

NL

Netherlands



Circular Buildings: constructing a sustainable future



HAUT, a timber hybrid 21-storey residential building in Amsterdam by Team V Architecture. Photo: ©Jannes Linders

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“It is very important that the progress made in terms of circular construction in the Netherlands corresponds with developments in the rest of Europe (and vice-versa)”

Prof.dr.ir. Vincent Gruis

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Professor of Housing Management - Delft University of Technology
Chair of the (Dutch) Circular Construction Economy Transition Team

Circular Buildings: constructing a sustainable future

A sustainable use of our earth and its resources is important for everyone and the urgency to make the transition to a circular economy is greater than ever.

The principles behind circular construction are obvious. We stop depleting natural resources, emitting hazardous substances and polluting our living environment. Instead, we will reuse materials, reduce our waste stream and build sustainable and future-proof.

Buildings – both residential and non-residential – make up a significant part of the built environment and are the backbone of a healthy economy. Buildings form the basis of communities, power businesses, connect workers to their jobs and protect the nation from an increasingly unpredictable natural environment. Society and the economy need reliable buildings that shelter, house, and connect people and communities.

However, construction consumes around 60% of the world's materials and is responsible for around 53% of the world's greenhouse gas emissions, a big part of which is attributed to buildings. Population growth, the need for more residential buildings, upcoming renovation waves and climate change will place new challenges and demands on the buildings sector and unprecedented pressure on the supply of raw materials.

The construction sector has been focusing on more sustainable use of materials for years, but the actual transition to a circular construction economy has yet to take place. Many national and international partners are needed to make this important transition. This includes demolition companies, contractors, wholesalers, financiers, real estate investors, architects, public and private clients, developers, government, science and education.

In the Netherlands, the construction sector is recognized as one of the key sectors in the transition to a circular economy. A dedicated Dutch 'Circular Construction Economy' Transition Team with public, private and knowledge partners has been set up with a clear strategy to achieve a circular construction economy by 2050.

The strategy and goals document geared towards 2023 states that:

“It is very important that the progress made in terms of circular construction in the Netherlands corresponds with developments in the rest of Europe (and vice-versa).”

As the chairman of the transition team, I am therefore very pleased with this publication.

It clearly shows the enormous potential of circular buildings, the need for international cooperation and the best practices and knowledge that the Netherlands has to offer as a partner in reaching our joint circular and climate goals. These solutions can inspire the world and create opportunities for frontrunners.

In the global drive towards circular and net zero economies, buildings have an essential role to play. Circular buildings have clear potential to bring about long-term impact in terms of climate change mitigation and resource scarcity and contribute to the realization of the 1.5°C Paris Agreement target, as recently re-emphasized during the UN Climate Change Conference.

Now is the time to act. The COVID-19 pandemic has shown first-hand how vulnerable supply chains are worldwide and how shortages of (critical) raw materials can affect the delivery and pricing of building projects. Strengthening efforts to transition to circular buildings internationally is needed to secure sustainable supply and diversify material sources.

As building projects tend to be large, create jobs, have a long lifespan, and are mostly market-driven, they are ideal projects for post-COVID-19 green recovery funding. International cooperation to change the way green building projects are financed is of vital importance and comes at a timely moment.

For a circular buildings sector to reach its full potential and scale necessary for a sustainable future, we need to work together. International cooperation is paramount to boost knowledge and innovation development, to ensure alignment and harmonization of protocols, norms and standards for driving more circularity in infrastructure, to create a well-functioning common market for renewable and secondary raw materials and to make sure that the use of raw materials is increasingly efficient and of high quality.

The good news is: circular solutions already exist across the entire value chain and we can start from existing knowledge and lessons learned about how to make buildings circular and climate neutral. Initiatives such as dedicated value chain collaboration programmes, circular public procurement, data strategies, design principles and measurement methods have proven successful in providing clear insights and guidance to a wide range of stakeholders in order to advance the transition.

