular construction (see paragraph 3.1). This turned out not to be the case for most of them.

8.3 Indicators and their methods of determination

8.3.1 Indicators for protecting materials stocks

The action team considers the first steps of an environmental LCA to be a good theoretical basis for indicators of the protection of material stocks. However, extra labels have been added and other labels have been omitted.

Labels which have been added are those for sustainably produced and non-sustainably produced raw materials (see paragraph 5.3.3). The action team considers this distinction to be important since renewable raw materials can also be susceptible to depletion. The probability of a renewable resource being depleted must be considered at the level of the production unit as a whole. For example, consideration is given to the regrowth of the forest from which the wood was sourced, instead of looking at the regrowth of one specific tree.

A label that has not been copied is the subdivision into three types of waste. LCA calculations carried out according to the SBK method differentiate between non-hazardous, hazardous, and radioactive waste. This distinction is not necessary for the goals of this core measurement method.

Scarcity indicators

The scarcity indicators (see paragraphs 5.3.5 and 5.3.6) were drawn up following a desk study. That study revealed that scarcity is more complex and broader than just the absolute stocks of raw materials. Scarcity is relative and can be influenced by, among other things:

- demand for a raw material (which may vary over time);
- the growth of stocks (natural growth, new stocks being discovered, new techniques);
- the extent to which it is profitable to extract a raw material (irrespective of any existing stocks);
- geopolitical and social changes (conflicts, energy transition, rising sea levels);
- local circumstances (local scarcity);
- available stocks in existing objects or sub-objects (human stock);
- how a raw material is connected to other materials and components.

User stories (see annex F) revealed which dimensions of scarcity stakeholders consider to be the most important. Three such dimensions emerged:

- the impact on natural reserves;
- socio-economic risks and the degree of security of supply;
• the impact on non-natural reserves (stocks) in objects or sub-objects.

In response to this, the action team looked at which existing methods would be suitable for measuring impacts on these three dimensions. This led to the summary shown in figure 23.

![Figure 23 – Dimensions of scarcity and associated measurement methods](image)

The percentage of recycled and recyclable is determined by indicators 1.2 and 2. ADP is used in indicator 1.4 and the CRM list is used in indicator 1.5.

Due to the complex nature of scarcity, specific situations may require the addition of the above-mentioned dimensions.

### 8.3.2 Indicators for protecting the environment

According to the action team, the environmental impact categories from the SBK method are a valuable means of determining the degree to which the environment is protected (see paragraph 5.3.9). There is also broad support for the environmental system impact categories.

### 8.3.3 Indicators for protecting value

The action team decided to include two types of value in the core measurement method: techno-functional value and economic value. Other types of value (such as social value and aesthetic value) are not taken into account because they are hard to measure and difficult to influence.

Many literature sources make a subdivision into technical, functional, and economic value. However, functional value is difficult to define and be made measurable if it is not considered in conjunction
with technical and economic value. It was therefore decided to assess functional and technical value together.

Economic value depends on techno-functional value, but also on other social factors. Examples are the relationship between the prices of labour and of raw materials, technological developments, and the social acceptance of secondary inputs. The economic value dimension has been added mainly because it helps to clarify the feasibility and cost-effectiveness of various circular options and circular revenue models. As a result, this value dimension also helps to clarify policy and other measures to take away potential barriers.

According to the action team, a measurement method with two value dimensions helps to clarify the relationships between those dimensions (over time). If considered separately, the value dimensions say little about the degree of value retention.

It was decided that the value indicators should only apply to the scale levels of product, element and material. Many non-technical aspects, such as the location, also play a role in the value of a structure. Making these aspects measurable as well is complicated. It was also decided that results could not be inherited by a higher level of scale since the value of a structure is not the sum of the values of the objects or sub-objects.

**Techno-functional value**

The frameworks for the techno-functional value indicators were based on information from asset management, systems engineering, and value engineering.

**Economic value**

The indicators of economic value were based on the principle of Total Cost of Ownership (TCO). TCO is the total cost incurred whilst a structure is in use. In practice, investment costs and operating costs are often the only aspects that are considered and attempts are made to minimise them. The action team has chosen the TCO approach in order to ensure that any costs and benefits at the end of the cycle of use are also considered. This also includes residual value (which in practice has often been considered to be zero up to now). Only then will the indicators of economic value actually provide a picture of value retention.

The Whole-Life Costing (WLC) method is used to calculate the TCO. The WLC method is an extension of the frequently used Life Cycle Costing (LCC) method. The main difference is that the WLC calculation also includes positive cash flows (income). The WLC method therefore also includes the residual value of the land and the residual value of objects or sub-objects in the calculation for economic value retention.

Figure 24 illustrates the difference between the WLC and LCA methods.

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96 Nonetheless, functional value is a useful and widely used concept as a process approach to design.
By opting for the WLC method, the action team has opted for the life cycle phases (see table 9 in paragraph 5.3.12) which are also used to calculate the degree of protection of the environment (indicator 4, see paragraph 5.3.9). This makes it easier to make an integrated assessment where protecting the environment is compared to protecting economic value.

8.4 Report on adaptive capacity

An extensive desk study was carried out to establish the instruments for reporting on adaptive capacity. Experts from the civil engineering sector were consulted as well.

The list of aspects of adaptive capacity (see paragraph 6.4.2) was partly based on the scientific measurement criteria for adaptive capacity of a building. Scientific research (Schmidt III, 2014) into support for measurement criteria was used to identify the relevant criteria, since it is not common that direct measurement criteria from research can be generalised, or can be sufficiently generalised. Measurement criteria for which there is support are overdimensioning, standardisation, multifunctionality and open floor plans.

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Figure 24 – Differences between the WLC and LCC methods

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97 Scientific literature predominantly uses the term ‘measurement criteria’ instead of ‘aspects’.
9 Relationships with other measurement methods and initiatives

9.1 Environmental LCA methods

The environmental LCA method is quite a popular instrument in the Dutch construction sector when making statements about the sustainability of an object or sub-object. These statements are usually made in the statutorily required form of an MPG calculation (buildings sector) or an ECI calculation (civil engineering sector). The SBK method is one of the ways in which an LCA can be performed.

There are many similarities between the environmental LCA methods (and specifically the SBK method) and the core measurement method. These similarities include:

- The methods share the same scope and conceptual framework, including life cycle thinking, and they are all based on material flows and a materials balance.
- The data needed is largely the same.

Figure 8 in paragraph 4.2.6 and the workflow in paragraph 7.2 show the calculation steps that the two methods share.

There are also differences. Several aspects of the two methods differ, including the following:

- The core measurement method focuses on the three goals of circularity. Environmental LCAs only focus on protecting the environment (see figure 9 in paragraph 5.2.3) and are also used in the core measurement method to measure impacts in that area. Measuring impact on the existing value and stocks of materials is not part of the environmental LCA method.
- There are a few minor differences in the method of determining the indicators. These differences are discussed in paragraph 8.3.

