FutureBuilt Circular - criteria for circular buildings

Authors: Anne Sigrid Nordby (Gjenbrukbar), Stein Stoknes, Reidun Aasen Vadseth, Erlend Seilskjær, Nora Holand Hay (FutureBuilt)

Date: 20.04.2023

Versjon: 3.0

Availability: Open

Translated by: James Kallaos (SINTEF Community)

Contents

1. Introduction

FutureBuilt quality criteria encompass several topics that are central to the development of the sustainable city. The criteria are compiled in the overarching document "FutureBuilt kvalitetskriterier" and elaborated in separate thematic criteria documents. All documents can be downloaded from www.futurebuilt.no

Some of the thematic criteria are mandatory for all FutureBuilt projects while some are optional. *FutureBuilt Circular – criteria for circular buildings* is an optional criterion.

The development of the criteria is based on discussions between FutureBuilt, Gjenbrukbar, Asplan Viak, Resirqel, Reduzer/NTNU, SINTEF/FME-ZEN, Green Building Alliance, Multiconsult, Höegh Eiendom, Context, Vill Energi, Insenti, Prodecon, Madaster and Birk&co.

1.1. Purpose

In line with the Paris Agreement, Norway will reduce its greenhouse gas emissions by 50% by 2030 and 95% by 2050. FutureBuilt encourages a corresponding increase in the degree of circularity, so that by 2050 we will in practice have a near fully circular construction industry.

The purpose of *FutureBuilt Circular – criteria for circular buildings* is to motivate circular principles in rehabilitation, demolition, and new construction, and set a standard for what should be the ambition level for a circular building. The aim of the criteria is therefore to establish a measurable, predictable, and dynamic set of criteria that points the way towards a fully circular society in 2050. *FutureBuilt Circular* should be significantly better than the industry standard – and in practice 10 years ahead.

FutureBuilt Circular aims to help close material flows in the construction industry. It contributes to solving several environmental challenges, including greenhouse gas emissions, emissions of hazardous substances (environment and health), waste production, land consumption, destruction of biodiversity, etc. Circularity is therefore seen in this context as a goal in itself.

FutureBuilt Circular is part of a series of FutureBuilt criteria addressing different topics. Criteria for circular buildings are limited to the material flows of buildings. Adjacent topics such as operational building energy consumption and greenhouse gas emissions from buildings are addressed, for example, in FutureBuilt criteria for near-zero energy (nZEB) and energy-positive buildings (*plusshus*) and FutureBuilt ZERO.

2. Main criterion

A circular FutureBuilt model project should facilitate resource utilisation at the highest possible level, and aim for a minimum of 50% circularity.

The long-term goal is a fully circular construction industry. The industry standard is currently[11] set at 0% circularity in 2020, with the goal of full circularity in 2050. The orange curve in Figure 2-1 shows how the degree of building circularity must increase towards 2050 to meet this goal.

The goal for *FutureBuilt Circular* is to extend from 50% circularity from 2020, with a gradually increasing expectation of circularity in the future. The expectation increases in line with the project year of completion, as shown in Figure 2-1 and the table in Figure 2-2. However, there is great uncertainty associated with the rate of development of circular solutions, and the potential for circularity also depends on the type of project (rehabilitation, new construction, transformation, etc.). For the time being, circular FutureBuilt projects should therefore as a minimum be better than the industry standard (within the light green field in Figure 2-1) and extend towards FutureBuilt Circular quality (within the dark green field in the Figure 2-1).

The degree of circularity is based on the FutureBuilt circularity index described in section 2.1.

