



Climate-KIC

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Berlin's Circular Construction Ecosystem

Project report

Understanding circular
construction in Berlin:
barriers and enablers

Berlin | December 2019

Executive summary

The project *Berlin's Circular Construction Ecosystem* was realised from May - December 2019 and was carried out by Climate-KIC Germany. The key objective was to identify leverage points in Berlin's construction sector, which stakeholders can use to enable a circular economy.

During the project, the construction market overview in Berlin and Germany showed that new construction in Berlin keeps growing steadily. Furthermore, 18 interviews with experts were conducted with diverse stakeholders to obtain key insights on circular construction in Berlin. Through the extensive interview analysis, a list of challenges for Berlin (and Germany) to transition to circular construction was identified.

The top three challenges were:

- **Limited access to knowledge and no communication about the topic**
- **Complex norms, regulations and standards**
- **Costs and economic risks**

As for the enabling factors to support the transition, these areas were identified as key levers:

- **Knowledge creation and sharing, awareness and communication**
- **Technologies supporting industry digitalisation and material improvement**
- **Promotion and improvement of use of natural building materials, recycled and reused materials**

During the project, construction best practice examples in Berlin were also identified that could serve as a knowledge baseline for circular construction methods and techniques.



Table of contents

1. Understanding the problem

- 1.1 Approach
- 1.2 Circular construction definition
- 1.3 The construction market in Berlin

2. Findings: barriers and actions

- 2.1 Challenges for the development of circular construction in Berlin
- 2.2 Action plan to enable circular construction

3. Findings: Berlin projects and actors

- 3.1 Key construction projects
- 3.2 Relevant actors for circular construction in Berlin

4. Appendix 1 - Identified areas as enablers from the interview

5. Appendix 2 - References



1

Understanding the problem

1.1

Approach

5

Project focus

The project *Berlin's Circular Construction Ecosystem* aimed to identify leverage points in Berlin's construction sector which stakeholders can use to enable a circular economy.

1. *What is Circular Construction?*

Circular Construction is a new topic for the construction industry that widens the industry focus **from energy towards resource efficiency**.

2. *Why Berlin?*

Berlin is a construction hotspot in Germany, however its **booming development** must be either improved or supported with **sustainable methods**

3. *What has to be done in Berlin to make a change?*

Circular Economy in the construction sector opens doors for **new discussions around sustainability**, but action is needed **now**.

Project approach

Project period: May - December 2019.

The project approach consisted of two main phases:

- I. Market research on construction trends in Berlin and Germany
- II. Interviews with a diverse group of stakeholders from the construction industry with the objective to:
 - A. Understand the motivation of stakeholders to take part in sustainable / circular construction projects
 - B. Understand interviewees' awareness / experience of circular construction projects, how it differs from other green construction trends (energy efficiency, recycling) in their view
 - C. Identify challenges to prioritise sustainability / circularity as the main factor in project realisation
 - D. Identify enablers for circular construction that can enable industry with circular economy methods.

1.2

Circular construction definition

Circular Building definition

A circular building can be defined as follows:

“The design, construction and demolition of a building in such a way that it incorporates not only the high-value use and reuse of materials, and an adaptive and future proof design, but also ambitions for sustainability in relation to energy, water, biodiversity and ecosystems at the building and area level.”

Three most effective ways to minimise climate and other environmental impacts on buildings:

- Energy solutions (use of renewable energy and energy efficiency)
- Minimisation of transport (including the use of extracted soil on-site, mass-balance)
- Choice of materials (as low carbon as possible, re-usable, safe, healthy).



Circular construction from a systems perspective

Circular Construction (CC) is an approach that uses Circular Economy (CE) principles for the built environment.

In this case, 3 main principles are considered:

- I. Keep buildings, parts and materials in use and reuse as long as possible with the highest value.
- II. Design out and minimise waste, emissions and pollution as much as possible.
- III. Regenerate natural systems using renewable, non-toxic materials and energy.

At the centre of CC are use and reuse of buildings without unnecessary resource depletion, environmental pollution and ecosystem degradation. The focus areas of the 5 layers are:

1. Circular Materials and Resources
2. Circular Building (as a product)
3. Circular Construction Processes
4. Use, space and internal components
5. Circular Business models in construction.



I. Circular materials and resources

Circular materials and resources sourced for construction needs focus on material types, material health, and material treatment to maximise their value.

For circular materials, the following material types are considered:

- Renewable materials (e.g. wood, and other bio-based materials)
- Renewable fuel
- Recyclable materials (such as steel, recycled concrete)
- Components for reuse.

Material health and locality:

- Toxic, dangerous and damaging materials for health and environment are avoided
- Ecological impacts of the materials used (e.g. land, soil use)
- High quality materials with long life span
- Preference in use of local resources.

Material treatment, maintenance.

II. Circular building as a product

In circular building, we distinguish between new buildings and existing construction. Both are important to consider and to focus on equally.

Criteria for designing new buildings:

- Commercial viability and integration into surrounding infrastructure and mobility (impact of use model, demolition and waste costs)
- Flexible and adaptable building design
- Security and technical quality
- Environmental impact in use phase
- Integrated building technology for energy efficiency and less intensive resource use
- Information exchange on materials and resource use within district.

Efficiency for existing constructions:

CC for existing constructions tries to reuse high-grade building materials, building parts through transformation or retrofitting of a complete building. Recycling is considered a last resort.

III Circular processes for construction

The objective of a circular construction process is reflected in the value chain steps and corresponds to life cycle (LC) thinking and assessment as well as waste and emission reduction during construction.

Key criteria to assess processes include:

- Material supply e.g. with sustainable material sourcing and resource extraction, transparency of used materials and and zero-emission sourcing
- Design, plan and manufacture e.g. with reverse building design (built to be disassembled and reused at end of life stage), LC assessment and LC costs for planning

- Construction and installation process (e.g. LC costs in construction realisation, building-related life cycle costs, zero emission construction site)
- Transportation e.g. with consideration of local use and less transportation, integration of local infrastructure
- Use of building in a flexible and adjustable way
- Maintenance with Repair, Replace, Refurbishment
- Deconstruction and demolition e.g. with maximisation of value preservation of the resources for recycling
- Waste processing

IV. Use, space and internal components

The design and use of the internal space of a building impacts costs for construction, acceptance and a sustainable operation of the building. It is closely related to the building assessment:

- User acceptance and user control of the building
- Efficient space use (Maximisation of space use, Temporary use of the building / interim use, Plan the unplanned: leave space for unforeseen activities)
- Sociocultural and functional quality (Indoor air, acoustic comfort, thermal control, etc ;. Necessity of additional costs for heating / cooling)

V. Circular business models in construction

Circular business models are key to the transformation from a linear to a circular economy in the construction sector, and have to **integrate design strategies, governance and regulations** for the transition to be a success

- **Circular Supply:** Replace raw materials with materials that are renewable or reusable in order to minimise input of virgin materials
- **Resource Recovery:** Recover discarded products or by-products to recycle or upcycle materials. Reuse and repurpose different components & materials by other industries
- **Life Extension:** Extend the life cycle of a product, or parts of a product, while preserving the original function.
- **Sharing Platforms:** Increase the use of a product through new business models for sharing, accessibility, and ownership.
- **Product as Service:** Optimise productivity of a resource or product while maintaining ownership of the product.

This approach includes collaboration between different stakeholders across the value chain from Design, Sourcing, Construction, Operation, to Renewal, Disassembly and Repurpose.

Sources:

ARUP, DGNB, BNB standards, Circular Berlin, Circular City report
<https://www.oekobaudat.de/fileadmin/downloads/0048g170606mh.pdf>
<https://www.designingbuildings.co.uk/wiki/BAMB>, <https://www.circle-economy.com/wp-content/uploads/2018/10/A-Framework-For-Circular-Buildings-BREEAM-report-20181007-1.pdf>,

Key elements of circular construction named by interviewees

Building materials

- Materials and structure reuse
- Transparent supply chain
- Material sourcing and use
- Renewable (timber) and recycled materials

Building operation

- Building systems and components (like lighting system)
- Resource efficient building along with energy efficiency

Space use

- Shared spaces / multiple area use
- Material sourcing and use
- Flexible building plan

New processes and methods

- Design for disassembly
- Deconstruction processes
- Material and structure reuse
- Circular internal corporate processes
- Modular system construction

"Circular construction in my understanding - [...] - revolves around the selection, separation and recyclability of materials and thus the reintroduction into the material cycle."

**Marc Kimmich,
COPRO**

"CO2 emissions is more important than circular construction for the moment - I want to change this practice so that both the energy question and the material question are considered more in environmental debates."

**Andreas Otto, Member
of the House of
Representatives,
Bündnis 90/Die
Grünen Party**

"Building plan should be quite flexible: today it is an office building, tomorrow it could be a house."

**Sibylle Bornefeld,
Falco Herrman
Sauerbruch Hutton**

"We might get to a point where buildings are more assembled than constructed."

Stuart Smith, ARUP

1.3

The construction market in Berlin

Summary of Berlin trends

Promotion of sustainability in construction

Berlin had a construction volume of €2.83 billion in 2018, an estimated amount of €0.57 billion in sustainable buildings, prioritising the topic of energy-efficient housing stock for new buildings and building renovations.

New construction growth

New construction in Berlin keeps growing steadily, mainly through residential dwellings. 50,000 new dwellings are planned by 2030, about 26,000 by 2021. A new program in Berlin pushed by the Senate for City Development and Living provides affordable housing for Berliners, aiming to push prices down on dwellings.

Berlin wood construction

Timber construction permits for office and public buildings, as well as dwellings, are increasing in Germany. The Berlin city senate embraces and promotes wood construction including fast wooden lightweight constructions to meet the growing demand for new school buildings in Berlin.

Resource-efficient construction and construction waste recycling

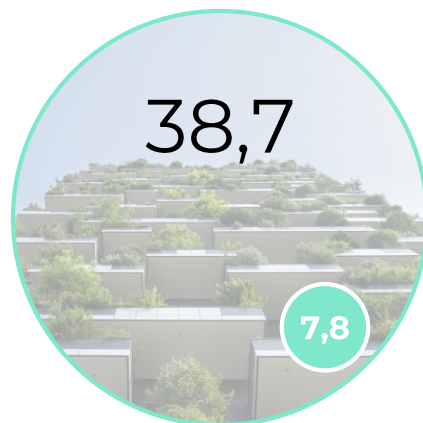
Construction waste remains the biggest waste category in Berlin (61% of the whole waste). For the upcoming decade, Berlin sets the ambitious measures to prevent and recycle this waste fraction.

Promotion of sustainability in construction

€7.8 billion (20%)

of the overall volume of €38.7 billion was invested in sustainable buildings in Germany in 2017, with a focus on high volume business real estate. About 50% of the documented number of Green Buildings in Germany were built in the “Big Six” Locations of Berlin, Düsseldorf, Frankfurt, Hamburg, Cologne and Munich. Berlin had a construction volume of €2.83 billion (+3,2%) in 2018, an estimated amount of

€0.57 billion in sustainable buildings.



Public buildings [...] are at the centre of social attention with regard to the implementation of sustainable construction goals. That's why the public sector carries a special responsibility for the development of values and conveying sustainable practices into the construction sector.

Sustainable construction in public buildings in Berlin / BNB

- Public calls for tenders include demand for sustainable construction
- Recent public construction projects more often have a focus on general sustainability practices than they did before but don't necessarily also call for circularity.
- “Zukunftsinitiative Stadtteil II” calls for „Improvement of district-related climate protection and measures to prevent climate change.”
- A large investment will be focused on schools until 2026 with renovation of existing buildings and new constructions including fast wooden lightweight construction. Estimated overall investment: €5.5 billion.