By joining forces, the Circular Construction Economy Transition Team, the Ministry of Infrastructure and Water Management, the Ministry of Interior and Kingdom Relations, Holland Circular Hotspot and Arcadis, have summarized their expertise, insights, networks and a number of demonstration cases in this publication. I hope it will inspire to take action and kick-start circular building initiatives in other parts of the world.

For us, circular buildings are essential in constructing a sustainable future; join us on this road and do not hesitate to contact the authors for further information.



Photo: Superlocal, circular area development in Limburg, source: Circular Construction Economy Transition Team

Introduction and context

Buildings – both residential and non-residential – make up a significant part of the built environment and are the backbone of a healthy economy. But, the construction sector is one of the largest consumers of (heavy) raw materials. It consumes around 63% of all materials in the world¹ and buildings are responsible for a large part of that. Buildings are also responsible for more than 30% of the European carbon footprint and more than 40% of the primary energy consumption in Europe.² The environmental impact of the buildings sector will be huge if we keep building in the traditional linear way as we do now, as almost 70% of the world's population is expected to live in urban areas by 2050. Additionally, many of the current buildings are aging and need to be replaced or renovated soon, especially in Europe. An upcoming renovation wave of existing building stock and forecasted growth of the amount and size of cities creates momentum for future proof solutions in the buildings sector.

New innovations and perspectives can be the solution for future proof buildings that improve quality of life and reduce the heavy toll the sector pressures on our living environment. Circular economy principles can help solve building sector challenges in several ways. Circular design, for instance, pre-integrates lifespan considerations, and future reuse of materials and structures at every stage of building projects. Taking into account renewable and biobased materials as well. But we need to search for an integrated approach, maximising benefits.

Installations, for example for heating and cooling, make up an integral part of buildings. Most of the footprint impact of buildings today, takes place during the usage phase. Circular strategies aimed at installations should be incorporated upfront during the design phase. Next to energy efficiency, these strategies should also focus on material resource impact. Strategies can focus on circular manufacturing, new business models like products as a service, digital innovations or lifetime extension by making installations easy to repair, refurbish or dismantle.

This publication explores how circular economy concepts can help tackle the challenges the sector faces, supporting the transition towards a more sustainable and futureproof buildings sector. It showcases best practices from the Netherlands, which is a country with challenging terrains and very few natural resources. An action agenda is presented in the concluding chapter, calling for international cooperation to unlock the potential of circular buildings in the global run towards climate neutrality and circular economy. It proposes an international action agenda which looks in more detail at what is needed to realize the transition to circular buildings on both the EU and international levels.



Chapter 1

Buildings & utilities sector

Construction of residential and non-residential buildings

Construction is a sector of high strategic importance due to its essential role in the socio-economic development of a country. It connects many sectors such as mining, industrial, energy, waste, and mobility sectors. In the European Union, the construction sector is among the largest economic sectors, composed of nearly 3.3 million enterprises and 12.1 million employees.³ To these numbers, the contribution from the mining and quarrying sector has to be added, with more than 17 thousand firms and 0.4 million employees.³ The construction sector can be divided into two major subcategories, infrastructure and buildings. This brochure focuses on the latter.

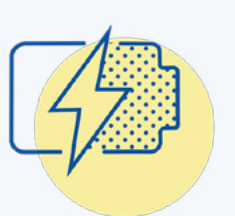
Buildings represent roughly half of the construction sector. The building sub-sector can be further divided into residential and non-residential buildings. On average in European countries, the share of residential buildings in terms of floor area surpasses that of non-residential buildings. Unlike infrastructure, construction for buildings can be undertaken by individual landowners as well as corporations or public institutions. Housing is among the most significant drivers of the sector, with investments worth 5.4% of EU GDP in 2020 (figure 2).