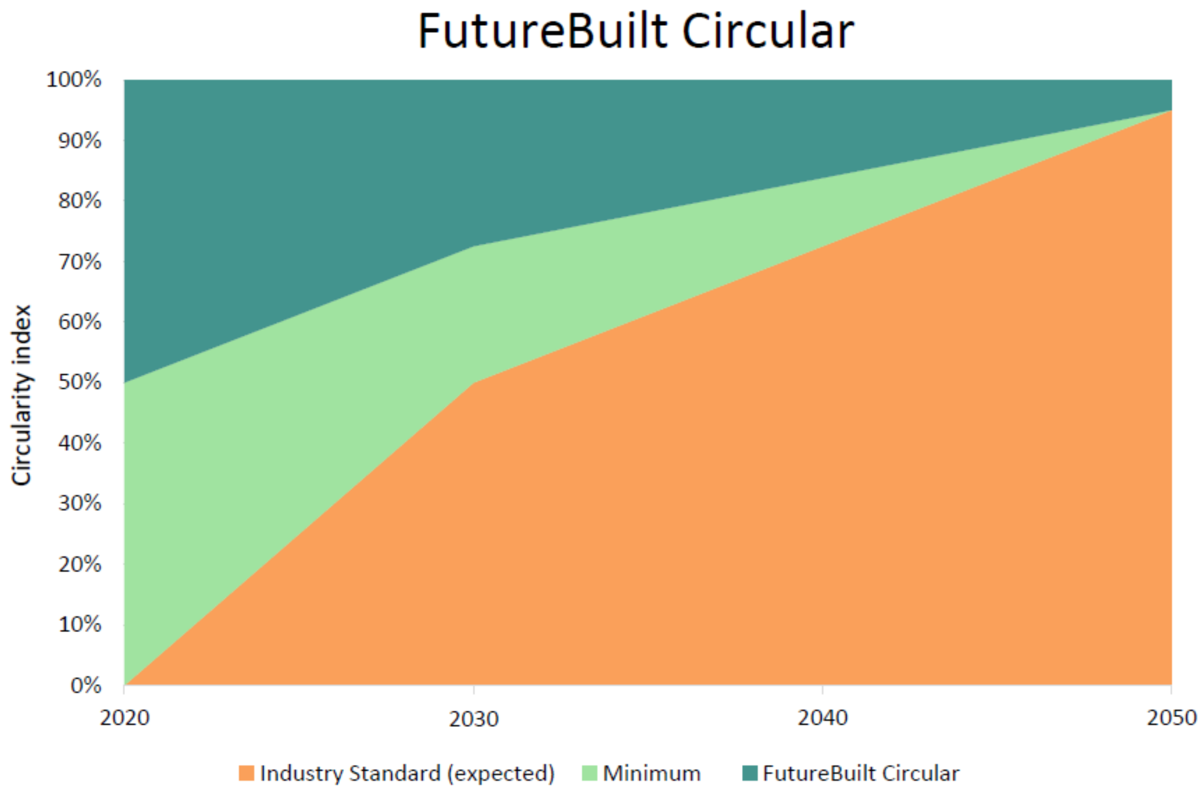

Figure 2-1: Target curve for *FutureBuilt Circular – criteria for circular buildings. The figure shows how current practice (orange) must be adjusted to achieve full circularity (95%) in 2050. FutureBuilt Circular will be 10 years ahead (dark green field) with the understanding* that the *uncertainty surrounding circular material flows* may *mean that the projects may lie somewhat below (light green field).*

[1] The current industry standard is being studied in more detail in a separate project under the auspices of [FME-ZEN.](FME-ZEN.)

The table below shows the main criterion from 2020 – 2050 for *FutureBuilt circular* and the minimum requirement in relation to the expected industry standard.