In order to make the core measurement method suitable for use in real-life situations, the action team aims to merge the data collection for circularity indicators with data collection for MPG/ECI. If an adjustment to the data collection is necessary in the future, the action team will submit a request to that effect to the Dutch national government and the manager of the national environmental database (SBK).

9.2 Material Circularity Indicator (MCI)

The Material Circularity Indicator (MCI) is intended to measure the degree of circularity. The method was developed by the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015), a non-governmental organisation (NGO) committed to a circular economy.

Both the MCI method and the core measurement method take flows of materials during the entire life cycle of an object or sub-object as their starting point. However, there are some differences:

- The MCI method only provides information on the impact on protecting stocks of materials; The core measurement method extends this to protecting the environment and retaining value.
- The MCI method only takes waste from recycling, use, and reuse into account. The core measurement method also includes production waste and thus covers the entire life cycle.
- Renewable primary raw materials, or other raw materials that are less susceptible to depletion, do not have a separate status in the MCI method, i.e. the MCI method is based on the technical cycle and does not consider the biological cycle.

- The MCI method has an indicator for service life extension. This is not, or at least not yet, the case in the core measurement method.

The data from the core measurement method can also be used to calculate an MCI score. Annex G shows how to do this.

### 9.3 Level(s) Framework

The Level(s) Framework (European Commission, 2017) is a European framework that is intended to assess the environmental performance of buildings during their life cycles. The framework pays special attention to the efficient use of relevant resources such as energy, materials and water. Experience with the framework is currently being gathered in various countries.

The main difference between the Level(s) Framework and the core measurement method is that the Level(s) Framework is more extensive. The core measurement method is 'leaner' because it only contains those indicators needed to measure the impact on the three goals of circular construction.

Table 13 shows the topics covered by the Level(s) Framework. Topics that are also part of the core measurement method are shown in pink.

### Table 13 – Comparison between Level(s) Framework and the core measurement method

<table>
<thead>
<tr>
<th>Thematic areas</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gas Emissions along a construction’s life cycle</td>
<td>Use stage energy performance [kWh/m²/yr]</td>
</tr>
<tr>
<td></td>
<td>Life cycle Global Warming Potential CO₂eq/m²/yr</td>
</tr>
<tr>
<td>Resource efficient and circular material life cycles</td>
<td>Life cycle tool: Building bill of materials [kg]</td>
</tr>
<tr>
<td></td>
<td>Life cycle tools: scenarios for service life, adaptability and deconstruction</td>
</tr>
<tr>
<td></td>
<td>Construction &amp; demolition waste and materials kg/m²</td>
</tr>
<tr>
<td></td>
<td>Life Cycle Assessment (cradle to cradle)</td>
</tr>
<tr>
<td></td>
<td>Data for core measurement method</td>
</tr>
<tr>
<td></td>
<td>detachability</td>
</tr>
<tr>
<td></td>
<td>adaptive buildings</td>
</tr>
<tr>
<td></td>
<td>value</td>
</tr>
<tr>
<td></td>
<td>primary and secondary input and output flows</td>
</tr>
<tr>
<td></td>
<td>upcycling or downcycling of recycling flows</td>
</tr>
<tr>
<td></td>
<td>quantities per waste flow</td>
</tr>
<tr>
<td></td>
<td>Environmental performance</td>
</tr>
</tbody>
</table>
9.4 R principles

R principles are often used to think about and improve circularity. Examples of the R principles are refuse, rethink and reduce. The main distinction between the R principles and the core measurement method is that the core measurement method measures circular impact. The R principles can only be used to check whether a circular strategy has been used (see paragraph 3.3 for this difference). The core measurement method basically measures the impact of each circular strategy (see paragraph 2.2.3), including that of the R principles.

The R principles are often presented in the form of a ladder, suggesting that a strategy which is located higher on the ladder contributes more to circularity. However, the circular impact differs from application to application. The core measurement method can visualise these differences, whereas the R principles cannot.

An example of an application where the R principles would not suffice is a modular bridge deck. Such a bridge deck can be reused four times in two hundred years. After that, some parts of the bridge deck will no longer be functionally or technically adequate. If a new bridge deck can be made from the composite materials (recycle), then the use of primary raw materials will be avoided even after those two hundred years. If this is not possible, it should be considered whether the advantages of modular design for four cycles outweigh the disadvantages of a design that cannot be recycled at the end of those cycles.

9.5 National initiatives

Where possible, the core measurement method will be used as input for initiatives and measurement methods at the national level. There are contacts with the management board of Platform CB’23 and
the Transitieteam circulaire bouweconomie (Transition Team for a Circular Construction Economy), SBK and PBL, and others.

For example, SBK and Platform CB’23 intend to ensure that the SBK method and the core measurement method will jointly form a single system and thus be compatible and complementary. Steps have already been taken to achieve this.

In addition, there is interagency coordination among the parties who are assessing and measuring the impact of adaptive capacity in the Netherlands. In this context, regular consultations take place with Brinkgroep and the Transition Team for a Circular Construction Economy and other parties.

### 9.6 International standardisation initiatives

The action team formulates working agreements which may form the basis for future standards. Standards for circularity are also being considered at an international level. The action team has also taken information from international initiatives into consideration since European standards will eventually apply in the Netherlands. In addition to this, the action team itself also provides input from the Netherlands in the form of the core measurement method which can be used in international standards.

The action team is aware of the following standardisation initiatives:

- A global ISO committee on *Circular Economy* has been established. This committee’s focus is on the application of circular principles in business operations. A measurement method is also being developed for this.\(^{98}\)

- There is a European standards committee *Energy-related products - Material Efficiency Aspects for Ecodesign*. This committee is defining material efficiency requirements for energy-related products.\(^{99}\) This also includes construction products such as lighting and electrical doors and windows.

- Consideration is being given to setting up a European standards committee on the *Circular Economy in the Construction Sector*.

\(^{98}\) For more information, see ISO/TC 323, 2018.

\(^{99}\) For more information, see European Commission, 2019.
10 Results, follow-up steps and recommendations

10.1 Results

10.1.1 Further development of indicators and reporting on adaptive capacity

Various parts of the core measurement method have been developed further in guide 2.0. As a result, the method now truly measures impact on all three goals of circular construction. The main indicators that have been added are those for scarcity (indicators 1.3 and 1.4) and for value (indicators 5 to 7). There is now also a chapter on adaptive capacity (see chapter 6).

So far, only the broad outlines of the indicators for functional and technical value have been developed. However, this is an important step towards having indicators that are consistent with existing design processes. Double ‘value pyramid’ thinking (see paragraph 5.3.11) is helpful in this respect. The study into value indicators also revealed the knowledge about value which is still lacking.

The scarcity indicators have been developed. These provide a broad picture of the degree to which scarce materials are used.

Guide 2.0 explores the theme of adaptive capacity in more depth, both for the buildings sector and for the civil engineering sector. This has provided much information on the influence of adaptive capacity on future flows of materials. The research into adaptive capacity also showed that multiple life cycles will have to be analysed for the purpose of the core measurement method in the future. This also emerged from the study into value indicators.