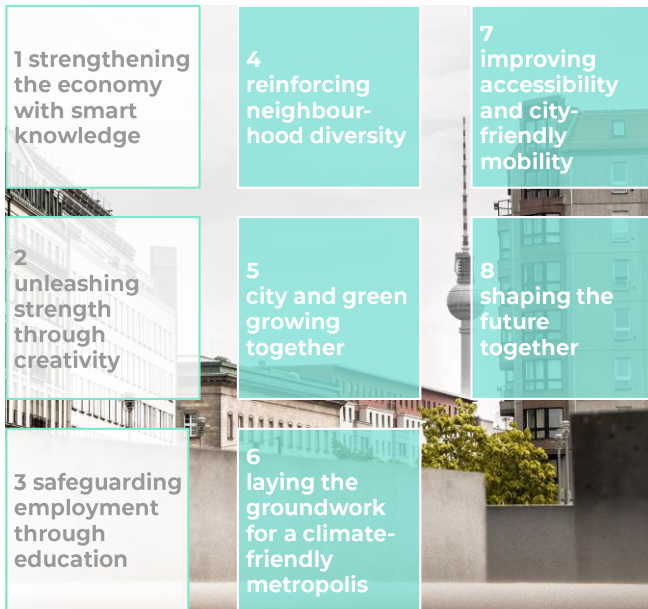
In Berlin in 2014 Urban Development Concept Berlin 2030 was published promoting sustainable growth for the future smart and green city

The Urban Development Concept Berlin 2030 developed by the Senate Department for Urban Development and the Environment (current name being changed) described different urban strategies for the long-term, sustainable development of Berlin. Some of the measures also included the trends for in construction

- Berlin as a “rental city”, 85% of flat accommodation is for rentals and about 1,062,000 single-person households, yet only 391,996 small flats under 50 m².
- The 25 major new residential development sites set out in the Urban Development Plan for Housing offer the potential for some 50,000 dwellings.
- Energy efficiency is focused not only on new buildings; energy-efficient building renovations are particularly important.
- Local initiatives are being set up and climate and neighbourhood management teams are being encouraged to raise public awareness locally and apply climate efficiency principles at the community level

Sources:

https://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen/BBSROnline/2018/bbsr-online-09-2018-dl.pdf?__blob=publicationFile&v=2
https://www.realestate.bnpparibas.de/upload/docs/application/pdf/2018-09/2017-q4_green_building_investment_de_final.pdf?id=p_1707299&hreflang=de
<https://www.greenimmo.de/immobilienthemen/green-buildings/>
https://www.hausbau24.de/news/presse/hausbau/bauentwicklung_2018_in_berlin_leichtes_wachstum_auf_hohem_niveau
http://www.stadtentwicklung.berlin.de/planen/stadtentwicklungskonzept/download/strategie/BerlinStrategie_Broschuere_en.pdf
https://www.ihk-berlin.de/blob/bihk24/politische-positionen-und-statistiken_channel/Strategien-fuer-Berlin/2969198/bac7b1661ed9cac3af22532cae622e6/Studie-Berlin-2030--1--data.pdf



In this concept, Berlin prioritised the topic of energy efficient housing stock for new buildings and building renovations

In 2013 the Climate Neutral Berlin 2050 was published, where measures for energy efficient housing stock were proposed. A large proportion of Berlin's housing was modernised in the years following reunification. However, this mainly affected the stock of large housing corporations, while the scattered private property still shows modernisation deficits.

By 2050, Berlin needs a graduated refurbishment roadmap.

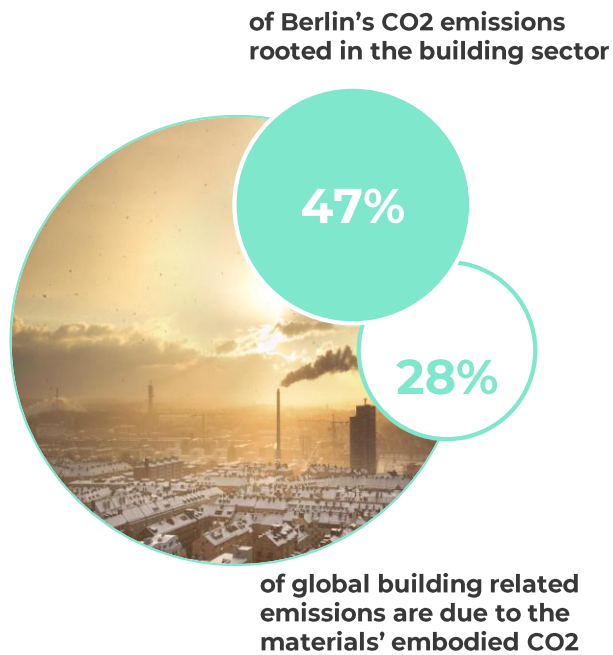
Berlin needs to continue pursuing inner development and redensification in order to absorb the population growth expected up to 2050 efficiently within the city limits. This will require offering flexible and adapted use of residential space, decreasing the area requirement per person.

Climate change adaptation measures need to be taken into consideration, which means keeping strategically important green and open spaces free and improving their quality.

For the refurbishment of Berlin's housing stock for energy efficiency, it is important to bear in mind renovation and modernisation cycles, to balance out renovation deficits and to find efficient holistic solutions in districts with manageable ownership

structures.

The considerable new construction of residential and commercial buildings which will take place in Berlin until 2050 must be carried out respecting exemplary standards as far as the building and its energy supply are concerned.

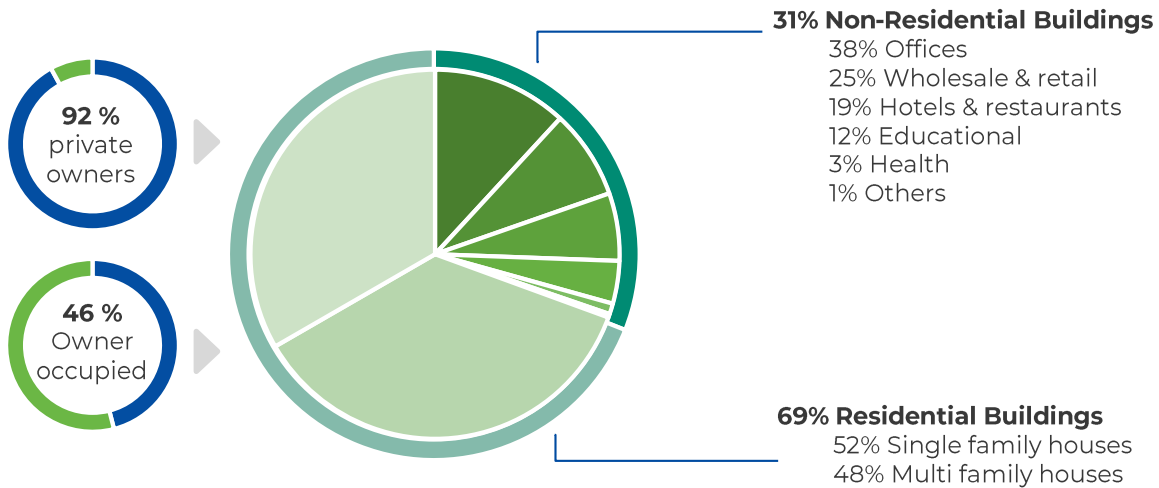


Sources:
https://www.berlin.de/senuvk/klimaschutz/studie_klimaneutrales_berlin/download/Machbarkeitsstudie_Berlin2050_EN.pdf
<https://www.unenvironment.org/news-and-stories/press-release/buildings-and-construction-sector-huge-untapped-potential-emission>

New construction growth

In Germany, residential housing accounts for 69% of the total floor area

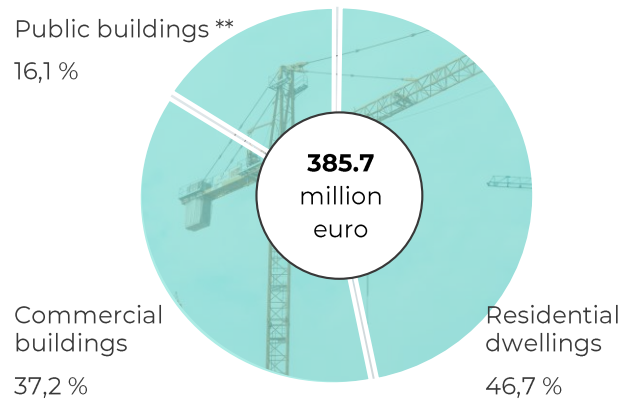
Breakdown of the building stock, 2018



In Berlin approximately half of the construction turnover in 2018* was in residential dwellings

- The key construction focus currently in Berlin on residential dwellings
- In 2017, in total 49,605 construction sites planned for residential dwellings, with the objective to be realised already in 2018-2019.
- Key clients for the construction project's realisation were private housing companies and cooperatives to build 26,510 homes.
- Only about 3% of the entire stock of office space in Berlin was vacant in 2016.

Types of construction in 2018



Sources:

Building Market Brief Germany, 2018

https://www.statistik-berlin-brandenburg.de/publikationen/stat_berichte/2019/SB_E02-02-00_2018j01_BE.pdf

https://www.ibb.de/media/dokumente/publikationen/berliner-wohnungsmarkt/wohnungsmarktbericht/ibb_wohnungsmarktbericht_2018.pdf

*based on volume split for June 2018

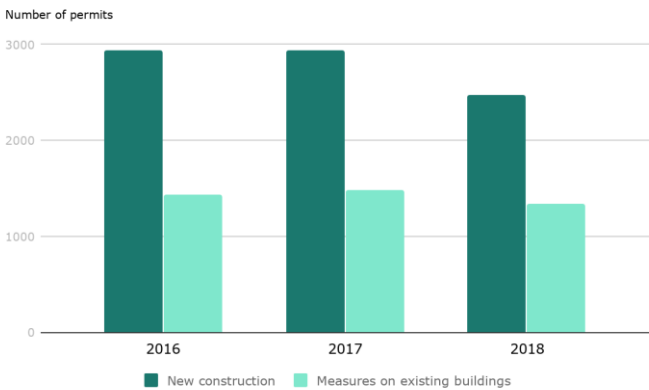
** incl. road construction

Despite a construction boom in Berlin, number of building permits started declining in 2018

Berlin is experiencing a construction boom, nevertheless the number of granted building permits started declining slightly from 2016 to 2018.

It demonstrates the general trend that the current construction boom in Berlin is reaching its declining phase

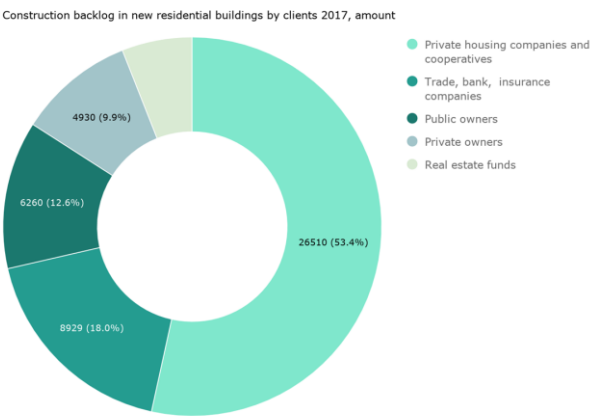
Nevertheless, estimated costs for construction are still increasing: up to 17% in 2018 compared to 2017, reaching €5.426mn



In 2017 private housing companies and cooperatives played a key role in the development of dwellings

In 2017, in total 49,605 construction sites planned for residential dwellings, with the objective to be realised already in 2018-2019.

Key clients for the construction project's realisation were private housing companies and cooperatives, to build 26,510 homes.



Sources:
https://www.statistik-berlin-brandenburg.de/publikationen/stat_berichte/2019/SB_F02-01-00_2018m12_BE.pdf
https://www.ibb.de/media/dokumente/publikationen/berliner-wohnungsmarkt/wohnungsmarktbericht/ibb_wohnungsmarktbericht_2018.pdf

Berlin wood construction

Wood as a sustainable building material is used with a share of 17% in Germany

:

In Berlin's urban development, structural timber buildings are becoming more and more important. To support this positive development, in June 2019 the Senate Department for Urban Development and Housing in Berlin for the first time awarded its own timber construction prize.

58 projects were submitted in the categories of New construction, Refurbishment and Upgrading, and Concepts, realised in Berlin over the past 15 years.

In 2019 the Berlin Parliament decided that Berlin needs to build more wooden buildings in the interests of climate protection and sustainability.

Impact on:

- building and environmental standards
- woodwork industry to build up additional production capacity.

The new objective is:

- To develop a timber construction cluster for Berlin-Brandenburg.
- To link producers with end users
- To promote the development of this sector in the region.

Timber construction permits for buildings in Germany

	Offices and public buildings	Residential Dwellings
2018	17,8 %	23,5 %
2017	17,1 %	17,7 %
2016	19,3 %	16,2 %



Nr. 2019/39/17
Drucksache 18/1726

Abgeordnetenhaus BERLIN

– 18. Wahlperiode –

Gemäß Beschlussprotokoll über die 39. Sitzung des Abgeordnetenhauses von Berlin am 21. März 2019 hat das Abgeordnetenhaus folgenden Beschluss gefasst:

Nachhaltigkeit auf den Bau: Berlin baut mit Holz

1. In Umsetzung des Berliner Energie- und Klimaschutzprogramms (BEK) soll der Baustoff Holz in Berlin in deutlich stärkerem Umfang eingesetzt werden und als Kohlendioxid-speicher einen Beitrag zum Klimaschutz und zur Ressourceneffizienz leisten.
2. Der Senat wird aufgefordert, Forstwirtschaft, Handwerk, Industrie und Wissenschaft dabei zu unterstützen, Berlin-Brandenburg zu einer Region des Holzbbaus zu entwickeln. Langfristig soll ein Holzbaucuster entstehen.
3. Der Senat als größter Bauherr der Region muss beim Holzbau vorangehen. Holz soll bei Neubau und Erweiterung von Gebäuden des Landes Berlin und seiner nachgeordneten Einrichtungen und Beteiligungsunternehmen in verstärktem Maße eingesetzt werden. Zu verarbeitendes Holz muss grundsätzlich zertifiziert sein, um nicht Raubbau an Wäldern, insbesondere bei Importen, zu befördern.
4. Der Senat wird aufgefordert, in Auswertung der Förderprogramme anderer Länder und Kommunen (Baden-Württemberg, Hamburg, München etc.) Ziele und Potentiale für ein Förderprogramm „Urbaner Holzbau Berlin“ zu untersuchen. Damit sollen private Akteure animiert werden, stärker Holz als Baustoff einzusetzen.