	Degree of circularity, as a percentage		
Year	**Industry standard (<)**	**Minimum requirements (<>)**	**FutureBuilt Circular (>)**
2020	0	0 - 50	50
2021	5	5 - 52	52
2022	10	10 - 55	55
2023	15	15 - 57	57
2024	20	20 - 59	59
2025	25	25 - 61	61
2026	30	30 - 64	64
2027	35	35 - 66	66
2028	40	40 - 68	68
2029	45	45 - 70	70
2030	50	50 - 73	73
2031	52	52 - 74	74
2032	55	55 - 75	75
2033	57	57 - 76	76
2034	59	59 - 77	77
2035	61	61 - 78	78
2036	64	64 - 79	79
2037	66	66 - 80	80
2038	68	68 - 81	81
2039	70	70 - 82	82
2040	73	73 - 84	84
2041	75	75 - 85	85
2042	77	77 - 87	87
2043	79	79 - 88	88
2044	82	82 - 90	90
2045	84	84 - 92	92
2046	86	86 - 93	93
2047	88	88 - 95	95
2048	91	91 - 97	97
2049	93	93 - 98	98
2050	95	95 - 100	100

Figure 2-2 Degree of circularity, given as a percentage, based on year of completion.

2.1. FutureBuilt Circularity Index

In order to quantify the requirements for circular buildings, FutureBuilt has developed a circularity index. The index applies to all types of construction projects, both new construction and rehabilitation/transformation projects.

The Circularity Index should be calculated using the *FutureBuilt Circularity Index calculation tool*. The calculation of the index shall, as a general rule, include building parts 2, 3, and 4 pursuant to the Building Act. NS 3451 Building sub-table[2], incl. fill materials adjacent to the building body. The main principles of the FutureBuilt Circularity Index are shown in the calculation example in Figure 2-3 below.

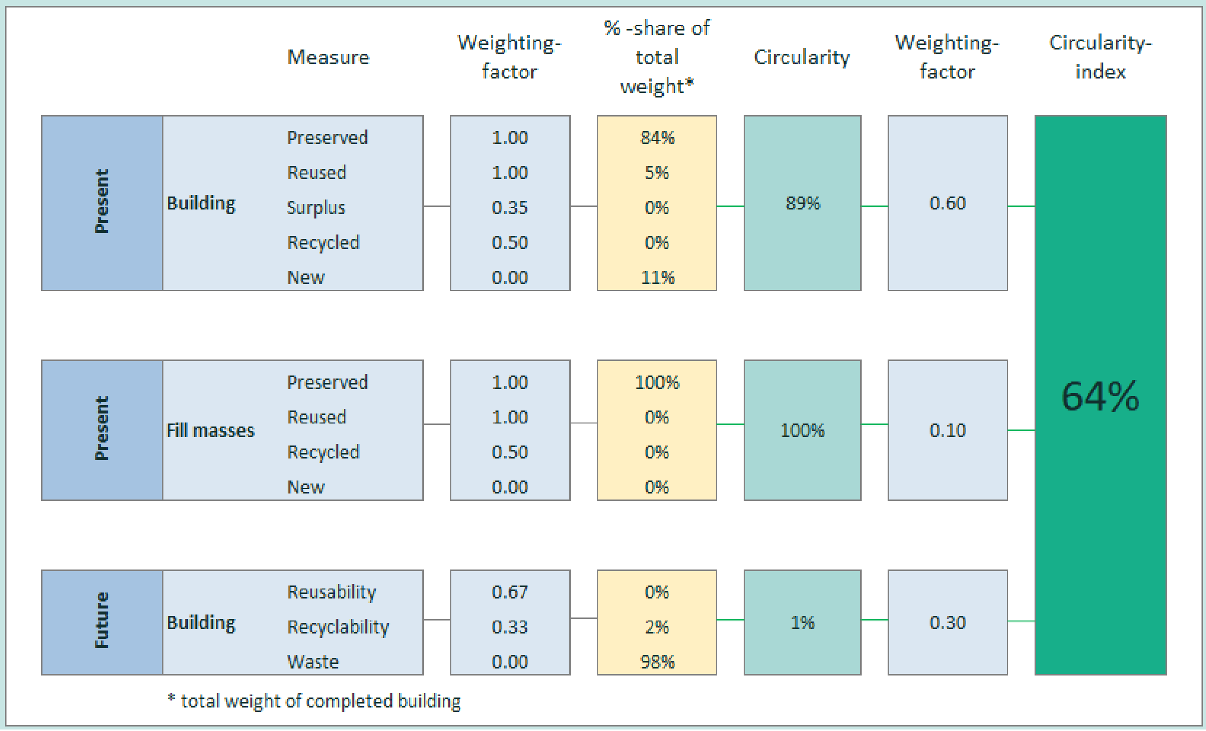

Figure 2-3 Example FutureBuilt Circularity Index.