As was the case with the parts in guide 1.0, it has become clear where there is broad consensus and on which parts. This allows for harmonisation and adds transparency to the transition to a circular construction sector.

10.1.2 New action team members

The process of developing guide 2.0 has also had added value. Many new action team members were involved in the guide, thus making the core measurement method more widely known and more widely applicable.

Action team members conducted much research and talked extensively with each other. This resulted in interesting exchanges of ideas. Action team members shared their knowledge and gained new knowledge. They experimented with new ideas together and, where necessary, put their own interests aside for the greater good. This joint learning process has helped to speed up the circular transition.

10.1.3 First steps with tests

The intention was that the core measurement method should be tested in real-life situations. Although it turned out to be difficult to get data, the first steps have been taken. Analysing the flows of materials (see paragraph 5.2.1) continues to be extremely feasible for users. The core measurement method is also very compatible with environmental performance calculations, where they are available.

Parts of the method have been used by Rijkswaterstaat and NIBE, as well as by students of HAN University of Applied Sciences and students of the University of Amsterdam.
10.1.4 Agreements about use and implementation

During a final meeting, working group members considered what their organisation could do to further develop and apply the core measurement method. They made the following commitments:

- Consultants will start using the core measurement method in projects.
- A tool builder will gradually adapt their tool based on the core measurement method.
- An architect will use the core measurement method to design a sample project.
- An action team member will use the core measurement method as a basis for a response to the Letter to Parliament on measures to promote circular construction (Dutch national government, 2019).
- A researcher is going to bring the core measurement method to the attention of international research groups.
- A researcher is going to use the core measurement method in university education. The method will then serve as a reference for new projects, including a graduation project on adaptive capacity in the civil engineering sector.
- The core measurement method will be used for the development of the Global Sustainable Enterprise System (GSES). GSES is a worldwide system that assesses companies and organisations as regards corporate social responsibility and circular business operations.

10.2 Follow-up steps in guide 3.0

10.2.1 Terminology

Using uniform terms and definitions is important when transitioning to a circular construction sector. This had already become apparent before and it once again became evident during discussions among the action team members working on guide 2.0. According to the action team, there is reason to (re)consider the following terms:

- terms related to life, such as useful life, life cycle, cycle of use, end-of-life scenario, technical life, economic life and service life;
- primary and secondary materials: how should materials extracted as residual products be categorised?;
- reuse and recycling: after how many operations does an object or a sub-object no longer qualify for the term of ‘reuse’?
- the human time scale in the case of renewable material (see paragraph 5.3.2).

At all levels of Platform CB’23, there is an ongoing discussion about whether neutral terms (e.g. ‘protect’) or motivational terms (e.g. ‘improve’) should be used. Motivational terms may make a stronger contribution to the transition.

All terminology issues must be discussed at the level of Platform CB’23 and not only at the level of the Measuring Circularity action team. This is because many of the terms referred to are also listed in the Circular Construction Lexicon version 2.0 (Platform CB’23, 2020a). If any terms and definitions are reconsidered, they must also be consistent with the SBK method.
More than one life cycle. As indicated in paragraph 3.4, the action team is of the opinion that the results of the core measurement method should cover more than one life cycle. The action team intends to implement this in guide 3.0.

One of the things that should be established in the next guide is what the starting point will be: a fixed number of life cycles, a fixed number of years, or something else. In addition, consideration should be given as to whether data is needed for all input flows (for upgrading, maintenance, etc.) in subsequent life cycles and how the core measurement method deals with that data. Users’ knowledge of objects or sub-objects in later cycles can help to make progress with this topic.

Another question is which method can be used to add up LCAs (indicator 4) for multiple life cycles. Since Stichting Bouwkwaliteit is going to make changes to its determination method which may possibly be used for this purpose, it is advisable to first await these changes.

**10.2.2 Degree of uncertainty of expected circularity**

The action team would like to make it transparent which part of the results of the core measurement method is based on expected circularity and which part on achieved circularity (see paragraph 3.5). As regards expected circularity, it must also be made clear how certain the expected results are.

An important question here is how to make the degree of certainty transparent. The problem with long-term calculations is that people are inclined to assume that multiple probable events will occur. The action team does not consider a black and white division into ‘certain’ and ‘uncertain’ to be the best solution. Alternatives are solutions with probability percentages or a best-before date for results.

Guide 3.0 should also examine the desirability of using a weighting factor (possibly linked to the probability percentage) for results based on uncertain data.

And finally, it should be examined as to whether making the degree of uncertainty transparent is useful in all cases. Is it equally relevant for construction products and structures for instance? And does it apply to all moments in the life cycle?

**10.2.3 Future scenarios**

The use of future scenarios also has to be further developed in guide 3.0. Future scenarios are already part of the report on adaptive capacity (see paragraph 6.3). However, if the core measurement method includes multiple cycles in its calculations (see paragraph 10.3.2) and the degree of certainty becomes transparent (see paragraph 10.3.3), the importance of future scenarios will increase.

The main question about future scenarios is which rules should apply to make them reliable. What assumptions are users allowed to make? How may they claim expected input and output flows and the corresponding circular results? Should recording reproducible best practices for the next cycle be required? Does it make any sense for the action team to develop some basic scenarios, e.g. the scenario for the energy transition or a scenario for innovations that impact on adaptive capacity? All these questions will have to be developed in more detail in guide 3.0.

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100 The article entitled 'Beter omgaan met onzekerheid bij MKBA’s infrastructuur’ (Dealing with uncertainty in infrastructure SCBAs more efficiently; Bos et al., 2016, see also section 6.2.2) is a good starting point for this.
10.2.4 Upcycling and downcycling

The action team has not differentiated between upcycling and downcycling as regards reuse and recycling (indicators 2.1 and 2.2). However, the value indicators, or at least these first attempts at value indicators, will lead to more information about different types of reuse and recycling. Whether this adequately covers the need for upcycling and downcycling indicators will have to be demonstrated in practice by the real-life application of these value indicators, or these first attempts at value indicators.

When exploring the distinction between upcycling and downcycling, the action team encountered the following and other issues:

- Harmonising existing methods was not easy. This may be due to the fact that the terms upcycling and downcycling are mainly used in waste legislation (Dutch Nation Waste Management Plan - LAP). Such legislation does not necessarily serve circularity purposes.

- Upcycling and downcycling is a binary subdivision. The action team came to the conclusion that a scale (degree of upcycling or downcycling) makes for a more useful indicator.

- It is not always possible to assess whether the new reuse function is of a higher or lower value than the previous one.

10.2.5 Further development of adaptive capacity

The action team has identified another three steps for examining the topic of 'adaptive capacity' in more depth:

- Embed the consequences of adaptive capacity at a quantitative level in the materials balance which forms the basis for calculating the indicators. This will make adaptive measures in certain future scenarios really visible in the results on the indicators.

- Study the relationship between adaptive capacity and value retention further.

- Establish the conditions for 'assuring adaptive capacity' (see paragraph 6.5) before circularity results are allowed to be claimed.