Dem Abgeordnetenhaus ist bis zum 15. August 2019 zu berichten.

Für die Richtigkeit:
Berlin, den 21. März 2019

Dr. Reiter

Sources:

<https://de.statista.com/statistik/daten/studie/456639/umfrage/quote-der-genehmigten-wohngebaue-de-in-holzbauweise-in-deutschland/>,
https://www.holzbau-deutschland.de/aktuelles/presseinformation/ansicht/detail/holzbauquote_2018_liegt_bei_178_prozent/
http://www.stadtentwicklung.berlin.de/aktuell/pressebox/archiv_volltext.shtml?arch_1910/nachricht6810.html

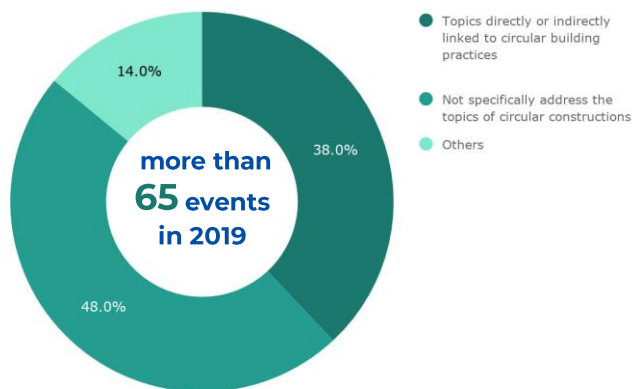
Resource-efficient construction and construction waste recycling



of resources are captured in existing buildings and infrastructure in Germany.

If it is built, reused and recycled properly, a building would become a massive human-made raw material warehouse at end of lifecycle.

Main topics of events in Berlin, 2019



In Berlin discussion about circular construction does not take place broadly - only indirectly through distinct topics

Main topics related to circular construction covered:

- Modular construction
- Natural materials (timber, clay)
- Smart use of (digital) technology for innovation
- Legal frameworks (BIM*, allocation criteria, DGNB certification**)
- Open discussions about the future of construction/ use of spaces

Key organizers:

- Architektenkammer Berlin
- Architects and planners
- City of Berlin
- Diverse private businesses

Sources:

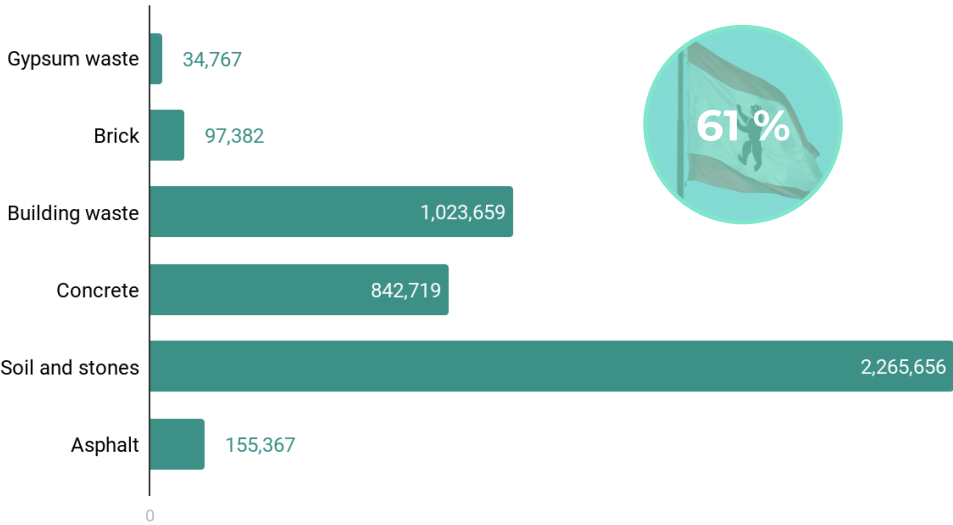
<https://www.umweltbundesamt.de/daten/ressourcen-abfall/verwertung-entsorgung-ausgewaehelter-abfallarten/bauabfaelle#textpart-2>

In 2019 new draft of Berlin Waste Management Concept (WMC) was published, focusing on the construction waste

As the construction waste remains the biggest waste category, the concept evaluates future trend development and proposed measures to be taken to reduce and recycle this type of waste. 61% of total waste in Berlin is construction and demolition waste (about 4,4 million tons in 2016)

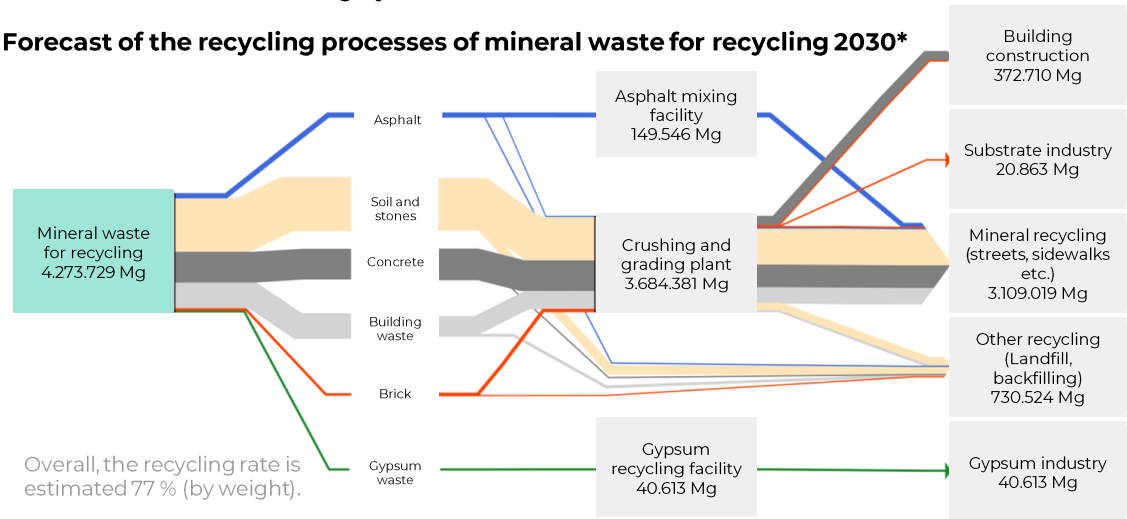
Growth in the fraction soil and stones, comparing to 2012 (17 wt.%) was contributed among other things, by the growing number of new residential and non-residential buildings, which also rose by 13 wt.% from 2012 to 2016

Total mineral construction waste, 2016, Mg (Ton)



Compared to 2016, the total volume of mineral construction waste will increase to 5.5 million Mg by 2030

Forecast of the recycling processes of mineral waste for recycling 2030*



Sources:

https://www.berlin.de/senuvk/umwelt/abfall/konzept_berlin/download/AWKBerlin2020-2030.pdf
* According to AWK 2020-2030, status December 2019 as draft version
1 Mg (Megagramm) = 1 Ton

New Berlin Waste Management Concept 2020-2030* embraces waste prevention and reuse measures in the construction

The concept is not yet officially approved, but it set ambitious action lists for the upcoming decade.

Obligation of public institutions to check in all their building projects to what extent components or structural building elements can be reused. Within the framework of the Berlin building regulations, requirements are specified for the design of deconstruction and demolition projects. The amendment is currently being prepared and envisages the mandatory introduction of selective deconstruction.

Promotion of the reuse of components by supporting initiatives, associations and networks. In addition, comprehensive consulting and services are offered, ranging from advice on expansion directly at the point of origin to reinstallation. The offer is aimed at private end consumers, commercial companies (demolition companies, crafts enterprises, planning offices), construction companies) and to public authorities. One example is the cooperation between the initiative "bauteilnetz Deutschland" and the city of Bremen, whose waste management company cooperates closely with the "Bauteilbörse Bremen"

Pilot project for deconstruction Reuse of component. The aim is to identify suitable public construction projects that are suitable as demonstration projects for the reuse of components. The scientific support can be used to achieve learning effects in terms of expansion, logistics, storage and marketing. It has to be examined to what extent components can be reused in planned new building projects.

Invitation to tender for an architectural competition which calls for recycling-friendly structures and comprehensive recovery of the building elements for reuse and later conversion of the building for a new building.

Preparation of a brochure for building owners and

architects on the avoidance of construction waste.

Mandatory use of recycled building materials in public buildings.

Berlin WMC addresses measures for the high-quality recycling of mineral construction waste in road and underground engineering. The construction market in Berlin: resource-efficient construction and construction waste recycling

Increasing the use of recycled building materials in road construction (into asphalt granulate in asphalt mixing plants). The aim is to develop a strategy that a) provides more high-quality granulate for the asphalt mixing plants and b) increases the recycled concrete content in the asphalt layers. This must be done in close cooperation with road construction companies and asphalt manufacturers. By specific tendering, incentives for the development of recipes and investment in plant engineering are promoted.

Development and implementation of a concept for the resource efficient construction of new cycle paths.

Updating of the Administrative Regulation on Procurement and the Environment (VwVBU): Specification for the Use of Secondary Raw Materials in Road Construction

Promotion of reuse in construction measures where excavated soil can also be reused in urban agglomerations if the quality of the masses is already checked in the planning phase and recycling concepts are drawn up. As a rule, however, decentralised areas are required for interim storage and/or processing.

Initiation of research projects to promote innovative processing technologies. In order to provide sufficient quality raw materials for the building materials industry, technically processing methods must be developed.

Sources:

https://www.berlin.de/senuvk/umwelt/abfall/konzept_berlin/download/AWKBerlin2020-2030.pdf

* According to AWK 2020-2030, status December 2019 as draft version

Berlin WMC addresses measures for the high-quality recycling of mineral construction waste in road and underground engineering

The recycling of construction waste in new building construction has only been applied within the framework of research and pilot projects and has not yet been established in the construction industry. Berlin WMC suggests the following measures to move towards implementation:

Definition of the technical feasibility and economic feasibility for the separate collection and the obligation of supply to a treatment plant.

Advising the actors involved in collection and recycling with regard to separation and documentation obligations.

Increasing the number of staff for the implementation of the Ordinance on the Management of Commercial Municipal Waste and of Certain Construction and Demolition Waste (Ordinance on Commercial Waste - GewAbfV).

Control a transfer of enforcement responsibility to the districts.

Initiation and implementation of a research project to determine the recycling potential of mixed building waste.

Supporting the building materials industry in its use of secondary raw materials, throughout creation a network that promotes bilateral exchange at company level to determine the production locations and the use of raw materials, available technologies, pilot projects.

Diverse promotion measures for recycled concrete, gypsum, flat glass and bricks.

The key focus of the planned measures is around better sorting of the building waste and its recycling

- Selective demolition / deconstruction of public buildings (currently as part of the school construction offensive) until 2021
- High-quality recycling of construction waste to high-quality recycling building materials
- Increased use of recycled building materials in underground engineering (Tiefbau)
- Increased use of the recycled brick in gardening and landscaping (as substrate for tree plantings, roof greening)
- Priority is given to the technical processing of all

material flows from the construction sector instead of their filling, landfilling or thermal recycling

- Until 2023 creation of disposal channels for the recycling of gypsum waste (in particular gypsum plasterboard)
- Until 2022 establishment of recycling concepts for new construction projects in public buildings
- Reuse of usable building materials elements and components
- Strengthening of the enforcement of the waste legislation frameworks, especially the Ordinance on Commercial Waste - GewAbfV
- Further development of the Regulation on Procurement and the Environment (VwVBU) under the aspect of Zero Waste

As for the regulation update the two main changes will appear:

Amendment of the Berlin Building Regulations (BauOBlN) for the implementation of the obligation for selective deconstruction and its design.

Update of the VwVBU: Mandatory certification according to the Sustainable Building Assessment System (BNB-System) for buildings of the State of Berlin and mandatory preparation of a deconstruction concept.

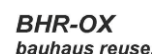
2

Findings: barriers and enablers

Interviews: key objectives

1. Understand motivation of stakeholders to take part in sustainable / circular construction projects.
2. Understand interviewees' awareness / experience with circular construction projects, how it differs from other green construction trends in their view (energy efficiency, recycling).
3. Identify challenges to prioritise sustainability / circularity as the main factor in a project's realisation
4. Identify Enablers for circular construction that can empower industry with circular economy methods.