2.2. Definition of intervention categories

The index calculator is based on the following categories of circularity measures in the present and future:

2.2.1. Conservation

Consists of what is preserved on site of existing buildings, including load-bearing structures, foundations, and fill materials. The amount of fill in connection with the building body that can be included includes fill masses 40 cm below the building and 150 cm from the basement wall/ ring foundation.

[2] https://www.standard.no/fagomrader/bygg-anlegg-og-eiendom/ns-3420-/ns-3450----ns-3451---ns-3459-2/

2.2.2. Reuse

Consists of components and fill materials from own buildings (during rehabilitation/transformation) or from external buildings, procured directly or via a third-party supplier.

2.2.3. Surplus

Consists of new materials that are surplus from the construction site(s) and residual stocks at developers, contractors, manufacturers or retail outlets.

2.2.4. Recycling

Consists of components with recycled material content and fill materials that have been processed/treated for reuse. The proportion of recycled material content is generally based on manufacturer documentation.

2.2.5. New

Consists of all new components and fill materials that do not belong to the above intervention categories. Also includes excavated (and/or blast spoil) material from the plot that is used as fill material.

2.2.6. Reusability

Consists of building elements and structures that are prepared for dismantling and future reuse. For a component to be considered reusable, the following principles apply:

Material selection:

- Durable materials and components that can be reused in several building generations.
- Module design, standard dimensions, and low complexity of components and building components.
- Building parts that consist of mono-materials, or that can be disassembled into components of mono-materials (avoid composites).

Demountable/dismantlable:

- Reversible connections between components and between building components.
- The number of different connection methods is minimized, and connections are planned for disassembly with ordinary tools.
- Components and building elements with customized tolerances for repeated disassembly and reassembly.
- The construction layers are designed as independent systems, and the layers are arranged according to the expected lifetime of the components.
- Other principles that enable future reuse.

Information:

- Materials and component types are labeled.
- Fastening points are labeled, visible, and accessible.
- There is a material passport (information about products and materials, including EPDs, maintenance advice, and information about building systems with dismantling instructions), as well as a declaration of performance and other documentation necessary to show compliance with TEK and, if applicable, the Construction Products Directive (DOK), as part of the FDV documentation. To be archived centrally and updated during rebuilds.

Circular business models (optional):

- Use of leasing agreements with the manufacturer/supplier instead of purchasing.
- Return schemes have been established with the manufacturer/supplier.

2.2.7. Recyclability

Includes building elements or structures that can be recycled in the future, and as a minimum satisfy the following requirements:

Material selection:

- The building element is adapted for dismantling/demolition to pure material fractions.
- Construction elements consist of homogeneous materials (mono-materials) where all components consist of the same material.
- The building element contains no more than 0.1% by weight of substances hazardous to health and the environment on the Priority List[3] or REACH Candidate List.[4]

Information:

- Materials and component types are labeled.
- Material passports (information about products and materials, including EPD) are included as part of the FDV documentation that is archived centrally and updated during conversions.

Circular business models:

- There is a takeback mechanism and solutions for material recycling of the material fractions that the building element consists of at the time of construction of the building.

2.2.8. Waste

Includes construction waste, such as all remaining materials and building components that are not adapted for reusability or recyclability (material recycling). Fill materials are not included.