10.2.6 Aggregated overall score

In due course, the core measurement method should lead to an aggregated overall score for the degree of circularity (see paragraph 2.2.1). This calls for an interpretation exercise in which the relative importance of all indicators must be weighted.

10.2.7 Usability for tendering

Many parties in the construction sector (see paragraph 8.2 and annex E) want to use the core measurement method for tenders. At present, it cannot be guaranteed that the same data will lead to the same results in the core measurement method. It is therefore important that clients have a good idea of which decisions the guide still leaves to the user. For example, the guide does not define in sufficient detail which data sources may be used, how to arrive at an aggregated overall score, which functional units should be used, and how to determine the service life to be taken into account (see paragraph 10.3.10).

Platform CB’23 wants to draw up a separate guide for the use of the core measurement method in tenders. Experimenting with tenders in real-life situations is also planned in order to identify risks of misinterpretation and manipulation.
10.2.8 Consistency with national and international initiatives

Platform CB’23 always aligns working agreements with other national and international initiatives (see paragraphs 9.5 and 9.6). This will continue to be an area of attention for guide 3.0.

At the national level, it is particularly important that the core measurement method is consistent with the SBK method (Stichting Bouwkwaliteit, 2019) and the monitoring by the Netherlands Environmental Assessment Agency (PBL). At the international level, the action team remains committed to ensuring that findings from the core measurement method are included in standards.

Data sets (see paragraph 5.2.2) play an important role in measuring circularity. At present, existing datasets are not always aligned with the core measurement method. Furthermore, data sets are not available to everyone. The action team will therefore continue discussing the development and accessibility of the NMD with SKB, the manager of the National Environmental Database (NMD).

10.2.9 Other topics

Finally, there are a number of isolated, unanswered questions that can or should be addressed in guide 3.0. The questions are:

- Should a unit other than mass in kilograms be used with the scarcity indicators (indicators 1.3 and 1.4)? A kilogram of scarce material can actually already be a problem from the point of view of protecting material stocks, even though it is only a small part of the total mass of a structure.

- To what extent is the core measurement method suitable for biobased raw materials? Is a separate indicator for the incineration of renewable raw materials (as a sub-indicator of indicator 3) desirable?

- How can information from asset management about the use phase of objects or sub-objects become part of the core measurement method?

- Which frameworks should apply to data? The current guide mainly focuses on transparency and the origin of materials, but there are few restrictions on the use of databases.

- How should the functional units for different objects or sub-objects be determined so that results of the same type of object or sub-object can be compared?

- What role should topics such as air quality, biodiversity and food supply play in the core measurement method?

- How can the core measurement method be made 'more robust'?

- How can the core measurement method be made easier to understand for a broader target group? Examples of circular objects or sub-objects may play a role in this.

10.3 Recommendations for other parties

10.3.1 Organisations in the construction sector

Since the core measurement method has only been tested on a very small scale (see paragraph 10.1.3), the action team considers more testing to be an important follow-up step. The action team is therefore inviting organisations in the construction sector to carry out joint circularity calculations using the core measurement method. A condition is that relevant data is available and that organisations are willing to share the test results.
One of the things that can be assessed by testing is whether the core measurement method is really suitable for broad use (see the scope in paragraph 2.2). For example, can the method also be used in the civil engineering sector, for processes at the beginning of the production chain (such as making concrete mortar), in the design phase, and for mutations/renovations?

Testing will also show how reproducible and reliable the core measurement method is and which agreements are still lacking in the method. The action team also wants to use tests to assess what is needed to make the method more user-friendly, e.g. tools (see paragraph 10.4.2) or guidelines for using the core measurement method in tenders (see paragraph 10.3.8).

10.3.2 Tool builders

The core measurement method has not yet been embedded in tools that perform calculations for users. The action team would like to change that. The first step in this direction would be to talk to commercial parties who provide tools for measuring circularity. The action team wants to use these talks to find out what commercial parties need in order to create a calculation tool.

Commercial parties, such as tool builders, can also play a role in weighing and/or interpreting scores from the core measurement method. This step is not yet part of the scope of this guide (see paragraph 2.2.1), but is important for the use of the core measurement method in practice.

10.3.3 Universities

This guide sets out the broad outlines of the value indicators (see paragraphs 5.3.10 to 5.3.12). The conditions that apply in order to further complete these indicators are also given. Since the step towards indicators is complicated, the action team advises universities, and specifically technical universities, to conduct research into this.
**Background**

**Platform CB’23**

Platform CB’23 was set up by Rijkswaterstaat, the Dutch Central Government Real Estate Agency (Rijksvestgoedbedrijf), De Bouwcampus and NEN (Netherlands Standardization Institute) in 2018. Its main goal was to accelerate the transition to a circular construction sector.

As indicated early on in this guide, the construction sector plays an important role in the transition to a circular economy. The activities of the platform take place in conjunction with the national implementation programme, the Transitieteam and Transitiebureau Circulaire Bouweconomie (Transition Team and Transition Agency for Circular Construction Economy). By extension, the platform is linked to the Dutch Bouwagenda (Construction Agenda).

The precise form the transition to a circular construction will take is still unknown. This is something that the construction industry as a whole will have to work out. The development of this guide is a good example of this.

**2023 as a dot on the horizon**

CB’23 is short for Circular Building in 2023. The platform has thus identified its dot on the horizon as 2023. 2023 is only three years away. This is close enough to both keep the pressure on and yet far enough away to enable concrete results and agreements to be reached.

**Development of the guide for Measuring Circularity**

Parties throughout the sector contributed to creating this guide and the *Guide to Passports for the construction sector*. NEN set up ‘action teams’ for this. Many companies and organisations responded to the call to take part in these action teams. The participants were selected to ensure a diversity of disciplines and perspectives. The lists of participants can be found in annex H (2018-2019) and annex I (2019-2020).

The action teams subsequently formed working groups. These working groups each gained a deeper understanding of one part of the guide and developed it further. The working groups for this guide addressed the following topics:

- scarcity of raw materials;
- adaptive capacity in the buildings and civil engineering sectors;
- testing and implementation of guide 1.0;
- value and upcycling or downcycling.

Whenever the guide reached a new phase, the working group members presented their results to the action team. Other members of the action team could give feedback on the work of the working group members during these joint sessions. This method of working was intended to ensure broad support for the guide.

The kick-off meeting for developing the guide was held on Monday October 7, 2019 at NEN in Delft, the Netherlands. The full action team attended this meeting. In total, the action team met three times whilst the guide was being developed. The working groups met seven times in plenary sessions.
**Support team**

Platform CB'23 set up a support team to coordinate the process. This support team consisted of a chairman, a coordinator, working student and a rapporteur. The chair led the action team and working group meetings. The coordinator representing NEN ensured that all meetings went smoothly and monitored the progress of the guide. NEN’s working student drew up the reports of the meetings and assisted the coordinator and rapporteur where possible. This latter position was a new position, added this year. The rapporteur’s task was to compile the information provided by the members of the working group into an accessible and readable document.