Figure 1: Impact of the construction sector

Based on a building's full lifecycle, the building sector is responsible for:



1/2 of all extracted materials



1/2 of the total energy consumption



1/3 of water consumption



1/3 of waste generation

Source: European Commission 2021⁸

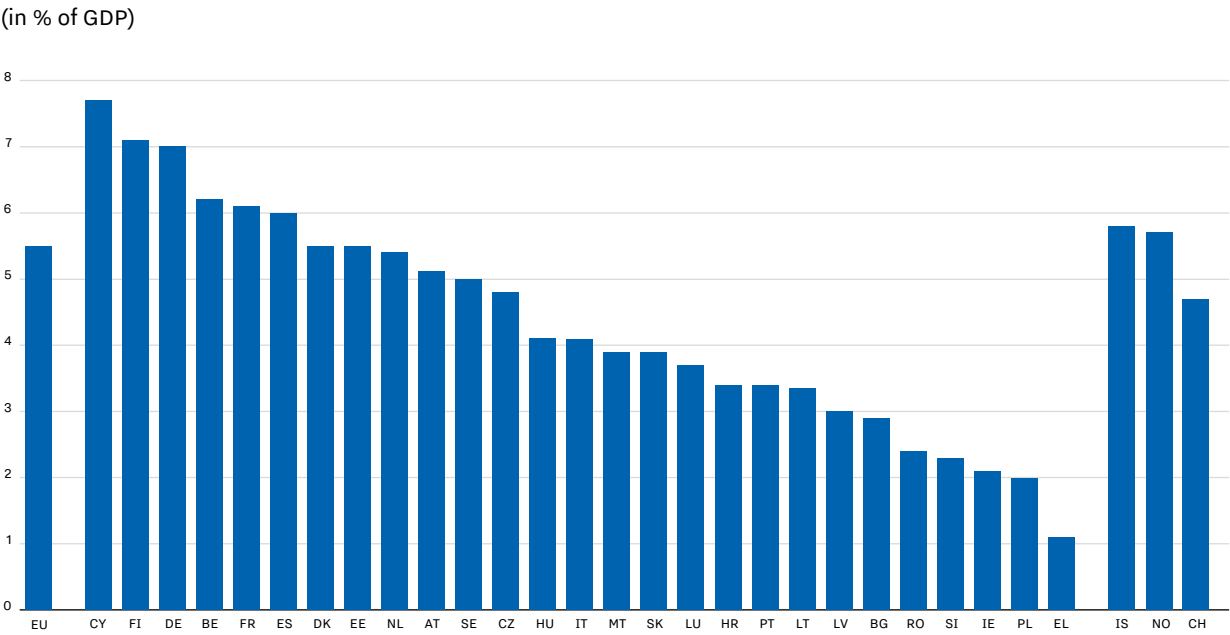
The building materials market refers to the market in which products for structural construction works (cement, concrete, sand, bricks, wood or glass panels, etc.) and products for finishing works (insulation, glass-wool, mortars, clay tiles, ceilings, etc.) are traded. In 2020, the European building materials market size exceeded USD 110 billion.⁴

The aggregate sector extracts raw materials that are produced from natural sources and extracted from pits and quarries, including gravel, crushed stone, fill and sand. They form the base of compound materials used in the buildings sector, such as concrete and cement.

The average demand for aggregates in Europe³, for the total construction sector, is almost 6 tons per capita per year. The total amount of production in Europe was more than 3 billion tonnes in 2018, of which 327 million tonnes (a share of 10.6%) recycled and reused aggregates.⁵

The environmental impact of the buildings sector will be huge if we keep building in the traditional linear way as we do now. Almost 70% of the world's population is expected to live in urban areas by 2050. If this expansion happens at the expense of natural ecosystems, and without biodiversity integration plans in the built environment, the outcome can be detrimental for many natural ecosystems and therefore climate change. In fact, buildings are responsible for more than 30% of the European carbon footprint and more than 40% of the primary energy consumption in Europe.² Furthermore, there is room for improvement as 75% of existing buildings in Europe are energy-inefficient⁶ and 15% of building materials are wasted in the construction phase. While recycling rates of construction materials are high across the EU, most of its value is lost after the first cycle as 70% can be defined as downcycling.⁷

Figure 2: Investment in housing 2020 (EU)



Source: Eurostat 2022⁹

Materials in buildings

The construction sector is one of the largest consumers of (heavy) raw materials. It consumes around 63% of all materials in the world¹ and buildings are responsible for a large part of that.