2.3. Weighting

The various circularity measures are weighted in the index according to the following main principles:

- The present takes priority over the future. This is because it is urgent to reduce greenhouse gas emissions and other negative environmental impacts, and because there is greater uncertainty associated with the effect of facilitating future measures.
- The waste pyramid[5] forms the basis for the priorities, so that the preservation and reuse of buildings and components, as well as reusability, are given higher priority than material recycling and recyclability.
- Measures targeting buildings are weighted over measures targeting fill materials. Reuse of fill materials is considered a more "low-hanging fruit".
- Weighting factors are shown in Figure 2– 3.
- All measures are calculated by percent (%) of the total weight of the completed building.

[3] Priority list: Prioritetslista - Miljødirektoratet.no

[4] REACH candidate list: REACH kandidatliste - Registration, Evaluation, Authorisation and restriction of Chemicals. EU-forordning (EF) nr. 1907/2006

[5] waste pyramid: avfallshierarki – Store norske leksikon (snl.no)

3. Additional criteria

3.1. Competence

The project must be staffed by a reuse coordinator or other dedicated professional responsible for following up and documenting the criteria throughout all project phases, in accordance with the requirements set out in this criteria set.

3.2. Environment-based decision on conservation, demolition, or rehabilitation

Where there are existing buildings on the site, the following assessments shall be carried out:

- A thorough assessment to determine what is the best environmental option in terms of conservation, degree of transformation, rehabilitation, or demolition.
- The assessment is carried out by a multidisciplinary team of advisors and executives, to expose all advantages and disadvantages of the alternatives.
- Parts of the assessment can be carried out using life cycle analysis (LCA)/ greenhouse gas calculations, following *FutureBuilt ZERO – criteria for low-emission buildings and areas*[6] and/or other relevant assessments/analyses related to resource consumption, waste, pollution, biodiversity, etc.

3.3. Resource utilisation in the demolition phase

If it is decided to demolish all or part of existing buildings, efforts shall be made to preserve existing material resources at the highest possible level in accordance with the waste pyramid.

The following requirements must be met:

- Reusable and recyclable components are mapped with consideration of the potential for reuse and material recycling early in the project, so that the material values are visible to the designers.
- Reusable and recyclable components that are not used in the project are made available to external stakeholders or returned to the manufacturer.
- Sufficient time is set aside for selective demolition/ gentle dismantling. Requirements for the demolition method are incorporated into tender documents and contracts. Dismantling and securing components for reuse and material recycling are specified in the demolition description. There are requirements for understanding the assignment and references when awarding a contract.
- As a general rule, components containing substances hazardous to health and the environment are not reused/ recycled, but are removed from the cycle. This is safeguarded through environmental remediation and handling of environmentally hazardous waste (regulatory requirements).

[6] *FutureBuilt ZERO – kriterier for lavutslippsbygg og områder*

3.4. Resource utilisation during the construction phase

- Waste during the construction phase is reduced to a minimum, and as much of the material resources as possible are preserved at the highest possible level according to the waste pyramid.
- Cutoffs, scrap, packaging, incorrect orders, and surplus goods are limited as much as possible. Where this nevertheless occurs, measures are implemented to exploit these resources.
- Incorrectly ordered and surplus goods are not thrown away. These are either returned to the manufacturer or made available to internal and external stakeholders.

3.5. Adaptability

Design for adaptability (or adaptability) involves planning buildings in such a way that the building can change its function and use without major material intervention. In this way, the building will have a long lifetime.

Table 3-1 is an adapted version of the requirements in BREEAM NOR v6.0 Mat07, and shows examples of measures that enable future changes. This will be used in the planning of adaptability.

Table 3-1 Examples of measures for adaptability (revised version of BREEAM Mat 07).