**Guide during the consultation round**

The guide was published when it was eighty percent ready. The 'eighty percent version' was introduced by a short introductory film on the Platform CB'23 website. Anyone could download this version and then give feedback. The action team received some 700 comments from about 50 organisations.

After the end of the consultation round, the working group members discussed the feedback and, where necessary, incorporated it in the guide. If you have submitted any feedback and you cannot find it in this final version of the guide, please contact Platform CB'23 for further information about this.

**Coordination of the guide with the other action team**

The action team involved in Passports for the Construction Sector set to work in parallel with the action team working on Measuring Circularity. The structure and planning schedule of the action team involved in Passports for the Construction Sector is similar to that of the action team working on Measuring Circularity. During the development of this guide, there were a number of coordination moments during which the two action teams were informed of each other’s activities.
Bibliography


101 The bibliography only contains sources that are referred to literally in the text of the guide. Any other sources that were used while developing the agreements are not listed.


Royal HaskoningDHV (2018). Circulair sturen op hoogwaardig hergebruik van toegepaste en toe te passen materialen. (Circular promotion of upcycling of materials that have been or will be used.) Nijmegen: Royal HaskoningDHV.


Schmidt, R., T. Eguchi, S. Austin, A. Gibb (2010). What is the meaning of adaptability in the building industry. Bilbao: 16th International Conference on Open and Sustainable Building.


Annex A

Agreements for a transition to circular construction

As indicated in paragraph 1.2, Platform CB'23 is committed to agreements that support the transition to a circular construction economy. Platform CB'23 sees a need for unambiguous agreements on seven interlinked main topics; the number of main topics may change in the future. These main topics are shown in figure 25.

First of all, it is important that all parties involved in circular construction speak the same language (topic 1). Agreements on concepts, terms and definitions help in this respect. For this purpose, Platform CB'23 prepared the Circular Construction Framework version (Platform CB'23, 2019a) and the Circular Construction Lexicon (Platform CB'23, 2020a).

The topics 2 to 6 are content-related topics that need further development. A start was made on the topics of ‘measuring circularity’ and ‘information & data’ in this guide, and in the Guide to Passports for the construction sector (Platform CB'23, 2020b). No indication can yet be given of where and when the other topics will be developed in more detail. It is also still unclear whether any topics (the right-hand block in figure 25) should be added.

The last topic is the chain transformation needed (topic 7). This is an underlying change at process level.

The focus of the various transition phases will be on agreements on different subjects. Platform CB'23 has identified four phases. These phases are shown in figure 26. This figure outlines which topics are the most important for the first two phases.

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Note: Figures 25 and 26 can be downloaded as separate files on platformCB23.nl.

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102 These phases are based on Lodder’s transformation model (Lodder et al., 2017).
103 Figures 25 and 26 can be downloaded as separate files on platformCB23.nl.
Figure 26 – Developments in agreements over time

1. Framework incl. lexicon
2. Circular design & circular building
3. Measuring circularity
4. Information & data
5. Value creation & financing
6. Assurance
7. Chain transformation

Experiment
• Radically new way of thinking
• Radically new way of acting

Accelerate
• Connect alternatives
• More people will switch over

Emergence
• New structures will become visible
• Transition no longer a subject of debate

Institutionalise
• This new norm in thinking and acting
• Consolidate new structures
Annex B

Existing methods for the development of techno-functional value indicators

Paragraph 5.3.11 indicates that existing methods in the buildings and civil engineering sectors can be used to develop the indicators for techno-functional value. The action team thinks that the following methods should be considered:

- **Systems engineering**
  The systems engineering and value engineering design methods both start by determining functional value. Since both of these methods translate functional value into technical performance requirements, they can both be used for the indicators of techno-functional value.

- **Asset management**
  Asset management is a method for good management during the use phase. The method provides a better understanding of quality management of materials/products and constructions, degradation, and prevention of degradation, and value retention by service life extension. The method can also be used to assess service life extension, adaptive capacity and use in subsequent cycles.

- **Condition assessment - NEN 2767**
  The NEN 2767 condition assessment is a method to assess the condition of a structure through visual inspection. This standard can also be used to assess the quality/value of a structure after an initial life cycle.

- **Technical baseline measurement**
  The technical performance of an element or product is recorded in a technical baseline measurement. There are several different methods for different materials and their desired performance. This baseline measurement can be carried out at different moments for circular construction (e.g. during the use phase, at the end of the first life cycle, after disassembly of an element and after transportation).

- **DGBC for detachability**
  The DGBC method for detachability is related to design aspects that can indicate how well products/elements lend themselves to being disassembled.

- **Service life - NEN-ISO 15686**
  NEN-ISO 15686 can be used to determine the residual service life of a structure, using a reference service life and specific factors. This standard can also be used to determine future value. This is because the standard provides instruments to determine the residual service life based on generic basic principles with corrections for the specific circumstances of the project under consideration.

### Formula for estimated service life

Estimated service life = reference service life * form factors
Annex C

Example of economic value calculation

Paragraph 5.3.12 sets out the method for determining the indicators of economic value. This annex contains an example of this method of determination in order to clarify it.

The example is an office building with approx. 1000 m² of GFA, built in 2020, with a service life of 50 years. The calculation of the economic value of this building is as follows:¹⁰⁴

- Life cycle phase A \( (K_A) \): €1,000/m² of GFA in construction costs;
- Life cycle phase B \( (K_B) \): €50/m² of GFA in operating costs, discounted until 2020;
- Life cycle phase C \( (K_C) \): €25/m² of GFA in end-of-life cost, discounted until 2020;
- Life cycle phase D \( (B_D) \): €75/m² GFA in revenues, discounted until 2020.

The quantity of economic value available for the next cycle (indicator 6.2) will then be:

\[
EW_b = \frac{75}{1000 + 50 + 25} \times 100\% = 7.98\%
\]

The quantity of economic value lost (indicator 7.2) will then be:

\[
EW_v = 100\% - 7.98\% = 92.02\%
\]

The lower \( EW_v \), the better it is from a circular point of view. Ideally, \( B_D \) would be equal to or greater than the sum of \( K_A \), \( K_B \) and \( K_C \). This brings \( EW_b \) to 0% or even gives it a negative value (which is actually positive from a circularity point of view). In that case, the investments in an object or a sub-object will have been retained or even increased at the end of its life cycle. Of course, this is not the actual case yet.

¹⁰⁴ The numbers are arbitrary; the example is only meant to illustrate the method of determination.
Annex D

Schmidt scale

Paragraph 6.4.1 introduces the Schmidt scale. This scale differentiates six types of adaptive measures. The Schmidt scale is used in the tables with aspects of adaptive capacity. This annex gives a further explanation of the Schmidt scale (see figure 27).

Figure 27 – The Schmidt scale

Making a building adjustable means that its function can be changed by making adjustments to movable furniture, without making any adjustments to the building. Versatility concerns the possibility to divide spaces in a building differently, e.g. by means of movable walls or panels. A refitable building has elements (e.g. a wall or floor) that can be replaced, moved or removed. A building is convertible if its function can change due to internal or external adaptations to the building. If a building is scalable, its size can be adapted, mostly by expanding the building. Finally, a building is movable if it can be moved to another physical location.