Concrete is the most widely used man-made material in existence and second only to water as the most consumed resource on the planet.¹⁰ In the Netherlands concrete makes 77% (in weight) of the materials in buildings.¹¹ As it offers flexibility in shaping, durability, high resistance to compression, fire and water, it is obvious why concrete is such a popular building material. It does however come with some drawbacks. Cement, which is the main binding material in concrete, is on its own responsible for around 8% of the world's CO2 emissions.¹² It is also extremely water and energy-intensive during its production phase and hard and costly to recycle.

Steel is another fundamentally relied-upon material in construction due to its durability, flexibility, stress resistance, and its high density that allows the realization of relatively lightweight structures. It is used in almost all structural elements. The construction of infrastructure and buildings is estimated to account for more than 50% of the world's steel demand.¹³ Similar to cement, steel production is a major contributor to climate change. According to the world steel association, every ton of steel produced in 2018 emitted on average 1.85 tons of carbon dioxide, equating to about 8% of global CO2 emissions.¹⁴ On the other hand, steel is a 100% recyclable material and keeps almost all of its original properties when reused. The downside though, is that the recycling of steel is quite energy consuming. Other construction materials are brick, wood, insulation materials, glass.



Photo: Upcycle Centre Almere, by Modulo Milieustraten. modular and circular environmental waste sites. Thanks to the flexible construction method, user-friendly sustainable environmental waste sitse are built that can be adapted, recolated and reused over time. Credits: Ronald Tilleman

Secondary, renewable and biobased materials

A significant amount of end of lifetime materials go to waste. The largest amount of overall waste generated globally is construction and demolition (C&D) waste, which also includes waste from infrastructure. In Europe, the construction sector is responsible for over 35% of the total waste generated.¹⁵

Looking at resource efficiency to minimize the use of primary materials in the buildings sector, two construction approaches can be distinguished: The focus on the output from disassembly for building materials (lifecycle extension, reuse and recycling), and the application of renewable and biobased

solutions rather than finite materials. In the Netherlands approximately 38% of construction materials account for secondary materials (mainly fill sand, recycling granulates and soil) and only 3% renewable (mainly clay, bricks, wood and ceramics¹⁶).

Biobased construction can make an important contribution to the circular economy. On the one hand, because biobased building materials are renewable in a relatively short period of time, compared to other materials such as ore or petroleum. On the other hand, because they remove greenhouse gases from the air during growth instead of simply causing additional emissions. If biobased materials are handled properly, its application can even lead to a GHG positive result.



Photo: Circl in Amsterdam, a circular living lab that easily adapts to changes during its lifespan, by Architekten Cie

Building stock in Europe

The building stock across Europe is diverse. The characteristics of the building stock can be identified by categories such as [floor area per sector](#), [buildings by construction date](#), and [buildings typology](#); figures 3, 4, and 5 respectively.

The ratio between residential and non-residential buildings varies from around 60% in The Netherlands and Slovakia to more than 85% in more southern regions such as Italy and Cyprus. As seen in figure 4.

The majority of the existing building stock is over 50 years old. This generally indicates lower energy efficiencies typically in buildings constructed before the introduction of the first thermal regulations (before 1970). New dwellings (built after 2000) have higher overall energy performance.

The non-residential buildings distribution by function is diverse and depends on the economic structure of each sector. On average, public and private offices make up 30%, wholesale 27%, and education 16%.

Figure 3: Breakdown of building floor area (2013)