Examples of measures	**Generality** How to facilitate functional changes / co-use without making physical changes	**Flexibility** How to simplify physical changes	**Elasticity** How to facilitate growing or subdividing
Plan and section	General room solutions with regard to access, so that rooms can be used independently of each other All stays/work rooms have even and plenty of daylight	Provide the opportunity to divide larger rooms into smaller areas using folding walls / sliding doors. Demountable lightweight walls of the same type throughout the building	Areas are proportioned and coordinated so that they can be merged or subdivided. Floor heights allow for change of function and ventilation concept
Communication areas and cores: • **Corridors/distribution area** • **Toilets / kitchen cores** • **Stairs and elevators**	The building is planned so that the areas can preferably be fixed in the event of functional changes		The corridor and staircase widths are dimensioned so that they can allow for future functional changes with new requirements for escape routes
Suspension system: • **Foundation** • **Columns / load-bearing walls** • **Girders and covers** • **Roof elements**	Use of regular/modular load-bearing systems, including layouts for columns/girders and any load-bearing walls.	Few or no load-bearing walls Foundation as elements rather than cast in place	If future extensions are relevant, the load-bearing capacity of the foundation and structural system can be dimensioned in terms of this, if applicable. facilitated for future adjustments to the load-bearing capacity.

Climatic shell: •**Exterior walls** •**Floor to ground** •**Roof**		Load-bearing structure within external wall The material layers can be changed independently of each other	Use of modular and reusable building/ product systems
Light walls and fixed décor: •**Floor** •**Interior walls / doors** •**Ceilings**	Use of modular grid. Use of standardized material sizes	Use of products or systems where individual parts are easy to adjust/move. Use of unprocessed/finished materials Floors are laid and surface treated before interior walls are put up.	Use of modular and reusable building/ product systems
Technical installations: •**Heating system** •**Ventilation system** •**Sanitary** •**Electro** •**Fire**	A dense diffuser network allows for point extraction without major changes or structural interventions.	Use of products or systems where individual parts are easy to adjust/move/replace.	Over-dimensioning of technical rooms, shafts, installations and guide routes may allow future increases in capacities

3.6. Breadth of circular measures

To ensure that circular measures are implemented for a wide range of building components, measures shall be implemented for reuse, reusability, recycling and recyclability for a minimum of 10 different building parts in total, which are used in a significant scope, according to the building parts table, 2-digit level.

Solutions for reusability and recyclability are developed in line with the definitions for these as described in section 2.2.

4. Documentation requirements

It must be documented that the criteria in *FutureBuilt Circular – criteria for circular buildings* are met. The documentation requirements are shown in the table in Figure 4-1. The documentation is delivered at the following milestones:

1. at the time of framework application/completion of the preliminary project (as projected)
2. upon completion (as built)

FutureBuilt Circular – report template should be used for documentation, including attachments. If the project is certified according to BREEAM-NOR v6.0, documentation requirements in BREEAM can be used as a basis for documenting parts of the FutureBuilt criteria.

Documentation	Method	Format/Template
A. Degree of Circularity	**Circularity index** The degree of circularity shall be documented with the *FutureBuilt Circularity Index – calculation tool*, including input data and graphical representation of the result.	*FutureBuilt Circularity Index – calculation tool*

B. Description of main results in the present and future	**Environment-based decision on conservation, demolition, or rehabilitation** An account shall be given of how the assessment and conclusion have been reached, regarding the question of conservation, demolition, or rehabilitation according to section 3.2. **Resource utilisation during the demolition and construction phase** An account shall be given of how resource utilisation in the demolition phase and construction phase is planned/implemented in accordance with sections 3.3 and 3.4. Documentation can follow BREEAM-NOR v6.0 Wst01 Resource Management at Construction Site. **Measures for material utilisation in real time** An account shall be given of how internal and external material resources are planned/utilised, including a description of planned/implemented measures for conservation, reuse, surplus and recycling in real time, in accordance with the definitions of categories of measures in sections 2.2.2. - 2.2.4. Documentation can follow BREEAM-NOR v6.0 Mat06 Material efficiency and reuse. **Measures for material utilisation in the future** An account shall be given of how the building is designed for reusability and recyclability in the future in accordance with the definitions of categories of measures in sections 2.2.6 and 2.2.7. **Adaptability** An account shall be given of measures for adaptability that enable future changes pursuant to section 3.5. The documentation may follow BREEAM-NOR v6.0 Mat07 Adaptability and reusability. **Breadth of circular measures** It must be documented that measures have been implemented for a minimum of 10 different building components in total, in accordance with section 3.6.	*FutureBuilt Circular – report template*