Figure 28 provides a brief additional explanation of the various adaptive measures.

Figure 28 - Schmidt’s scale in relation to Brand’s building layers

For more information about the Schmidt scale, please refer to Manewa et al., 2013. The figure comes from Schmidt III et al, 2010.
Annex E

User stories for conceptual framework

Paragraph 8.2 indicated that fundamental decisions about the scope (see chapter 2) and the conceptual framework (see chapter 3) of the core measurement method were made on the basis of six user stories. These user stories are presented in this annex.

Table 14 – User story for the Dutch Ministry of Infrastructure and Water Management

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Rijkswaterstaat (RWS) (Dutch Ministry of Infrastructure and Water Management)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of the organisation</td>
<td>Client for major civil engineering projects</td>
</tr>
<tr>
<td>Project</td>
<td>New construction, management, maintenance, expansion and disassembly of highways, bridges, tunnels, locks, dykes and flood defences, i.e. projects which are assumed to have a relatively long service life.</td>
</tr>
<tr>
<td>Why circular construction?</td>
<td>It is our ambition to work fully circularly by 2030. According to the 2017 Dutch government-wide programme for a circular economy, this would involve reducing the use of primary raw materials by at least 50%. Circular construction will have consequences for a large number of work processes within Rijkswaterstaat and for the cooperation with partners from the construction cycle. We are working on a CE Impulse Programme that should show how these two ambitions can be achieved. Platform CB’23 not only plays an important role in implementing pilot projects with circular solutions together with market parties, but also in the development of new forms of collaboration with our partners in the construction sector. We see circular construction as part of a broader objective aimed at multiple sustainability goals. For instance, we are looking for an integrated approach to meeting climate and circular targets.</td>
</tr>
<tr>
<td>When or why would you use the measurement method?</td>
<td>Preferably throughout the circular building process, i.e. from the initial preliminary studies for a project (on the basis of which we determine the criteria for the design and construction) to providing support for the choices that have to be made in order to establish the eventual plan. We would also like to monitor performance with regard to the circularity of our entire area.</td>
</tr>
<tr>
<td>What would you like to know?</td>
<td>We would like to have more information about the properties of materials that are used: i.e. are they primary or secondary, upcycled or not, renewable or not, scarce or not. We would also like to know whether the materials used are really necessary. For example, do we really need guardrails? Doing the same with less may also make a structure easy, or easier, to adapt to the required capacity, or even to be moved and reused in its entirety if it is no longer suitable in a given location, but does not need to be written off completely yet. We would also like to know more about which waste flows to expect. To which degree can they be upcycled and which processing costs can we expect? Of course, we will always consider all these questions in relation to their environmental impact. In the end, this should lead to better results for all life cycles in order to justify all circular modifications.</td>
</tr>
</tbody>
</table>
### Table 15 – User story for Heijmans

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Heijmans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of the organisation</td>
<td>Contractor in construction and infrastructure, directs the work of many smaller subcontractors/partners and suppliers</td>
</tr>
<tr>
<td>Project</td>
<td>Responding to an invitation to tender for, or to carry out, an infrastructure project and/or construct a building. We are active in new build, renovation, management and maintenance and disassembly projects.</td>
</tr>
<tr>
<td>Why circular construction?</td>
<td>We consider circular construction to be a means of using fewer primary materials and reducing the environmental impact (e.g. CO₂ emissions).</td>
</tr>
<tr>
<td>When or why would you use the measurement method?</td>
<td>Construction companies want to be able to really deliver on circularity principles and thus be able to clearly set ourselves apart from others. We also want to be able to compare different design versions before making an offer. Furthermore, it is important that suppliers can clearly indicate how circular their products are.</td>
</tr>
<tr>
<td>What would you like to know?</td>
<td>In particular, the amount of the input flows of primary and secondary materials, the proportion of upcycled or downcycled materials in the input flows, and the expected degree of upcycling or downcycling of recycling flows. We would also like to be able to decide which is the better option: designs with a short service life and relatively low environmental impact or designs with a longer service life and a relatively high environmental impact.</td>
</tr>
</tbody>
</table>
### Table 16 – User story for the Dutch Central Government Real Estate Agency (Rijksvastgoedbedrijf - RVB)

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Dutch Central Government Real Estate Agency (Rijksvastgoedbedrijf - RVB)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Role of the organisation</strong></td>
<td>Manager of government buildings and land</td>
</tr>
<tr>
<td><strong>Project</strong></td>
<td>Commissioning construction, maintenance, renovation, expansion or disassembly of large offices (e.g. for ministries), prisons, courts, museums and palaces.</td>
</tr>
<tr>
<td><strong>Why circular construction?</strong></td>
<td>We consider circular construction to be an element of construction with a lower environmental impact. Within this context, circular construction specifically focuses on reducing the pressure on primary materials and preserving value, in short, improving upcycling of future product and recycling flows.</td>
</tr>
<tr>
<td><strong>When or why would you use the measurement method?</strong></td>
<td>We want to use the measurement method as part of our project and product procurement, both as a strict lower limit (requirement) and as an ambition to be pursued (award criterion). The measurement method enables us to demonstrate the circular level of our stock-wide annual activities, including the improvement steps we are taking. It is important that the method can be applied to many different types of real estate interventions (new construction, renovation, maintenance, procuring separate products and the disposal phase). In the disposal phase, the score (per product, Brand’s layer or building) gives information about values that can be reaped.</td>
</tr>
</tbody>
</table>
| **What would you like to know?** | A single circularity score that expresses a product's environmental impact and compares it with the assumed service life and the degree of reusability (e.g. through detachability) of the raw materials used. 
In this context, we assume that matters such as adaptive construction, using materials/products from other buildings, toxicity and assumed service life versus the regenerability of the earth are taken into account. 
We would prefer to combine circular performance with environmental performance into a single score, one that can be applied at different levels, from the product level to the building level. The score ought to lead to one and the same outcome regardless of the tool used and/or the implementing party. 
Although social fairness is an important aspect of, and a precondition for, sustainable procurement, we feel that this should not be made part of the guide. We think that this would overcomplicate things. |