18* organisations were interviewed on the topic of circular construction in Berlin



2.1

Challenges for the development of circular construction in Berlin

26

Key challenge areas for circular construction in Berlin

Through the interview process, the following 10 areas were identified as the key barriers to make a shift in the industry towards circular construction

Limited knowledge access, no communication or demand for the topic

Costs and economic risks

Lack of relevant business models

No common understanding and theoretical framework

Scarcity of relevant technologies

Lack of appropriate materials

Complex norms, regulations and standards

Lack of people and capacities

Infrastructure limitations

Industry complexity

Limited access to knowledge, no communication or demand for the topic

No demand for circular construction projects

- There is no demand in the market for circular projects, especially projects on a large scale. Also, no demand from tenants and final investors on sustainable certificates which could address circularity as well.
- In new construction projects, the environmental aspects are hardly considered, especially on the level of building materials.

Lack of transparency on the topic and its specificities

- The diversity of sustainable certificates and labels for building could be misleading. Unfortunately, the certification labels are becoming a marketing tool, rather than bringing transparency into the topic, which does not contribute to circularity on a full scale.
- On a material level, it is a challenge to evaluate which material is really sustainable, durable and healthy. Also, there is no clear guidance as to which material is recyclable and how (e.g. for gypsum recycling).

No publicity and communication about circular construction

- Wider society is not included into the discussion on circular construction, thus no communication takes place to explain to wider society and relevant actors that houses can actually be built to be disassembled, for example.

No collaboration and partnerships to spread knowledge

- There is a lack of knowledge exchange and collaboration among individual actors and firms in the field of circular construction. At the moment, actors deal with it, but there is still no large network for knowledge sharing.
- The cooperation between specific actors, e.g. building material manufacturers and architects, is still not sufficiently valued.

Berlin/Germany specifics:

- In Berlin, for district municipalities, energy efficiency is the topic which is prioritised; sustainability in terms of building materials is hardly considered
- Current discussions in Berlin are not about sustainable construction, but mainly about the *quantity* of construction sites.
- In terms of timber construction, Berlin has lost its wood construction culture due to historical developments and no demand in this area. Berlin and Brandenburg have focused on prefabricated concrete construction since the 1960s. The Berlin Senate aims to push the topic of wood construction, by embracing the topic of timber construction in 2019
- Lack of stakeholder engagement on the topic is one of the weaknesses in Germany, comparing to e.g. Nordic countries, where more actors are involved in the debate.

Complex norms, regulations and standards

Regulation and norm limitations for circular materials

- The current regulatory system does not integrate reused materials and there is uncertainty regarding material quality, which leads to low acceptance to work with them and higher risk of using them. Recycled / secondary materials are not part of current norms and regulations.
- According to the current Renewable Energy Sources Act (EEG), old wood is classified as biomass material, which prevents its reuse at end of life, as it will be burned.
- There is low acceptance of new alternative materials due to high risk of using them. E.g. old wood is difficult to use in new construction due to fire protection and risk to construction stability.

Complex regulatory norms prevent new innovative approaches and are costly

- Security measures and technical requirements are gradually getting more complex (following incident principles): it makes a construction project more expensive, and thus it restricts circular approaches.
- The existing construction legislation is complex, slow, strict and not transparent. It does not empower circular construction models and various actors don't have the willingness to change due to the complexity of legislation.
- Germany is the country of norms, and requires more time for construction processes: this prevents experimental work, prevents development and use of new materials, because they might not be tested enough to prove their quality. Country building legislation is unique and it makes it difficult to find a partner abroad. E.g. building wooden high-rises in Germany has challenging requirements.

Berlin/Germany specifics:

- There is a lack of legal framework and funds for districts to influence building owners to construct in a sustainable (circular) way
- The "Mietendeckel" (rent 'ceiling') in Berlin does not address the sustainability aspect of buildings. 80% of the CO2 in buildings is produced by heating and air conditioning. Owners are incentivised to invest money into renovation if they generate a return on investment, as there are no obligations by law to renovate on a voluntary basis, if it is not needed

Costs and economic risks

A perception that “Circular” materials have higher costs

- Building from circular building materials (recycled materials) usually requires higher costs and extended timelines that are not suitable for every client.
- The upcycling process of the concrete (Recycled concrete) is expensive and requires investment; however only 5% is going to landfill, which prevents investments. From an economic point of view, recycled aggregates are not cheap, mainly due to transportation costs.
- Despite the fact that certification of recycled concrete exists, a lack of trust in the material's quality results in only modest bank loans being granted.
- There is an economic risk for companies that work with recycled materials, as there is a risk that building permission will not be granted for construction using reused materials.

Sustainability costs money

- Security measures and technical requirements are gradually getting more complex (following incident principles), it makes the construction project more expensive, and thus it restricts circular approaches.
- Current conventional construction projects are not affordable from the cost perspective, thus sustainability will be even more expensive. Thus sustainable construction as a mass market tool is not profitable for the price category of affordable housing.
- The search for experienced firms in circular (sustainable) construction makes the construction process more expensive.
- There is a perception that clients (not the building owners) have to invest more money when it comes to sustainability.

No consideration of operational costs

- Operational costs are not included in construction cost. The discussion remains about

construction costs, but the question of what happens afterwards is more relevant, because a large part of the costs arise during operation and not during construction. The building owners who build for themselves have an interest in spending a little more at the beginning and then saving money later. Currently the topic of operational costs of the building is reflected mainly through certified projects.

- Waste disposal costs are high, which impacts the overall costs
- LCA is not broadly used during the planning process for both public and private buildings; the focus is mainly on construction costs, not operational ones. It decrease use of embodied energy, and potentially operational costs through e.g. sharing models and material ownership.

Berlin/Germany specifics:

Due to time pressure, Berlin public administration assumes that different construction methods, e.g. such as circular construction, will lead to cost increase and more time for project realisation. However in case of using timber it can speed up the process.

4

Lack of relevant business models

Current market gaps prevent development of a fully compatible circular business case

- To realise circular construction projects, there are a lot of gaps in the business model, e.g. in supply chain and storage infrastructure. There is no supply infrastructure that will guarantee the availability of resources.

Limited scalability for the circular construction business approach

- On a material level, It is too early to scale-up with the recycled timber and concrete construction. Also because there is no demand for large scale projects with recycled concrete today, which means it is not economically viable. More materials can be sorted out but only if there is demand for them.
- Models with the building (space) multiple use are only emerging, but not yet equally available and not yet economically viable.
- Models with the focus on material reuse often not yet economically viable, and not yet established due to low demand. It takes time to establish a market of secondary materials and new business models. In this case the business model should address the ownership of the material used in building.

Alternative business models are not yet developed or considered

- Materials value in the building is not considered an asset, which prevents alternative cost calculation and planning.
- Contemporary business models, eg when property owners develop the building and sell it again, is not attractive when secondary materials are used. Firstly because the building will be more expensive, secondly it will be less attractive for the buyer, as the image of secondary material is still negative (considered to be waste).
- There is no deposit system (or leasing models) in place for building technical equipment e.g. for ventilation system filters for residential and office buildings. It could impact the business models:

the producer would have to take it back, i.e. the purchase prices would then be somewhat more expensive, but it increases the motivation to think about reusable filter systems.

- The sustainable business concepts should be developed with long term thinking, nevertheless it is challenging to discuss the process of future deconstruction with investors in new construction.

Wrong market incentives

- In current construction projects, the payment to the architect is connected to the volume of the project (% of costs of the project), thus it is not connected to any sustainability KPIs. Why should the architect be motivated to reduce resources if the costs are higher and his income is reduced?
- Engineers involved in the construction process have no connection to the building operation process, and thus do not carry responsibilities for the impacts during operation.
- Project developers of building and office construction are currently not interested in the topic, as they are focused on short term margins.

No common understanding or theoretical framework

No clear definition for circular building, circular construction

- There is no clear definition and shared understanding of circular building in the construction industry. Many buildings are represented and promoted as 'circular/sustainable architecture' in Berlin. However, not many of them are based on circular construction principles.
- The term circular construction should be more concrete, so that it becomes more mainstream. Most construction stakeholders do not know what circular construction means.
- The term 'circular building' is difficult to grasp in comparison with 'energy efficient' or 'passive house'.

Lack of knowledge about circular construction as a topic and its specifics

- There is a big gap between theory and practical implementation in the area of circular construction. For example, In the public sector the framework conditions for sustainable construction are in place, but they have not yet been fully realised in practice.
- Currently the topic of circularity is not fully addressed in the certification process. It has not been recognised as an important topic because all the efforts have been focused on the one hand on recycling, on the other hand on energy efficiency. While energy efficient building pushes the industry forward, it doesn't consider resource efficiency as an issue.
- Other sustainable building practices are more widely known/ popular than circular construction among single house owners.

Berlin specifics:

For the building authorities, the senate department for urban development and the public sector as a whole, the topic is very new and not yet a focus point.

Lack of people and capacity

Lack of reliable partners

- It is a major challenge to find like-minded, reliable construction companies and suppliers who are willing to bring change to the industry, as the industry is booming and there is lack of available experts who can push the topic further
- There is a shortage of planning competence in this field, which can also accompany and go for ambitious projects. Often there is resistance: "This is not possible". Many architects prefer to do things as they always have done.

Lack of fitting expertise

- The lack of a qualified labour force, who are familiar with the topic of sustainable construction processes and who can think and plan in a circular way. Nowadays it is very expensive to find someone who is familiar with sustainable building, whether in planning phase or with carpenters.
- Construction companies also do not have know-how for circular construction processes.
- Planners must have the competence in timber construction, but that is not always the case. That's why quality criteria should be developed for planning offices so that they have the competence right from the start.
- Most workers are not able to work with reused materials, also there are no companies that can provide materials/ expertise.

Lack of facilities

- Lack of facilities to scale timber construction and lack of people who can work with timber.
- The demand for large scale projects from recycled concrete today are not considered viable, there is no supply infrastructure that will guarantee the availability of resources.

Berlin specifics:

- Due to the construction boom in Berlin, it is a challenge to find experienced employees and companies to respond to the project. Some companies will be working at full capacity over the next few years, thus there are not sufficient responses for tenders. This does not depend on the specifications, but on the capacity utilisation of the contractors. Building according to BNB standard is not complicated, but requires available capacity.
- Due to the significant gap in the educational system, there are not so many architectural practices, or carpenters who work with timber or look into circular constructions in Berlin-Brandenburg.
- In the Berlin Senate there is a shortage of qualified employees that can work on the topic of Sustainable Construction.
- Based on the trends for modular construction, in Germany it is possible through medium-sized, mostly owner-managed economy. The circular construction topic depends on small and medium-sized enterprises, as they are the ones who deliver the work and should be included in circular construction debates.

Scarcity of relevant technology

Technological limitations for materials

- There are no methods for minimizing impacts of the most high carbon building materials: concrete, steel, aluminium and glass.
- Current construction materials might also be unsafe in the future, e.g. there is no proof of safety for materials like fiberglass and currently there is no technology to test it.
- There is a scarcity of natural-based components that makes it impossible to avoid use of synthetic composites for timber construction.
- Composite materials are a challenge to recycle, e.g. impossible to scrape gypsum off polystyrene.

Digitalisation is not yet widespread in the construction industry

- Current documentation processes for building materials are very expensive and slow, and digital solutions not yet implemented. Thus there is high demand for technologies such as 3D scanning technology on an entire building to conduct analysis quicker and cheaper.
- Tracking of materials is technically difficult and expensive.

Lack of appropriate materials

Limited resource availability

- The construction process depends on resource availability, which can be limited in case of timber, or other secondary materials.
- Sourcing local materials as one of the circular construction principles is often a challenge. Recycled timber construction is dependent on seasonal resource availability.

Challenge to supply "circular" healthy and safe materials

- It is a challenge to consider timber as a circular material if there is not 100% transparency in the supply chain.
- Current materials are harmful to the environment or potentially unhealthy. HBCD is harmful to the environment, but makes polystyrene flame-retardant. Mineral wool is an alternative material. These fibres can, however, cause lung cancer, just like asbestos
- New materials are very diverse and go beyond standardised, it creates extra challenge for the recycling, if there is no clarification for it.
- Use of composite wood instead of pure wood contaminates the process of wood recycling.

Slow market acceptance for new materials

- Styrofoam is widely common material for insulation, also secured by DIN standards. At the moment it is cheaper to use, it is easily available, and while there are no companies with the new "sustainable" materials available, that makes it expensive.
- Lack of harmless and cheap building materials.

Berlin specifics:

- The Senate wants more recycled concrete to be used. The problem is that it is less standardised and more expensive than conventional concrete, and it is difficult to source it.
- The companies that work with reused materials today are not able to implement large scale projects, due to lack of recycled materials. For instance, it would not be possible to build a housing project in Berlin from recycled building materials as there is not enough available material.

Industry complexity

Slow rate of change in the construction industry

- Though there are a range of innovative technologies that can help enable circular construction, the construction industry is intrinsically extremely slow. Therefore it is difficult to implement technological innovations timely and on a large scale.