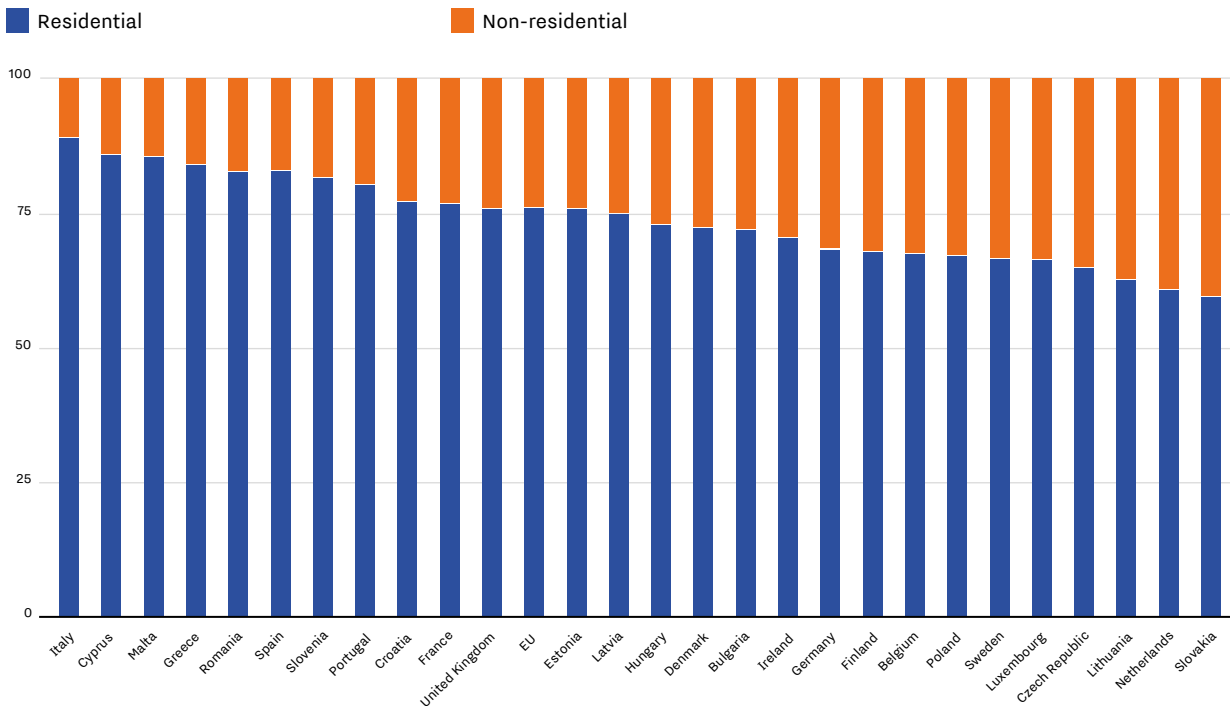


Figure 4: Breakdown of residential building by construction year (2014)