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107 Additional comment from RVB: It is important that the scores keep up with the state of the art, specifically with the latest developments as regards recycling. The environmental database may need to be linked to a database of upcycling potentials for individual raw material flows. When combined with a passport, this provides a circularity score that is always up to date. And that is not only interesting for procurement, but also at the end of the service life.
<table>
<thead>
<tr>
<th>Organisation</th>
<th>Branchevereniging Nederlandse Architectenbureaus (BNA) (Royal Institute of Dutch Architects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of the organisation</td>
<td>Professional association for architects</td>
</tr>
<tr>
<td>Project</td>
<td>Designing a structure or area to be newly built, renovated or extended.</td>
</tr>
<tr>
<td>Why circular construction?</td>
<td>As architects, we want to create as much value as possible by means of a structure. This means that, in the context of circularity, we have high ambitions regarding future-proof construction so that a structure will not have to be demolished, but continues to be interesting for another user or function.</td>
</tr>
<tr>
<td>When or why would you use the measurement method?</td>
<td>We like being able to make well-founded decisions about the best design options in conjunction with our clients, while weighing up all the different sustainable aspects that sometimes contradict each other. Being able to properly substantiate those decisions is important.</td>
</tr>
<tr>
<td>What would you like to know?</td>
<td>When developing a structure or an area, it is interesting to have information about how adaptive a structure is, since more value can be created in that case. On the other hand, the environmental burden and the input of primary raw materials must be as low as possible. We would like to have more information about the reuse value of a structure or products as a whole, and the expected degree of upcycling or downcycling of released materials.</td>
</tr>
<tr>
<td>Organisation</td>
<td>Waternet (Water company for Amsterdam and surrounding area)</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>Role of the organisation</td>
<td>Manager of water management facilities in the Amsterdam region</td>
</tr>
<tr>
<td>Project</td>
<td>Commissioning mainly relatively small maintenance and renovation projects, principally for infrastructure.</td>
</tr>
<tr>
<td>Why circular construction?</td>
<td>Waternet attaches great value to sustainability, and circular construction is an inherent element in this. We are particularly interested in the CO₂ savings and material savings that circular construction can bring in the long term.</td>
</tr>
<tr>
<td>When or why would you use the measurement method?</td>
<td>Prior to putting out a project to tender, we make certain decisions based on the results of the measurement method: we deliberately choose certain criteria or requirements. We try to prepare our invitation to tender in such a way that circular construction becomes more accessible for SMEs. We use the measurement method to compare offers during the subsequent procurement process. And we want to be able to answer the question of how far we have progressed, as regards Waternet as a whole.</td>
</tr>
<tr>
<td>What would you like to know?</td>
<td>We are extremely interested in the CO₂ emissions of a specific proposal, and also in the effects of a structure on its surroundings. Making some modifications to one structure may prevent others having to be built or renovated. We would also like some assistance to help us decide whether it would be better to keep using an existing structure for an extra-long time, or to disassemble it in the near future and then reuse its parts as much as possible. In addition, we would like to combine circular construction with the social goals our organisation has.</td>
</tr>
</tbody>
</table>
Table 19 – User story for the Amsterdam Metropolitan Region (MRA)

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Amsterdam Metropolitan Region (MRA)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Role of the organisation</strong></td>
<td>Promoting collaboration between municipalities in the Amsterdam Metropolitan Region</td>
</tr>
<tr>
<td><strong>Project</strong></td>
<td>Making agreements as to whether and how municipalities can initiate circular construction.</td>
</tr>
<tr>
<td><strong>Why circular construction?</strong></td>
<td>In the context of circularity, the municipalities in our region are particularly interested in reducing the pressure on primary materials and preserving value.</td>
</tr>
<tr>
<td><strong>When or why would you use the measurement method?</strong></td>
<td>The questions that are currently of interest to our municipalities are: What is the basis for the criteria for circularity we use in an invitation to tender and which criteria should we use? How can we make sure that the proof of compliance with these criteria is of comparable value? And how do we know how well we are doing as a municipality that promotes circular construction?</td>
</tr>
<tr>
<td><strong>What would you like to know?</strong></td>
<td>We have not reached agreement on this in the MRA but it is obvious that municipalities are interested in the following: input of primary/secondary materials, input of renewable materials, input of upcycled materials, efficiency of the use of materials, environmental impact of the use of materials, possibilities for upcycling of entire products or buildings and of material flows, and the expected waste quantities.</td>
</tr>
</tbody>
</table>
Annex F

User stories about scarcity

As indicated in paragraph 8.3.1, user stories have been used in order to ascertain which dimensions of scarcity should be included in the core measurement method according to different stakeholders. This annex briefly presents the results of the discussions with stakeholders.

Dutch Ministry for Infrastructure and Water Management (Rijkswaterstaat)

For RWS, scarcity has a lot to do with future security of supply. The security of supply of some raw materials may decrease although we do not immediately expect that to happen. An example of this is bitumen, which may become relatively scarcer in the future as a result of better refining processes and reduced availability of crude oil. A rise in sea level may also lead to relative scarcity of fill sand in the future.

In addition to the existing ADP (as part of an LCA) and the geological stocks, it is desirable for such factors to also be included when determining the future security of supply of raw materials for construction. The economic aspects will then probably be less important.

Heijmans

It is important that we include a measure of scarcity in the core measurement method. This measure should preferably be related to the security of supply of the raw materials. A measure of the depletion of raw materials is very important in this respect, but there should be no double counting with the ADP already used in the LCA method.

Dutch Central Government Real Estate Agency (Rijksvastgoedbedrijf)

The guide identifies protecting stocks of materials as one of its goals (see paragraph 3.1.1). According to the Dutch Central Government Real Estate Agency (RVB), this protection mainly focusses on the reusability of the raw materials used. This is already part of the degree of reuse and recycling in the core measurement method. This is less of an issue for materials that are renewable.

Scarcity can fluctuate. If you use scarcity as a factor to help determine the building score, this score will fluctuate too. What is scarce today may no longer be scarce tomorrow because alternatives have been found or demand has declined. So this is self-regulating. It would be preferable not to treat scarce materials differently from other materials.

However, it is important to establish which materials have been used in a building and the extent to which these materials can be reused. A materials passport does this.

Scarcity is therefore determined by the difference between supply and demand, which is an economic principle and does not have any bearing on the environmental issue. Making circularity measurable is about:

- The environmental impact of the materials used in relation to the quality and useful life of the structure.

---

108 The conceptual framework was also discussed with many of these stakeholders at an earlier stage (see annex E).
• The reusability (which environmental value that has been used will be destroyed / can be reused).

• The degree to which the earth can or cannot recover (what is the useful life / service life for which something has been extracted and how does this relate to its regenerability?).

This applies to all materials and is not tied to scarcity.

**Royal Institute of Dutch Architects (BNA)**

For BNA, scarcity mainly plays a role as a factor in the design for reassembly. Raw materials should remain available when the useful life of structures has ended. This will enable fewer construction materials to be added to the existing stock and it will decrease dependency on new raw materials. In this respect, BNA finds it important to retain the value of the raw materials or the construction materials produced from them. BNA envisages a quantitative measure of the scarce materials used. It is important that scarce materials whose use is socially or environmentally unjustifiable should not be used, regardless of whether these materials subsequently remain part of the cycle. This is an overall assessment that must always be made.

**TNO**

TNO has been involved in many studies on scarcity and security of supply in recent years. An indicator of scarcity can be derived on the basis of current studies, but the issue is actually what is understood by scarcity. Most parties involved will be mainly interested in the security of supply of raw materials, and so scarcity is not exactly the right term. Scarcity is related to the available stocks of a raw material rather than its criticality or security of supply. Security of supply is also determined by geopolitical division and concentrations of power, which goes beyond the depletion of raw materials.