Fragmented and non-transparent supply chain

- There is a lack of a supply chain transparency in the construction sector. The supply chains are fragmented and not well developed.
- Waste management companies do not know who makes decisions about the choice of materials in advance. The supply chain is very long and the companies at its end have no information at all about initial materials.

Too many stakeholders involved in the project at different times

- Complexity of a project creates a long chain of involved stakeholders with different interests: owners, project developers, companies that build themselves, architects, specialist planners, construction companies, tenants, property management, managers, end investors, end users.

High level of technical complexity

- High technical requirements and engineer-heavy solutions complicate any new processes.
- In order to make sure that all sustainable criteria are considered in the building process, the process must be controlled and checked thoroughly, which is very challenging to control until the very end.

Infrastructure limitations

No supply and storage infrastructure

- There is no storage infrastructure for reused materials.
- It is too early to scale-up for recycled timber and concrete construction. There is no supply infrastructure that will guarantee the availability of resources.
- It is a challenge to reuse parts of an old building for new construction.

No option of a deposit system in current infrastructure solutions

- There is no deposit system in place for building technical equipment e.g. for ventilation system filters for residential and office buildings. It could impact business models: the producer would have to take it back, i.e. the purchase price would then be somewhat more expensive, but it increases motivation to think about reusable filter systems.

Berlin specifics:

- There is no developed infrastructure for recycled timber and recycled concrete in Berlin and there is no secure supply for secondary materials in order to build with reused materials.

Challenges for specific stakeholder groups

Clients and project developers

- **Building permission:** Project developers or clients are not incentivised to work with recycled materials or reused structures, as it can be more complex to get building permission for construction with reused materials.
- **Limitation to engage with large scale projects:** The companies that work with reused materials today are not able to implement large scale projects, due to lack of recycled materials. For instance, it would not be possible to build a housing project in Berlin from recycled building materials as there are not enough available materials.
- **Business models for developers depend on margins:** Developers have to have a certain margin or revenue on your construction costs, which complicates a more experimental approach.
- **Business models for developers depend on margins:** Correlation between the scale of the project and financial impact makes it difficult for developers to find partners in Berlin and Germany for a large scale project.
- **Business as usual:** Lack of engagement from big companies and developers. Large companies and project developers build the usual way based on costs and proven technology.
- **Lack of awareness:** Initial generators of demand for construction, are not familiar with the topic of circular construction, so the topic is not usually reflected in the design letter. However, clients are getting more engaged in the topic of sustainability, also through other building practices (energy efficiency).
- **Lack of awareness:** It is hard to find planning competence everywhere, which can accompany the topic along with the process, without constant resistance, which costs money.
- **No willingness to pay more:** Few clients are willing to engage and pay for this type of construction process.

Public housing associations

- BNB certification is currently applied only to construction projects that are realised by the Senate itself, but not by housing associations, which limits application of BNB.

Tenants and buyers (clients)

- No interest and understanding on sustainability certification by tenants or buyers, thus there is no interest in sustainability certification. They are more interested in AFA, i.e. the depreciation of monuments. Whether developers have certificates or not it does not make any difference to the sale.

Architects and planners

- **Lack of understanding:** Architects do not deal with material suppliers for circular economy, rather with technical solutions. And if they start discussions on specifics of materials from circularity, they do not get transparent feedback, rather a marketing oriented response.
- **Lack of awareness:** For architects it is not clear why recycled concrete is more expensive.
- **Wrong incentives:** The payment of the architect is directly connected to the volume of the project: why should the architect be motivated to reduce the amount of resources if the costs are higher and his/her income is reduced?

City and district

- **No leverage on the local level:** District municipalities can hardly influence current regulation in order to empower circular construction, as they mainly act too late on implementation but not in the decision-making phase. There is no legal framework for districts to allow, order or forbid anything because that's up to federal law.
- **Lack of awareness:** For the construction authorities, the senator for construction and the public sector as a whole, the topic is very new and not yet on the agenda. It is also a false assumption that new approaches can be costly and more time consuming.
- **No capacities:** Shortage of skilled personnel in district administration and city administration that are familiar with the topic of circular (sustainable) construction
- **No public incentives:** The Senate wants more recycled concrete to be used. The problems is that it is less standardised, more expensive than conventional concrete, and it is difficult to source it.
- **No public incentives:** Lack of understanding that timber construction should become a mass market.
- **Time pressure:** The public administration has a lot of time pressure and therefore only focuses on the work that is urgent

Material developers, carpenters

- **Not included in the planning process:** Material developers are not included in the process of construction planning or are asked to join too late.
- **Lack of awareness:** There is a lack of education for carpenters, which is currently old fashioned and out of date. It has to change: new terms need to be included in the education and training system.

Waste management

- **Business models for waste management depend on margins:** They increase prices for waste as there is less recycled content in the materials received, which means less secondary materials could be so on the market.
- **Technical limitations:** More composite materials appear on the market which are difficult to recycle, and there is no demand for secondary materials.

2.2

Action plan to enable circular construction

40

In order to close the gap, the following 9 actions need to be addressed

I

Provide extensive knowledge access to the topic of circular construction, its methods and know-how, to raise market awareness and demand for circular construction.

II

Create a definition for circular construction that is generally understandable, recognisable and acceptable.

III

Relax building norms and focus regulation on supporting and incentivising innovative work in construction, to promote the use of circular materials (renewable and secondary materials).

IV

Use public instruments such as public procurement and tax breaks to incentivise demand for projects in circular construction, as well as private financial instruments to fuel construction with circular principles.

V

Develop and establish widely used alternative project calculation methods prioritising a building's operational costs and considering life cycle costs of materials and components.

VI

Support, collaborate and innovate to establish new and scalable business models for circular construction to foster the efficient and sufficient use of materials, components and spaces.

VII

Educate and prepare new generation of professionals (architects, planners and craftsmen) who embrace sustainable construction practices, and can work with circular materials as well as provide infrastructure and facilities needed for circular construction needs.

VIII

Make use of circular materials such as renewable, reusable, recyclable and healthy factors the key elements for the realisation of construction projects.

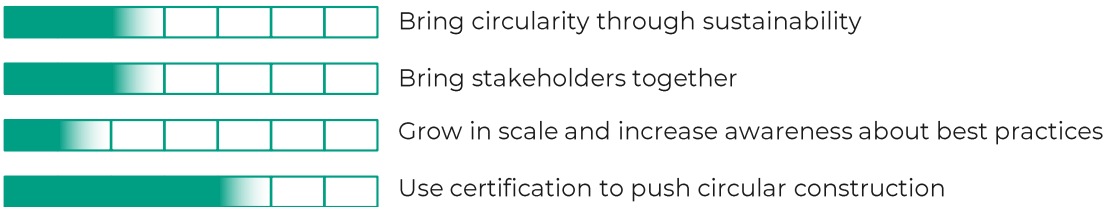
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Innovate with new technologies that can minimise the impact of current materials, improve usability of reused materials and bring transparency into the supply chain through traceability, into the processes and the industry.

Action # 1

Provide extensive knowledge access to the topic of circular construction, its methods and know-how, to raise market awareness and demand for circular construction.

Progress on the actions



Actions for stakeholders

For certification entities

- Push further the topics of circular construction; it forces the change down the value chain
- Make impact through material certification to grant material quality and reliability
- Incorporate circular economy principles into the certification process for public buildings.

For circular construction project developers, planners

- Disseminate circular projects, make them public and visible
- Incorporate circularity by "experiencing" circularity to make it attractive for clients and explicable in terms of the disassembly process
- Use the topic of sustainability to incorporate circular construction principles to educate clients about this topic.

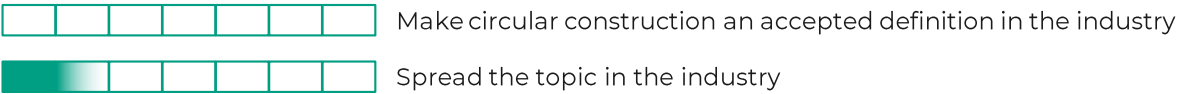
For networks and associations, and city administration

- Bringing stakeholders and the professional community together to raise awareness and help to spread knowledge
- Share good practices for circular construction openly with the construction community
- Build a good and practice-oriented network of reliable partners working in the field of sustainability, bringing all project partners onto a sustainable level, from suppliers, construction workers, who are assigned the tasks, also companies' own employees
- Make sure that buyers (private and public), tenants and institutional investors are informed and sensitised about sustainable and circular construction, in order to make adequate decisions and demand circular building
- Establish partnerships for project realisations (including public private partnerships/PPP) to foster circularity through collaboration.

Action # 2

Create a definition for circular construction that is generally understandable, recognisable and acceptable.

Progress on the actions



Actions for stakeholders

For networks, associations, and education organisation

- Promote the topic at conferences, seminars and conventional industry events
- Make it common currency, with explanations backed by examples and cases. It should be part of the discussion on resource treatment, resource collection and use
- Ensure that circular construction gets mentioned so that it is set as a topic and becomes an umbrella term
- Grow knowledge and change the mindset about construction with reused materials through education
- Shift the building paradigm for the design of buildings for both dismantling and material recovery.

For local authorities, politicians, administration

- Embrace the topic of circularity publicly, e.g. in city / construction objectives.

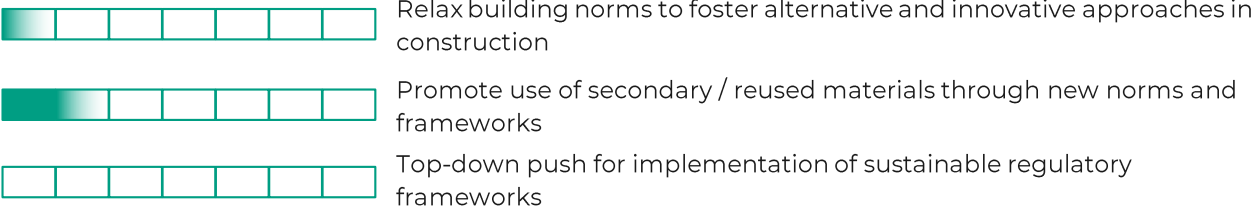
For circular construction project developers, planners

- Make the process of circularity visible and understandable by society, e.g. how disassembling buildings actually works
- Use widely, publicly accessible areas to promote the topic of circularity e.g. at main stations, airports etc.

Action # 3

Relax building norms and focus regulation on supporting and incentivising innovative work in construction, to promote the use of circular materials (renewable and secondary materials).

Progress on the actions



Actions for stakeholders

For construction industry

- Demand reevaluation of security measures and technical requirements that might unreasonably slow down the construction process and increase project realisation costs
- Be proactive with the use of legal measures - to kick-start the innovation engine

For certification entities

- Establish credibility for the secondary / reused material
- Incorporate reused materials into the certification process for public buildings.

For local authorities, politicians, administration

- The adjusted legislative system on circular construction should disseminate standards that govern and promote reused materials.
- Reevaluate the use of secondary timber, which should not be primarily part of a renewable energy act, as the first treatment step should be its reuse.

Action # 4

Use public instruments such as public procurement and tax breaks to incentivise demand for projects in circular construction, as well as private financial instruments to fuel construction with circular principles.

Progress on the actions

- Incorporate circular construction into public procurement
- Create adequate framework conditions through fiscal policy
- Link the topic of circular construction with financial institutions

Actions for stakeholders

For local authorities, politicians, administration

- Include natural building materials and recycled/ reused materials into public tenders, securing public procurement budget for circular construction
- Develop support for circular construction projects, similar to KFW-55, but with the focus on resource efficiency
- Incentivise to reuse fully functional materials through adequate framework conditions, e.g. through tax rebates..

For financial institutions

- Use financial instruments as loans to provide preferable conditions for sustainable construction projects
- Use different risk assessment models for circular construction projects.

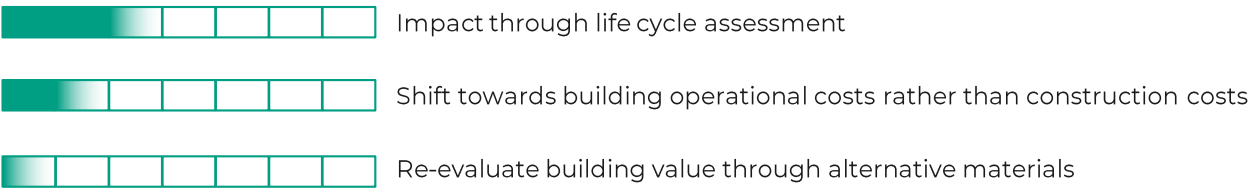
For developers, planners and industry associations

- Demand benefits in the form of e.g. tax rebates for sustainable and circular construction.

Action # 5

Develop and establish widely used alternative project calculation methods prioritising a building's operational costs and considering life cycle costs of materials and components.