Figure 4-1 Specific documentation requirements for FutureBuilt Circular – criteria for circular buildings

5. List of concepts

The list of concepts is based on own definitions, as well as definitions in *SINTEF Byggforskserien - Byggforvaltning 700.803 Ombrukskartlegging av bygninger* (SINTEF Building Research Design Guide 700.803 Reuse mapping of buildings), and the Green Building Alliance guide *Ombrukskartlegging og bestilling – slik gjør du det!* (Reuse mapping and ordering – how to do it!).

Concept	**Explanation**
Building part	A building part is a specific part of a building, such as a wall, partition, floor, ceiling, beam, or column. A building part can be a single building component or consist of one or more products (NS-EN 1363-1:1999). Example: A wall is defined as a building part. The wall may consist of several building components, such as wood, insulation, and drywall.

Building component	In this set of criteria, we use building components as a collective term for construction products, building products, building fractions, and building elements, while TEK17 distinguishes between building fractions (products and elements) and materials. Example: Building components here is anything that can be set to 3-digit level in the building parts table. Windows, moldings, technical installations, doors, elevators, bricks, etc.
Product	Building components or materials with information that allows them to be considered for sale, or already marketable. Products are what are offered to a market.
Material passport	Material passports are information about products and materials, including EPDs, maintenance advice, and building system information with dismantling instructions.
Declaration of Performance	A Declaration of Performance (*Ytelseserklæring*) is a document from the manufacturer describing the characteristics and intended use of a building component. This is mandatory for newly manufactured products covered by a harmonised product standard or where the manufacturer has obtained a European Technical Assessment as of 01.07.2013 for Europe and 01.01.2014 in Norway. Must be in Norwegian, Danish, or Swedish when the building component is sold in Norway.
FDV documentation	Common Norwegian abbreviation for "forvaltning, drift og vedlikehold" or management, operations, and maintenance. (The English abbreviation would be FM, for Facilities Management). FDV is used as a collective term for activities and costs throughout the total lifetime of a building or facility, from takeover after new construction to decommissioning or demolition.
Conservation	Taking care of something where it is, for example through maintenance, repairs, and rehabilitation.
Rehabilitation	Rehabilitation involves putting existing buildings, building components, technical facilities, and objects in usable condition, adapted to current regulatory and user requirements. Rehabilitation may include repair, restoration, upgrading and alteration of floor plan.
Transformation	A process by which an older building or area is modified to accommodate new uses or functionality.
Reuse	Reuse refers here to new use of an existing building part or component. It can be for the same purpose as originally, or for another function, with or without processing.
Internal reuse	Reuse of components in own construction project.
External reuse	Dissemination of reusable components to external actors. Reuse collected for a separate project is counted in the circularity index for the building.
Reuse Coordinator	An interdisciplinary role responsible for coordinating reuse in a project.
Surplus	Surplus materials are regarded here as new materials that are surplus from the construction site and residual stocks at developers, contractors, manufacturers, or retail outlets.
Recycling	See "material recycling".
Material recycling	Utilisation of the materials as raw material to produce new products.

Reusability	In this context, reusability refers to building components that have properties that enable or simplify reuse in the event of future changes to the building. Design for reuse involves planning buildings in such a way that components can be dismantled and reused during rehabilitation and demolition, either locally in the same building or externally in a new building. See section 2.2.6 Principles for components to be considered reusable.
Recyclability	Recyclability here means that the materials (or parts of the materials) can be made usable again as raw materials to produce new products in the event of future changes to the building. See section 2.2.7 for principles for materials to be considered recyclable.
Waste	In this context, waste means "construction waste" as defined in Section 9-5 of the Building Technology Regulations (TEK17): materials and objects from the construction, rehabilitation or demolition of buildings, structures, and facilities. Waste consisting of excavation material from construction activities is not covered.
Life expectancy	Life expectancy is used here as a term for the time a building part meets aesthetic or functional requirements.
Technical service life	Technical service life is the time a product is expected to work or the time it takes for the components or equipment to no longer perform their function.
Index	An index is a variable created by combining information from a set of several indicators or variables.
Circularity Index	FutureBuilt's quantified measure of building circularity, based on the proportion of the building (percent of completed weight) that is adapted to defined measures for circularity in the present and future according to section 2.1 Circularity Index.