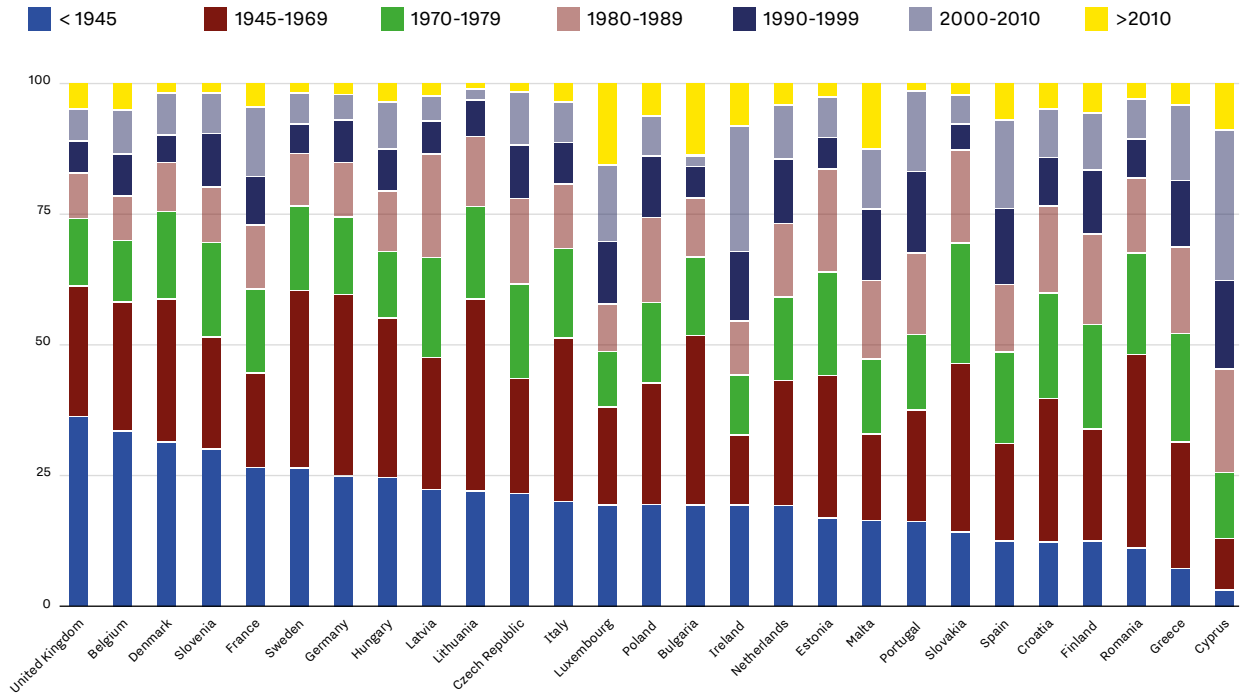
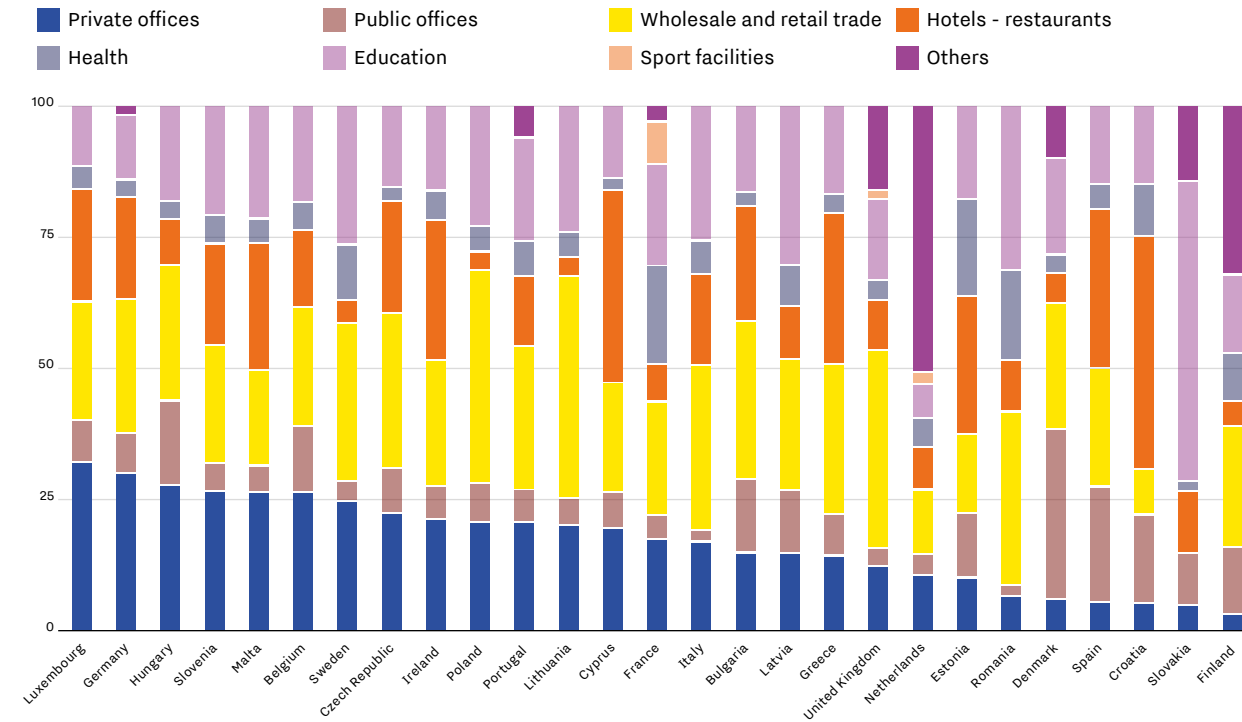


Figure 5: Distribution of non-residential floor area by area of use (2013)



Source figure 3, 4 & 5: European Commission 2022¹⁷

Challenges facing the sector

The world is changing around us every day. Macro-trends, such as population growth, migration rates to cities, increased demand for products and services, as well as climate change and the loss of biodiversity, are all factors that are putting pressure on all economic sectors to future-proof their processes and activities. This also goes for the construction of buildings. With a global population set to grow by 20% to almost 10 billion by 2050¹⁸, demand for buildings is bound to increase as well.