The ADP indicator in the LCA is not a good parameter for security of supply since the concept of ‘reserves’, which is a constituent of ADP, is hard to describe. This makes the result of this ADP a less reliable indicator of scarcity.
Annex G

Relationship between indicators of the core measurement method and the parameters of the MCI calculation

As indicated in paragraph 9.2, the data for the core measurement method can also be used to calculate an MCI score. This annex describes how.

The calculation of the MCI score is based on the different material flows during the life cycle of an object or sub-object. These material flows are shown in figure 29.

![Figure 29 - The life cycle as considered in the MCI method](image)

Every material flow is given a parameter in the MCI method. All these parameters are needed to calculate the MCI score. These parameters are shown in figure 30.

![Figure 30 - Parameters for calculating the MCI score](image)
In these parameters, M is the mass of the object or sub-object. \( W_c \) and \( W_f \) are waste flows. They are determined on the basis of the recycling processes that produce the secondary feedstock \( (F_r) \) and/or process the output flow \( (C_r M) \) to be recycled.

These parameters are then entered into the formulas below.

\[
MCI_p = 1 - LF1 \cdot F(X).
\]

\[
LF1 = \frac{V + W}{2M + \frac{W_f - W_c}{2}}
\]

\[
F(X) = \frac{0.9}{X}
\]

In this formula, X reveals something about the service life. If the service life of an object or sub-object exceeds the industry average, X will be higher. X is 1 if the service life equals the industry average and, for example, it is 2 if the service life is twice that long.

The data from the core measurement method can be used to calculate an MCI score. \( X = 1 \) then has to be used, because the core measurement method does not (yet) have an indicator for service life extension. Table 20 shows which indicators from the core measurement method are equal to parameters in the MCI method.

**Table 20 - Relationship between indicators of the core measurement method and the parameters of the MCI method**

<table>
<thead>
<tr>
<th>Description</th>
<th>Core measurement method indicator</th>
<th>Parameter in MCI model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin input flow(^{109})</td>
<td>1.1 The quantity of primary materials used</td>
<td>V</td>
</tr>
<tr>
<td>Secondary input flow from reuse</td>
<td>1.2.1 The quantity of secondary materials from reuse</td>
<td>( F_{r, M} )</td>
</tr>
<tr>
<td>Secondary input flow from recycling</td>
<td>1.2.2 The quantity of secondary materials from recycling</td>
<td>( F_r M )</td>
</tr>
<tr>
<td>Output for recycling</td>
<td>2.2 The quantity of end-of-life materials available for recycling</td>
<td>( C_r M )</td>
</tr>
<tr>
<td>Output for reuse</td>
<td>2.1 The quantity of end-of-life materials available for reuse</td>
<td>( C_{r, M} )</td>
</tr>
<tr>
<td>Waste from primary process</td>
<td>Sum of 3.1 (energy recovery) + 3.2 (landfill)</td>
<td>( W_0 )</td>
</tr>
<tr>
<td>Waste from recycling</td>
<td>Not available as a separate indicator</td>
<td>( W_f ) and ( W_c )</td>
</tr>
</tbody>
</table>

\(^{109}\) Madaster (online library of materials) uses a variant of the MCI method which considers renewable raw materials to be secondary raw materials, even if they are primary.
Annex H

Members of the 2018-2019 action team

The following organisations were members of the 2018 - 2019 action team:

- NIBE (Dutch Institute for Building Biology ad Ecology) (chair)
- Advieslab Jeeninga
- Alba Concepts
- BAM
- Betonhuis
- Branchevereniging Nederlandse Architectenbureaus (BNA) (Royal Institute of Dutch Architects)
- Boskalis
- Stichting Bouwkwaliteit (SBK)
- CE Delft
- Centrum Hout
- Dutch Green Building Council
- Ecochain
- Ecotex
- Heijmans
- KWS
- Mineralz B.V.
- Movares
- Metropoolregio Amsterdam (MRA) (Amsterdam Metropolitan Region)
- NVTB (Netherlands Association for Construction Supply)
- Optimal Planet
- Planbureau voor de Leefomgeving (PBL) (Netherlands Environmental Assessment Agency)
- Pré Sustainability
- Primum
- Rijkswaterstaat (Dutch Ministry for Infrastructure and Water Management)
- Rijnboutt
- RIVM (Dutch National Institute for Public Health and the Environment)
- Rockwool B.V.
- Roelofs groep
- SGS INTRON
- SGS search B.V.
- TNO
- University of Amsterdam
- Vlakglas recycling Nederland
- Vereniging van waterbouwers
- W/E adviseurs
- We boost
- Witteveen + Bos
Annex I

Members of the 2019-2020 action team

The following organisations were members of the 2019 - 2020 action team:

- NIBE (Dutch Institute for Building Biology ad Ecology) (chair)
- ABT B.V.
- Antea Group
- Arcadis
- Arup
- AT Lawyers
- Ballast Nedam
- BAM
- Betonhuis
- BNA (Royal Institute of Dutch Architects)
- Boskalis Nederland B.V.
- Cascade vereniging van zand- en grindproducenten (Association of sand and gravel producers)
- C-creators
- Centrum Hout
- DCBAadvies
- DE MAR BLOCK2BUILD B.V.
- Eco Intelligence
- EY
- FSC Nederland
- Municipality of The Hague
- Municipality of Utrecht
- Municipality of Rotterdam
- Heijmans
- Houtwerf
- HTC parking & security B.V.
- KNB
- LBP|SIGHT
- Lieverse Construction/Infrastructure/the Environment
- LKSVDD architecten
- Merosch
- Movares
- Nijhuis Toelevering B.V.
- NVTB (Netherlands Association for Construction Supply)
- Ooms architecten
- Optimal Planet
- Planbureau voor de leefomgeving (PBL) (Netherlands Environmental Assessment Agency)
- Peutz
- Pioneering
- PRé Sustainability
- Primum
- The province of North Holland
- RAU & Madaster
- Rendemint B.V.
• Rijksvastgoedbedrijf (Dutch Central Government Real Estate Agency)
• Rijkswaterstaat (Dutch Ministry for Infrastructure and Water Management)
• Rijnboutt
• RIVM (Dutch National Institute for Public Health and the Environment)
• ROCKWOOL B.V.
• Roelofs
• Royal Haskoning DHV
• Saint-Gobain Construction Products B.V.
• Sant Verde B.V.
• SBK
• SGS Intron B.V.
• SGS Search B.V.
• Smart Building Design
• Stichting Stimular
• Stroomversnelling
• Strukton Worksphere
• Sweco Nederland
• Ter Steege Advies & Innovatie
• TNO
• Transitiebureau circulaire bouweconomie (Circular Construction Economy Transition Agency)
• TU Delft - Faculty of Architecture and the Built Environment
• Unica
• Unilin panels
• University of Twente
• University of Amsterdam
• VELUX Nederland
• Vereniging Nederlands Kalkzandsteenplatform
• VMRG
• W/E adviseurs
• Waterschap Rivierenland (Regional Water Authority)
• Wienerberger B.V.
• Woonstad Rotterdam
• Xidoor