Progress on the actions



Actions for stakeholders

For developers, housing associations and planners

- Select materials which decrease building maintenance over time, and accordingly decrease operational costs, like timber (wooden facades can last for 100 years, which decrease operational costs, and later it could be recycled) or some concrete types that can insulate
- Consider life cycle assessment and deconstruction or recycling concepts at the planning stage
- Deal with innovative procurement concepts at an early stage, alternatively rising costs will force a company to act fast with no consideration for sustainability
- Use natural ventilation and natural light systems that enhance sustainable operation of the building for a low carbon footprint and reduced energy costs.

For construction companies

- Use prefabricated construction and modular systems to realise circular construction project. Prefabricated system refers to prefabricated elements, e.g. walls that are transported by truck and then assembled on the construction site. In the case of prefabricated timber construction, it must be strong enough to be picked up and transported in one piece (without deconstruction). For a modular system, where the volume is fixed, the realisation happens in the factory (90-99% complete) and is then transported to the location.

For material developers

- Work towards minimisation of the environmental impact of conventional materials and costs of recycled materials, also focus on better promotion to show that it fulfils some DIN standards.

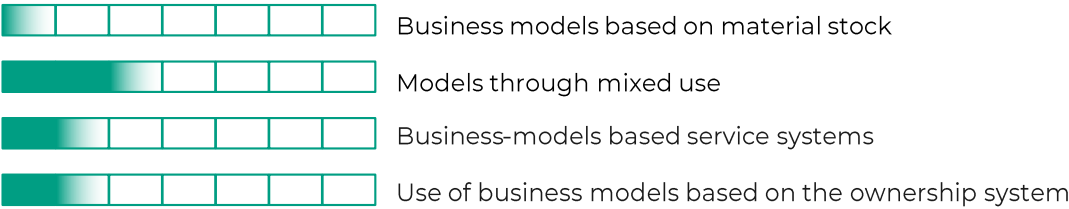
For financial institutions

- Define the model where the value of the building is higher through material stock, consequently the credit can be lower, which makes it possible to construct better and at lower cost.

Action # 6

Support, collaborate and innovate to establish new and scalable business models for circular construction to foster the efficient and sufficient use of materials, components and spaces.

Progress on the actions



Actions for stakeholders

For material developers, technical elements and waste management

- Improve the treatment of materials, so the industry can transition into a circular business model
- Develop deposit schemes through service models for building interiors, elements such as filters for ventilation, where producers own them and can take them back
- Focus on the business models with material value recovery through material ownership to foster the market for secondary construction materials.

For developers, building owners

- Establish new partnerships for new business models in terms of building operation e.g. for interior design that provides services with sharing models, e.g. for lighting systems, ventilation, elevators
- Collaborate with diverse stakeholders along the value chain to create innovative business models for circular construction. Several loops in the planning process are needed, meaning discussion with architects and then gaining feedback from the materials producers are needed
- Innovate with building for mixed use.

For planners and architects

- Include material developers in the project planning earlier, working together with architects in order to find solutions together.

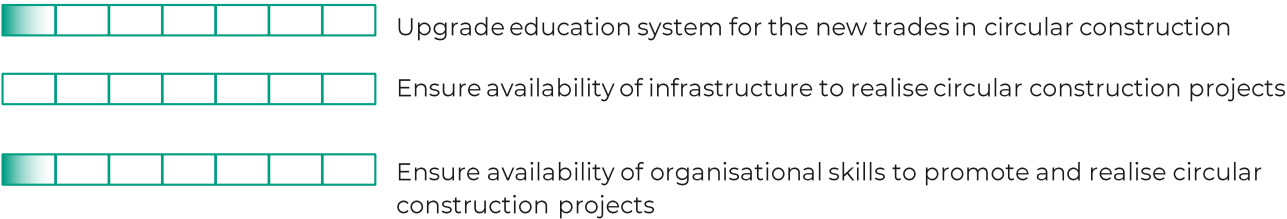
For public projects

- Test circular business models through public construction, because it is not mainly focused on profit maximisation. Public building owners look at prevention and damage avoidance.

Action # 7

Educate and prepare new generation of professionals (architects, planners and craftsmen) who embrace sustainable construction practices, and can work with circular materials as well as provide infrastructure and facilities needed for circular construction needs.

Progress on the actions



Actions for stakeholders

For public administration

- Bring more expertise about the sustainable construction in the public administration area / municipalitie, employing the stakeholders operating with the sustainable building solutions practically
- Support development of local timber workshop in your area to scale it up
- Invest into education of new professions - qualification offensive to reach the next generation of technicians, craftsmen/women and engineers.

For education organisations, networks and associations

- Focus on practical projects for construction with reused and renewable materials. It could involve diverse trades (metal workers, recycled concrete workers, plumbers, electricians, climate technicians, carpenters etc)
- Use vocational training, educational, apprenticeship programmes where participants and students work with whole-scale construction processes so they learn to work with reused materials and grow knowledge on more sustainable ways of building.

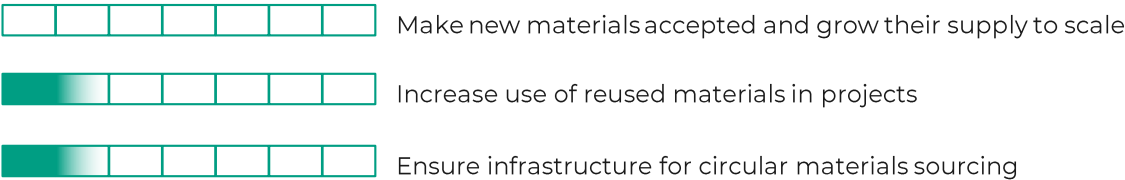
For architects, technicians and craftsmen & women

- Incorporate internal know-how and expertise into companies that can implement plans for circular / sustainable construction at realistic prices
- Introduce different incentives mechanism for architects, payment should directly connected to sustainability KPIs, rather than to the volume of the project
- Connect engineers to the building operation, so they carry responsibility for impacts during operation.

Action # 8

Make use of circular materials such as renewable, reusable, recyclable and healthy factors the key elements for the realisation of construction projects.

Progress on the actions



Actions for stakeholders

For public administration

- Bring more expertise about the sustainable construction in the public administration area / municipalitie, employing the stakeholders operating with the sustainable building solutions practically
- Support development of local timber workshop in your area to scale it up
- Invest into education of new professions - qualification offensive to reach the next generation of technicians, craftsmen/women and engineers.

For education organisations, networks and associations

- Focus on practical projects for construction with reused and renewable materials. It could involve diverse trades (metal workers, recycled concrete workers, plumbers, electricians, climate technicians, carpenters etc)
- Use vocational training, educational, apprenticeship programmes where participants and students work with whole-scale construction processes so they learn to work with reused materials and grow knowledge on more sustainable ways of building.

For architects, technicians and craftsmen & women

- Incorporate internal know-how and expertise into companies that can implement plans for circular / sustainable construction at realistic prices
- Introduce different incentives mechanism for architects, payment should directly connected to sustainability KPIs, rather than to the volume of the project
- Connect engineers to the building operation, so they carry responsibility for impacts during operation.

Action # 9

Innovate with new technologies that can minimise the impact of current materials, improve usability of reused materials and bring transparency into the supply chain trough traceability, into the processes and the industry.

Progress on the actions

<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	Enforce industry digitalisation to bring transparency into the processes and materials supply
<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	Innovate with technologies to understand building material content better as for potential for reuse
<div><div></div><div></div><div></div><div></div><div></div><div></div></div>	Minimise the impact of the materials through technological improvement

Actions for stakeholders

For material developers

- Improve recycled concrete process development (grind the concrete) in such a way that only water needs to be added
- Develop technologies to minimise the environmental impact of conventional building materials
- Improve and use the technologies for materials tracking to know material duration and properties
- Develop and use digital cloud database and a materials marketplace to understand when the specific materials become available for reuse. It enables the understanding of what materials are available, but then also creates the potential to share, resell and reuse materials

For public administration

- To push digitalisation for material and construction processes, digital reporting as an official administrative requirement of city authorities should be introduced for public projects
- Enforce the development of digital dossier of the buildings for new construction

For technology solution providers

- Match such solutions for the industry needs, such as technology-based hand held tools that allows on-site live analysis and identification of timber material categories of treatment; or 3D scanners for buildings to help to reuse building materials as it attempts to understand what is inside

3

Findings: Berlin projects and actors

3.1

Relevant projects for circular construction in Berlin

52

Relevant projects for circular construction

New construction projects

Artis Workshop, BERLIN-TEMPELHOF

Workshop building,
CC specifics: prefabricated construction, use of natural building materials, a Plus
Energy building
Status: Completed
Costs: NA
Size: 1,970 m²
Architect: ZRS Architekten
Client: ARTIS GmbH

B-Part am Gleisdreieck

Multifunctional building, coworking space
CC specifics: modular timber construction of a two-storey building on a
construction site
Status: Completed
Size: 1,000 m²
Costs: NA
Architect: RENGGLI
Client: COPRO

EDGE East Side Berlin

Office building
CC specifics: principles of shared economy incorporated into the mixed-use
model, developer aims to introduce the concept of space as a service by
facilitating sustainable operation of the building
Status: In progress
Size: 80,500 m²
Architect: Bjarke Ingels Group
Developer: EDGE Technologies

EDGE Südkreuz Berlin

Office ensemble
CC specifics: modular wood-hybrid construction of the two office buildings
Status: In progress
Size: 32,000 m²
Costs: NA
Architect: Tchoban Voss
Developer: EDGE Technologies
Client: [Vattenfall](#)

EDGE Grand Central Berlin

Office building
 CC specifics: developer aims to introduce the concept of space as a service by facilitating sustainable operation of the building
 Status: In progress
 Size: 22,800 m²
 Architect: Bolwin Wulf Architekten
 Developer: EDGE Technologies
 Client: [Scout24](#), [Oracle](#)

Effizienzhaus-Plus

Pilot project for an energy-efficient single-family house
 CC specifics: designed for 3 years, possible to dismantle and use the building at another location or to recycle it completely.
 Status: Completed
 Costs: NA
 Architect: Institute for Lightweight Construction, Design and Construction (ILEK), Werner Sobek
 Client: Federal Ministry of Transport, Building and Urban Development (germ. Bundesministerium für Verkehr, Bau und Stadtentwicklung)

FRIZZ23

Multifunctional building
 CC specifics: community-led and self-organised building cooperative, mixed-use building
 Status: Completed
 Size: 9,324 m²
 Costs: €18,160,000
 Architect and Client: Deadline Architekten: Britta Jürgens and Matthew Griffin

Gut Buchholz – New Eco-quarter Berlin-Pankow/Circular Neighborhood

Neighbourhood development
 CC specifics: constructions of 90 houses are reversible and recyclable, and with a conscious decision to refrain from composite materials and construction methods
 Status: In progress
 Size: 23,000 m²
 Costs: NA
 Architect: ZRS Architekten
 Developer: Incept

Integrated secondary school Berlin-Mahlsdorf

Public school building
 CC specifics: timber modular construction for the public building
 Status: Completed
 Costs: €34,800,000
 Architect: NKBAK
 Client: Part of city investment program Berlin School Construction program (Berliner Schulbauoffensive) conducted by Senate Department for Urban Development and Housing (germ. Senatsverwaltung für Stadtentwicklung und Wohnen)

Flexim Headquarters, Berlin - Marzahn

Office building
 CC specifics: timber-concrete structural system of six courtyard buildings
 Status: Completed
 Size: 9,900 m²
 Costs: NA
 Architect: ZRS Architekten Ingenieure
 Client: Flexim GmbH

Kleinen Wannsee, Berlin

Housing Estate
 CC specifics: low-energy timber construction of the three-storey building: timber frame elements filled with cellulose insulation
 Status: Completed
 Size: 1,275 m²
 Costs: NA
 Architect: ZRS Architekten
 Client: KMD-Wohnen Am Kleinen Wannsee GmbH

Max-Delbrück- Centrum für Molekulare Medizin in der Helmholtz- Gemeinschaft

Laboratory building
 CC elements: public building, built with recycled concrete
 Status: Completed
 Size: 5,400 m²
 Costs: €35,000,000
 Architect: Staab Architekten
 Material producer: CEMEX
 Client: Federal Ministry of Education and Research (germ. Bundesministerium für Bildung und Forschung)

Ostseeplatz Genossenschaft, Lynarstraße

Housing Estate
 CC elements: hybrid timber construction of 98 seven-storey mixed-use residential houses, four commercial units and a kindergarten
 Status: In progress
 Costs: >€3,000,000
 Architect: Schäferwennigerprojekt GmbH

QUARTIER WIR – Weißensee

Housing Estate
 CC specifics: community-led and self-organised building cooperative, mixed-use building
 Status: In progress
 Size 7,000 m²
 Costs: NA €
 Architect: Architekt Deimel
 Cooperative: Begeno

**Rammed Earth Haus
Ihlow**

Private house
CC specifics: use of local natural building materials: earth, timber and hemp
Status: Completed
Costs: NA
Architect: ZRS Architekten Ingenieure
Client: private house

**Rhoda-Erdmann-
Haus (Humboldt-
Universität)**

Life Science Campus, Humboldt-Universität zu Berlin (HU)
CC specifics: public building, built with recycled concrete
Status: Completed
Size: 4,700 m²
Costs: €33,800,000
Architect: Bodamer Faber Architekten, Stuttgart and technical department of the HU
Material producer: CEMEX
Client: Senate Department for Urban Development and Housing (former Senate Department for Urban Development and Housing)

**"Urbanen Holzbau" in
Adlershof**

Apartment building
CC specifics: timber construction of three residential buildings with 42 apartments
Status: Completed
Size: 2,825 m²
Costs: NA
Architect: Kaden+Lager GmbH
Client: HOWOGE

**Zentrum
Stadtmission**

Multifunctional building
CC specifics: hybrid timber construction, mixed-used building: community centre, conference rooms, restaurants, offices and social housing apartments
Status: Completed
Size: 8,850 m²
Costs: NA
Architect: Sauerbruch Hutton
Client: Association Berliner Stadtmission

Relevant projects for circular construction

Renovation, refurbishment

BAUHAUS reuse

Temporary building for educational project
CC specifics: construction with secondary materials, reused windows from Bauhaus Dessau
Status: Completed
Costs: NA
Project developer: zukunftsgeraeusche

C2C-Lab

Pilot project of the living laboratory
CC specifics: refurbishment project with natural materials and C2C inner concept, established network for reuse of materials and structural elements
Status: Completed
Size: 400 m²
Costs: NA
Architect: Drees and Sommer
Client: C2C e.V.