6. Sources

3XN (2016) Building a circular future. http://www.buildingacircularfuture.com/

Arge, K. og Landstad, K. (2002) Generalitet, fleksibilitet og elastisitet i bygninger. SINTEF. https://www.sintefbok.no/book/index/175/generalitet_fleksibilitet_og_elastisitet_i_bygninger

Brand, S. (1994) How buildings learn. New York, Penguin Books. Circle Economy (2018) A framework for circular buildings. https://assets.website-files.com/5d26d80e8836af2d12ed1269/5dea6b3713854714c4a8b755_A-Framework-For-Circular-Buildings-BREEAM-report-20181007-1.pdf

GBA og Context (2017) Grønn materialguide. https://byggalliansen.no/kunnskapssenter/publikasjoner/gronn-materialguide-versjon-2-2/

GBA (2020) Slik lykkes du bedre med ditt BREEAM-prosjekt. https://byggalliansen.no/kunnskapssenter/publikasjoner/

GBA (2019) Tenk deg om før du river. https://byggalliansen.no/kunnskapssenter/publikasjoner/publikasjoner-tenk-deg-om-for-du-river/

ISO-standard 20887 (2020) Sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance.

Leland, B.N. (2008) Prosjektering for ombruk og gjenvinning. https://www.byggemiljo.no/prosjektering-for-ombruk-og-gjenvinning/

Madsen, U.S., Beim, A. og Beck, T. (2012) At bygge med øye for fremtiden. CINARK – Center for Industriel Arkitektur og Kunstakademiets Arkitektskoles Forlag. https://issuu.com/cinark/docs/at_bygge_cinark_2012

NGBC (2017) Hvordan planlegge for mindre avfall. https://byggalliansen.no/aktuelt/publikasjoner/hvordan-planlegge-for-mindre-avfall/

NHP (2018) Utredning av barrierer og muligheter for ombruk av byggematerialer og tekniske installasjoner i bygg. https://www.byggemiljo.no/13326-2-2/

Nordby, A.S. (2009) Salvageability of building materials. PhD, NTNU. https://brage.bibsys.no/xmlui/handle/11250/231092

SINTEF (2022) Ombruk av byggematerialer. Veileder for dokumentasjon av ytelser. https://www.sintefbok.no/book/index/1320/ombruk_av_byggematerialer_veileder_for_dokumentasjon_av_ytelser

SINTEF (2014) Anbefalinger ved ombruk av byggematerialer. https://www.sintefbok.no/book/index/985/anbefalinger_ved_ombruk_av_byggematerialer

Team Resirqel (2019) Forsvarlig ombruk av byggevarer. Dibk FoU-prosjekt. http://www.resirqel.no/nyheter/2019/12/5/rapport-om-forsvarlig-ombruk-av-byggevarer-lansert-p-litteraturhuset

Widenoja, E., Myhre, K. og Kilvær, L. (2018) DP 118 Ombruk av stål og tilknyttede materialer. Norsk Stålforbund. https://www.stalforbund.no/nyhet/ombruksrapporten-kan-lastes-ned-her#.Xia3g_ZFx5l

WRAP; Design out waste Guide (2009) https://authorzilla.com/xJ6V6/designing-out-waste-tool-for-civil-engineering-wrap.html

Miljødirektoratet (2019) Avfallsplan 2020-2025. https://www.regjeringen.no/contentassets/c6a9a384d90c4af18bfd8458f3167708/avfallsplan-2020-2025.pdf