CRCLR House

Refurbishment and extension of the former warehouse
CC specifics: implementation of circular methods, C2C material approach, two and a half storeys of modular timber construction
Status: in progress
Costs: NA
Architect: RENGGLI, ZRS Architekten, Hütten & Paläste
Client: CRCLR, TRNSFRM eG

Geisberg, Berlin

Refurbishment of the historical post office into new six-storey complex
CC specifics: repurposing of the heritage building into the mixed-use building
Status: Completed
Size: 14,800 m²
Costs: NA
Architect: Markus Penell and Sebastian Kablau of Ortner & Ortner Baukunst
Developer: COPRO

Malzfabrik

Refurbishment of a former malthouse: five of the nine buildings are now renovated, remodeled and rented
CC specifics: sustainable building use concept
Status: Completed
Costs: NA
Architect: ioo Elwardt + Lattermann Gesellschaft von Architekten mbH
Client: IGG MALZFABRIK MBH

Metropolitan school project (Berlin)

Lightweight construction on existing prefabricated school building
CC specifics: use of prefabricated timber system, construction work during school operating hours
Status: Completed
Costs: NA
Architect: Sauerbruch Hutton
Client: Berlin Metropolitan School

Plattenvereinigung

Temporary recycled building, educational project
CC specifics: a completely de- and re- assemblable, recyclable building
Status: Completed
Costs: NA
Architect and project developer: zukunftsgeraeusche

Tierpark administration building

Partial building replacement
CC specifics: prefabricated timber facade elements
Status: Completed
Costs: NA
Architect: ZRS Architekten Ingenieure
Client: Tierpark-Berlin LLC

3.2

Actors relevant for circular construction in Berlin

59

Actors involved in Circular Construction in Berlin

Architects, Planners

Arcadis
ARUP
Bolwin | Wulf
Braun-Kerbl-Löffler architekten
BuroHappold
Drees & Sommer
Hascher Jehle Planen und Beraten GmbH
Hütten & Paläste
Kaden+Lager GmbH
Kaufmann Bausysteme
KSP Jürgen Engel Architekten GmbH
Partner und Partner Architekten
Raumlabor Berlin
Renggli AG
roedig . schop architekten
Sauerbruch Hutton, Architekt
Schäferwenningerprojekt GmbH
ZRS – Berlin

Certification-related organisations

Bau Zert - Zertifizierung Bau GmbH
BNB certification
Cradle to Cradle e.V.
DGNB - Deutsche Gesellschaft für Nachhaltiges Bauen

Secondary construction waste resale

Restado

Real Estate Developers

COPRO Projektentwicklung GmbH
EDGE Technologies
INCEPT

Construction, Materials, Technicians

CEMEX
HATI - Gesellschaft für Handwerk, Technik und Innovation
GASAG
Heidelberger Beton GmbH
HU-Holzunion GmbH
Kaufmann Bausysteme
Lafarge Holcim
Nolde and Partner
Renggli AG
Würth Gruppe
Züblin

City and local level administration

BIM (Berliner Immobilien Management) GmbH
Bundestagsfraktion Bündnis 90/Die Grünen
District City development municipalities
Senatsverwaltung für Stadtentwicklung und Wohnen
Senatsverwaltung für Umwelt, Verkehr und Klimaschutz
Stadtwerkstatt

Associations

Architektenkammer Berlin
Holzbau Deutschland - Bund Deutscher Zimmermeister im ZDB e.V.
Lafarge Holcim Foundation
Unternehmerverband Mineralische Baustoffe (UVMB) e.V.

Housing Associations, Cooperatives

Am Ostseeplatz eG, cooperative
Begeno, cooperative
BUWOG-Berlin Wohnen GmbH
CRCLR GmbH
Edith Maryon Stiftung
Holzmarkt plus eG
HOWOGE Berlin
IGG MALZFABRIK MBH
Internationales Kultur Centrum ufaFabrik e.V.
Trnsfrm eG

Universities, Education

Bundesinstitut für Bau-, Stadt- und Raumforschung
Projekt Management Jülich - Forschungszentrum Jülich
Fraunhofer-Institut für Holzforschung - Wilhelm-Klauditz-Institut (WKI)
Informations- und Kompetenzzentrum für zukunftsgerechtes Bauen (IKzB)
Institut für urbanen Holzbau
TU Berlin - Natural Building Lab
TU-Berlin - Department of Urban and Regional Planning
TU-Berlin - Fachgebiets Bauphysik und Baukonstruktionen
TU-Berlin - Institut für Architektur
Zukunftsgeräusche (Bauhaus Reuse)

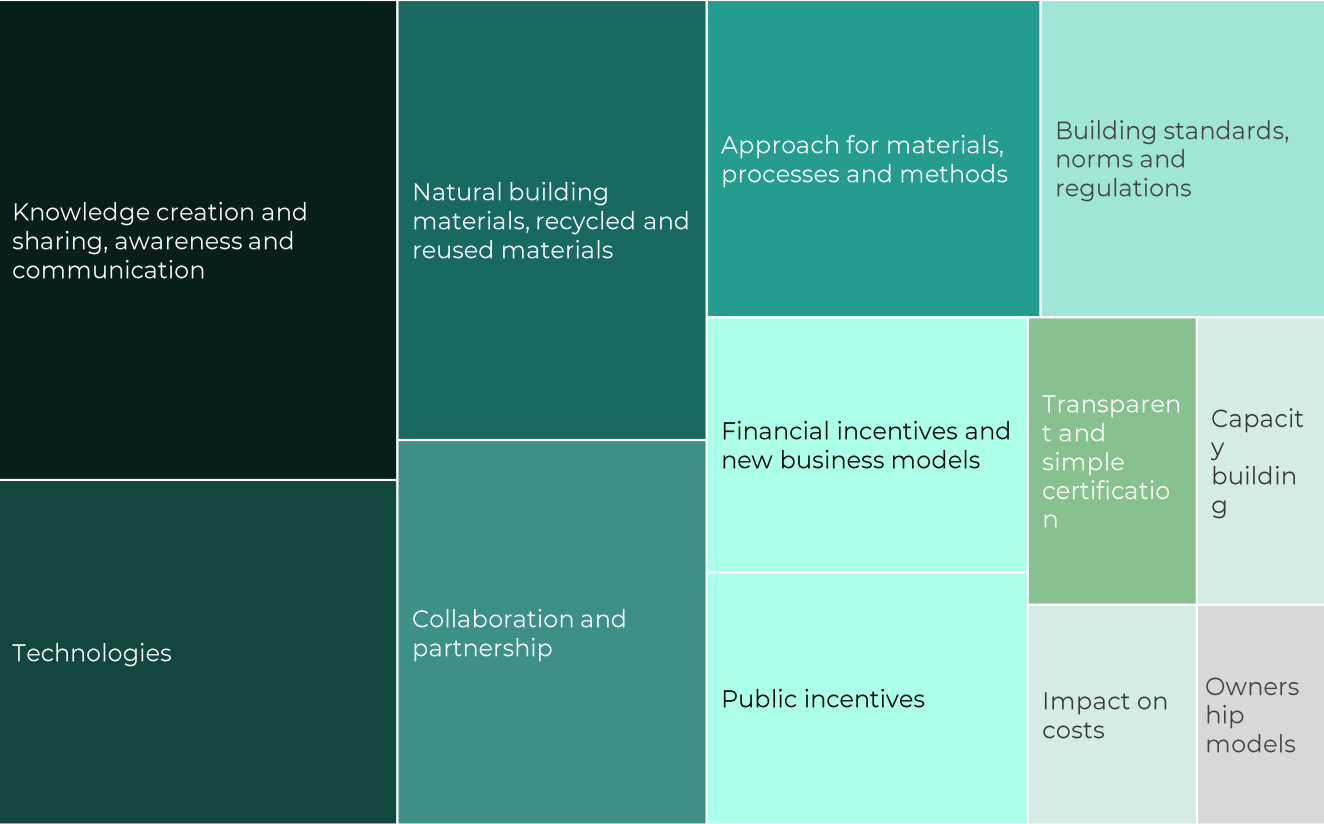
Waste management and Recycled materials

Gesellschaft für Boden- und Abfallverwertung mbH
GRAF Recycling-Baustoffe
Heinrich Feess GmbH & Co. KG
Otto - Rüdiger Schulze
Holz- und Baustoffrecycling
REMEX Mineralstoff GmbH

Appendix 1 - Identified areas as enablers

Key impact areas to enable circular construction in Berlin

Through the interview process the following 12 areas were mainly identified as the key enablers to make a shift in the industry towards circular construction



Knowledge creation and sharing, awareness and communication

1

Improve definition

- The definition of circular economy and circular construction must be a common one; explanations must be supported by examples and cases. It should be part of the discussion on resource treatment, resource collection and use.

Support for knowledge sharing

- Sharing practices and know-how is needed to support actors with the topics of sustainability / circular economy.
- The focus should be on raising awareness and creating a professional community, engaging more actors in circular construction projects also in the form of public private partnership.
- Berlin Senate supports information through promotion of information via video and diverse communication tools, expert dialogues with planners, owners, architects and material suppliers.
- As an approach, the creation of an exhibition on modular (circular) construction would be valuable.
- Projects will receive more visibility and awareness through public engagement, including residents into discussion, promotion in the media and in education

Growing in scale and increasing the cases of best practice

- The projects in circular construction should be better known. Circular projects should be more visible and more spread via communication, so people can start asking questions as to the "why?" and "how?".
- Examples should be made popular, so that people know where to go to experience circularity. We need more places where it is obligatory to show how the circular economy works.
- The initiation of the pilot project to show people how disassembling buildings works is valuable.

Certification as a means for awareness raising

- In cooperation with DGNB, members and

partners are searching for a credible knowledge partner. Thus DGNB tries to disseminate the topic further. Circular Economy was included in the form of bonus points / criteria in DGNB certification as a first step, not as part of certificate requirements.

Circularity through sustainability

- Clients are interested in sustainable projects, and there are more projects where clients would like to understand circular economy principles better. It is not a full project with regard to circular construction, but rather an opportunity to implement some circular construction elements, build a knowledge base and raise awareness among clients.

Raising awareness through education

- Educational task for schools, universities and colleges in the field of circular economy could help to create awareness.
- Through educational projects, it is possible to grow knowledge and change the mindset about construction with reused materials. It might involve diverse trades (metal workers, reinforced concrete workers, plumbers, electricians, climate technicians, carpenters etc)
- Through vocational training, educational, apprenticeship programs, participants and students occupied with whole-scale construction processes thereby learn to work with reused materials and growing knowledge on more sustainable ways of building

Berlin/Germany specifics:

- In Germany there is still a lack of an umbrella term that still needs to be given, a brand, whether cradle-to-cradle or circular building or reusable building, but we must all work to ensure that this gets a headline so that it is set as a topic.
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Enabling circular construction via technology

Materials treatment and tracking

- Technology-based hand tool allow on-site live analysis and identification of timber materials categories of treatment.
- Technologies for material tracking help to know material duration and properties.
- Technologies such as 3D Scanner for building will help to reuse the building materials as it attempts to understand what is inside.

Technologies for concrete

- Technological improvement is needed, e.g. adding other substances to the cement, such as fly ash, which has a similar binding consistency to reach concrete value need.
- Recycled concrete ideally requires very little or no cement to be added. The aggregates can be disputed. If companies manage to grind the concrete in such a way that only water needs to be added, it would revolutionise the construction industry.
- There are concretes that insulate. Using these despite somewhat higher material costs, savings could be made on insulation.

Digitalisation

- Better documentation of the building and materials is crucial, where digital technology can help build 'digital twins' of the building.
- Open source documentation to build digital dossiers for the buildings is needed, such as Madaster.
- Digital cloud database and a materials marketplace will help to understand when the specific materials become available for reuse, the database user can find and purchase them. It enables to understand what materials are available, but then also creates the potential to share, to resell and to reuse materials.
- Blockchain gives an opportunity to simplify the contracts and transaction processes. If the project requires more complicated ownership

structures of materials in the buildings, this kind of technology can accelerate the process and issue contracts in a very simple and quick way.

Berlin specifics:

- A mobile crusher of concrete waste for Berlin will help to reduce the amount of inner-city construction waste at the Spandau plant.

Natural building materials, recycled, reused materials

Increased use of Recycled concrete

- Recycled concrete ideally requires very little or no cement to be added. The aggregates can be disputed. If we manage to grind the concrete in such a way that only water needs to be added, it would revolutionise the construction industry.
- Advertising for recycled concrete is needed to show that it fulfils some DIN standards and that it is available at an affordable price.

Timber can be cost efficient, valid for lightweight construction and faster in use, with less noise

- If a future construction is created for short term use, timber is a good material for such projects (e.g. for refugee housing), because it is also possible to deconstruct it with this material.
- Construction with timber brings the advantage that it is less noisy, much faster and more reliable because a lot can be prefabricated.
- Timber construction means it's possible to keep the structure of the old building, and used it for the building extension, e.g. build on top of the building as it is light construction.
- The costs for wooden construction are not high anymore, which increase the chances for this material use, because the process is automated.
- Conventional facades need to be maintained every 15 to 20 years, or re-painted, wooden facades can last for 100 years, which decrease operational costs, and later it could be recycled.

Material acceptance is needed

- Promotion of natural building materials is needed, such as straw and clay, to make natural building materials more acceptable as technology progresses.
- Materials research is still needed to push the new materials on the market.
- The topic of wellness in building use can enable further development of the natural building materials topic.

Opportunities for secondary materials markets

- In the case of building reuse, there is a chance for secondary material markets to grow, e.g. for metal and pipes, heaters, tubes.

Berlin specifics:

- Berlin city administration is pushing the topic of recycled concrete and timber construction in the construction sector in Berlin.
- One argument for timber modules for school buildings in Berlin is that it's faster. Every half year the school is finished faster it helps the school authority due to the lack of places in school. Wooden construction is faster and can be completed in 3/4 months (depending on size), but in any case it is faster than concrete construction. It is a big advantage for developers.

4

Collaboration and partnership

Bringing stakeholders together, networking

- Bringing stakeholders and the professional community together can raise awareness and help to spread knowledge, engaging more actors in circular construction projects also in the form of public private partnership.
- It is an important process to build a good and practice-oriented network of reliable partners working in the field of sustainability, bringing all project partners onto a sustainable level, from suppliers, construction workers, who are assigned the tasks, also companies' own employees
- Develop partnerships for interior design that provide services with shared models, e.g. for lighting systems, ventilation, elevators etc.
- Circular building needs many partners: public sector and the private sector. Decision-makers could be motivated to engage via cooperatives, associations, chambers of trade, chambers of commerce and industry, and round tables.

Berlin specifics:

- Networking in Berlin-Brandenburg for timber construction is a first step forward, with the objective to support small businesses operating in the field of circular construction.

Approach for materials, processes and methods

Materials impact minimisation

- New methods to minimise impacts of most high carbon building materials are needed: concrete, steel, aluminium, glass.
- By combining water-permeable and aerodynamically shaped impermeable panels, a very sustainable form of cooling is achieved.

Considerations for planning and construction

- For the building, it is crucial to consider the timeframe of its use, since it impacts material selection and construction process
- Prefabricated construction helps to realise circular construction. It refers to prefabricated elements, e.g. walls that are transported by truck and then assembled on the construction site. In the case of prefabricated timber construction, it must be strong enough to be picked up and transported in one piece (without deconstruction). For a modular system, where the volume is fixed, the realisation happens in the factory (90-99% complete) and is then transported to the location.
- Several loops in the planning process are needed, as it is not a linear decision-making chain, meaning discussion with architects and then gaining feedback from the materials producers are needed. These overlapping construction processes are needed to reach a higher sustainability rate.
- Cross-laminated timber construction might be a solution for timber high rises and big timber beams.
- Shifting the building paradigm is needed for the design of buildings for both dismantling and material recovery.

Decreased costs for building operations

- Natural ventilation and natural light systems enhance sustainable operation of the building for a low carbon footprint and reduced energy costs.

The opportunity to increase building and elements for reuse

- Circular construction could be enhanced if the buildings are reused; adaptable building reuse is crucial, preserving the entire building structure.
- Everyone who makes decisions about construction should take a close look at the building materials selected, where solid combination materials should be avoided, so that the elements can be easily dismantled.
- Dismantling of the prefabricated elements should happen on site and then brought for recycling.
- Use of timber as a mono-material is the best approach for circularity currently. It will impact timber beams, meaning it is only possible for the small spaces (rooms). But in that case it can be recycled, upcycled and reused.

Handbook on how to build circular

- A catalogue of criteria for planning offices is needed **so** that they have the know-how on site.

Building standards, norms, regulations

A top-down shift is needed

- The shift should start on the political level by pushing for development and implementation of sustainable regulatory frameworks by the construction industry. Due to the intrinsic slowness of the construction industry itself, it is very difficult to accelerate the change bottom-up, so the demand for change should come from decision-making levels: local authorities, politicians, administration, etc.
- The construction industry (large craft businesses, planners, construction companies) should be proactive with the use of legal measures - to kick-start the innovation engine.
- Beyond networking, the next steps are legal requirements and incentives through support programmes.

Regulation for reused materials

- The adjusted legislative system on circular construction should disseminate standards that govern and promote reused materials.
- Secondary timber should not be part of a renewable energy act, as the first treatment step should be its reuse.

Relaxing building norms and regulation

- With speed and fewer regulations, costs can be saved that can then be invested in sustainability.

Public incentives

More support from city administration

- Support from city administration is one of the key factors in actual realisation of the project.

Tax reduction for buildings with a circular approach

- Benefits for circular construction should be given to the planners/ architects, while opportunities for developers for the development of circular building, e.g. by means of tax rebates, should be created.
- The incentives to reuse fully functional materials should be introduced. Adequate incentives to establish a relevant price. It is the task of municipalities to promote such framework conditions, e.g. through tax savings.

Public Procurement Systems

- A Public Procurement System (PPS) is an effective way of financing circular construction as implemented in other countries (Norway, Sweden, Netherlands). It is a very efficient instrument for finding funding for public construction. This type of project may be more complex in terms of implementation, but as an outcome, the buildings are likely to be better, and not only for the same price, but also sometimes even with lower costs.

Berlin/Germany specifics

- Implementing more efficient funding solutions. For instance, securing public procurement budget for circular construction in Germany. The current budget is 700 billion euros a year for all public projects. If there is 2% is allocated for sustainable construction on a regional or city level, it can make a huge difference and a major step forward.
- Public administration should promote recycled concrete and use of natural building materials via public tenders.

Financial incentives and new business models

Business models for building operations

- Partnerships for interior design can support new business approaches for building operations, going towards services with a shared model, e.g. for lighting systems, ventilation, elevators etc.
- In case of building interiors, such elements as filters for ventilation system could be ideal case for a deposit system for residential and office buildings; it could impact the business models - the producer would own them and have to take them back, i.e. the purchase price would then be somewhat more expensive, but the motivation would be there to perhaps think about reusable filter systems.

Business model based material stock using leasing models

- Constructing a building as material stock impacts the value of the building, thus if the value of the project is much higher, the credit can be very low which makes it possible to construct much better and less expensive buildings for the environment and for people.
- In the model where buildings are only leased, the materials belong to the company and the company is not only responsible for them, but has an interest in keeping the value of this material. At the end it should be only about the maintenance costs.
- If there is a further improvement in the material treatment, the industry itself can transition into a circular business model.

Investment into technologies to enable circular and sustainable construction

- Higher investment rates should be for technologies for green energy production, material recycling, energy efficiency, to make them more available and affordable. Incentives for the producers of circular materials and products should be created to make circular product development possible.

Business models through mixed building use

- Approaches for different use models of the building should be supported.

Risk minimisation as part of the construction business model

- Risk minimisation is a driver for all stakeholders along the value chain, and therefore not only about performance.

Regulate demand according to market situation

- During a construction boom, it is difficult to impact the demand side. The topic only becomes interesting again when the market goes down and then selective buying and renting processes resume once more.

Transparent and open certification

Promotion of circularity through certification

- DGNB, BNB and BREEAM certificates are considered to be an essential enabler of sustainability, but this must be made clear.
- Standards can push the topic of circular construction down to the construction value chain, even though it is not desirable there.
- Competition for the best eco-standard should be promoted.

Material certification is granting quality and reliability

- Certification for wood, for the material itself is needed.
- Transparency with materials, such as project “followfish” is needed: there is a need to know where materials come from.
- The quality of a material going into a manufactured product is as important as the reliability of the production process. Materials testing helps to understand and quantify whether a specific material or treatment is suitable for a particular application.

Certification processes considers life cycle costs

- Life cycle costs are considered through certification, but this is predominantly done in commercial construction.

Berlin/Germany specifics:

- Circular construction certificates are very important for Germany as an expert procurement entity. They are a crucial base for enabling and fostering circular construction, not only for the actors implementing the project, but also funding bodies, city administration. Without certificates, it is hardly possible to implement this innovative topic.
- Certifications have the advantage that they should be valid for all buildings and diverse clients. Once they have been introduced, you have something in your hand. Nevertheless, BNB certification should be better developed, towards an eco-label.
- BNB certification is currently applied only to construction projects that are realised by the Senate itself, not by housing associations, which potentially could be included.

Capacity building

Education for technicians, engineers, craftsmen and carpenters

- New professions must be well trained, so a qualification offensive to reach the next generation of technicians, craftsmen and engineers is needed.
- Education on practical projects for construction with reused materials is needed. It could involve diverse trades (metal workers, reinforced concrete workers, plumbers, electricians, climate technicians, carpenters etc).

More companies ready to implement innovative approaches

- Companies are needed that can implement plans for circular / sustainable construction at realistic prices. Ideally, this should be done through dialogue, where the procurement framework needs to become a little more flexible.

Berlin specifics:

- In the coming years, Architektenkammer will offer training for timber construction.
- Berlin is an attractive location for newcomers: this potential should be used to develop handcraft skills.
- Berlin politics support the timber trend. It encourages companies to open subsidiaries in Berlin. However, in order to scale timber construction, more timber workshops in Berlin are needed.

Impact on costs

Impact through life cycle assessment

- Life cycle assessment must be considered in the planning stage of deconstruction or recycling concepts, and it will impact cost evaluation.

Material choice impacts construction costs

- Timber construction is not as expensive, because the prefabrication process is automated.
- There are concretes that insulate. By using them despite somewhat higher material costs, savings could be made on insulation.

Shifting towards building operational costs rather than construction costs

- In construction, the initial investment and the decision whether to build or not is extremely important, but relatively insignificant throughout the entire life cycle of a building. Operational costs of the building should be considered, and also costs for maintenance should be included. E.g. a wooden facade with the right maintenance can last very long, and after that it is possible to recycle it. These are decisive points that have to be considered during the initial investment. They cost a little more per square metre in front, but are easier to handle at the back. Conventional facades need to be maintained every 15 to 20 years, or re-painted, but wooden facades can last 100 years, which decreases operational costs.
- Sustainable / circular construction might have higher initial costs in construction per square meter, but it can be easier to deal with the building during the operational phase. E.g. Energy saving is also cost saving.
- Due to rising construction costs, there is a need to deal with innovative procurement concepts at an early stage, alternatively rising costs will force a company to act fast with no consideration for sustainability.

Ownership model

Material ownership

- The new business models for circular construction should focus on the role of material value recovery. Material ownership can help with this and it fosters the establishment of a secondary materials market.

Ownership of the building elements

- In case of building interiors, elements such as filters for ventilation systems could be an ideal case for a deposit system for residential and office buildings. It could impact business models: the producer would own them and have to take them back, i.e. the purchase price would then be somewhat more expensive, but the motivation would be there to perhaps think about reusable filter systems.

Building ownership

- Building ownership also impacts decisions for circular construction, so mainly private clients, who use the building for themselves, are more interested in sustainable solutions.

Process ownership

- It is crucial to transmit ownership for the building through the construction process. Planners and engineers should carry responsibility until the end of life of the building. To create circular processes, this ownership and awareness for the development of buildings is needed. It will impact building design significantly.

Appendix 2 - References

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