The construction sector is predicted to add some 230 billion square meters of new building stock over the coming 40 years, according to the United Nations Environment Programme's Global Status Report.¹⁹ 85% of the EU's current building stock was built before 2001, and 85-95% of the buildings that exist today will still be standing in 2050. This indicates that in order to limit the impact of the building's sector, interventions need to happen at three main levels: design and sourcing materials for new buildings, adjustments and maintenance of current buildings, and clever reutilization and deconstruction of buildings approaching their end of life.

Increasing demand for materials

Global trends indicate a rapid increase in demand for new buildings in the coming decades. This is mainly driven by growing populations and increasing wealth around the world (especially in Asian and African regions), but also due to a demand for housing upgrades in highly urbanized areas.²⁰ As such, large amounts of materials are needed. Building technology has advanced substantially over the past decades. For example, buildings can be built with lower environmental impacts (such as using wood or less metal for the same structural properties), designed for a longer lifespan, or for a higher post-consumer recycling rate. However, despite these technological advances, less-efficient building practices are still being widely used, especially in regions that will see most of this demand.²⁰

There is a strong directly proportional correlation within the G20 countries, between the demand for materials and resources and the size of the population and the economy in terms of GDP. With a global population set to grow by 20% to almost 10 billion by 2050¹⁸, demand for materials is bound to increase as well. These trends pose a critical challenge in reducing greenhouse gas emissions from building materials and meeting global climate targets.

Renovation challenge and energy transition

Buildings account for a major energy consumption, both during the construction phase and in the usage phase. The total global share is estimated at around 35%, and the sector's total emissions, residential and non-residential, direct and indirect, and both during construction and usage, add up to 38%.¹⁹ These emissions resulting from construction phase only, can be referred to as embodied carbon. It is caused by the production of materials for buildings and the energy that is needed for construction. Emissions caused in the usage phase can be referred to as operational carbon. This is caused by energy needed for buildings in use. Currently, roughly 75% of buildings in the EU are not energy efficient, yet 85-95% of today's buildings will still be in use in 2050.¹⁹ Environmental policies have traditionally focused on improving energy efficiency and renewable energies in the use phase while neglecting material efficiency in construction. The more the sector improves its energy reduction in the use phase of buildings, the more important it will be to reduce the emissions related to materialisation. Circular economy contributes to this reduction.



Photo: BlueCity/ Sophie de Vos, architect: SuperUse Studios

Circular economy & buildings



Photo: Liander's fully circular renovated and energy-positive office, by RAU architects. Source: Circular Construction Economy Transition Team

The building sector faces a number of major social and environmental challenges. As previously discussed, due to the growing population and increasing living standards, the sector is expected to grow worldwide in the coming years. But the construction of new buildings, as well as maintenance and renovation of existing buildings comes with a heavy toll on the environment. In this chapter, we introduce the concept of circular economy and illustrate how the application of circular concepts can contribute to building a healthier, less harmful, and generally more sustainable building sector.

What is a circular economy?

Circular economy is an economic model that favors the preservation of natural resources and decoupling of economic growth from material consumption over the entire lifecycle of products and services. It contradicts the linear (take, make, dispose) economic system that is still widely adopted across industries.

The key to a circular economy is closing the loop of products and raw materials, keeping them in use as intensively and as long as possible, preventing wastage and waste as much as possible (along the [Ladder of Circularity \(10-R\)](#)). When discarded, products and materials are reused and recycled. Where new materials are added, they have a low environmental footprint, e.g. natural, renewable and regenerative materials used instead of fossil based primary materials.

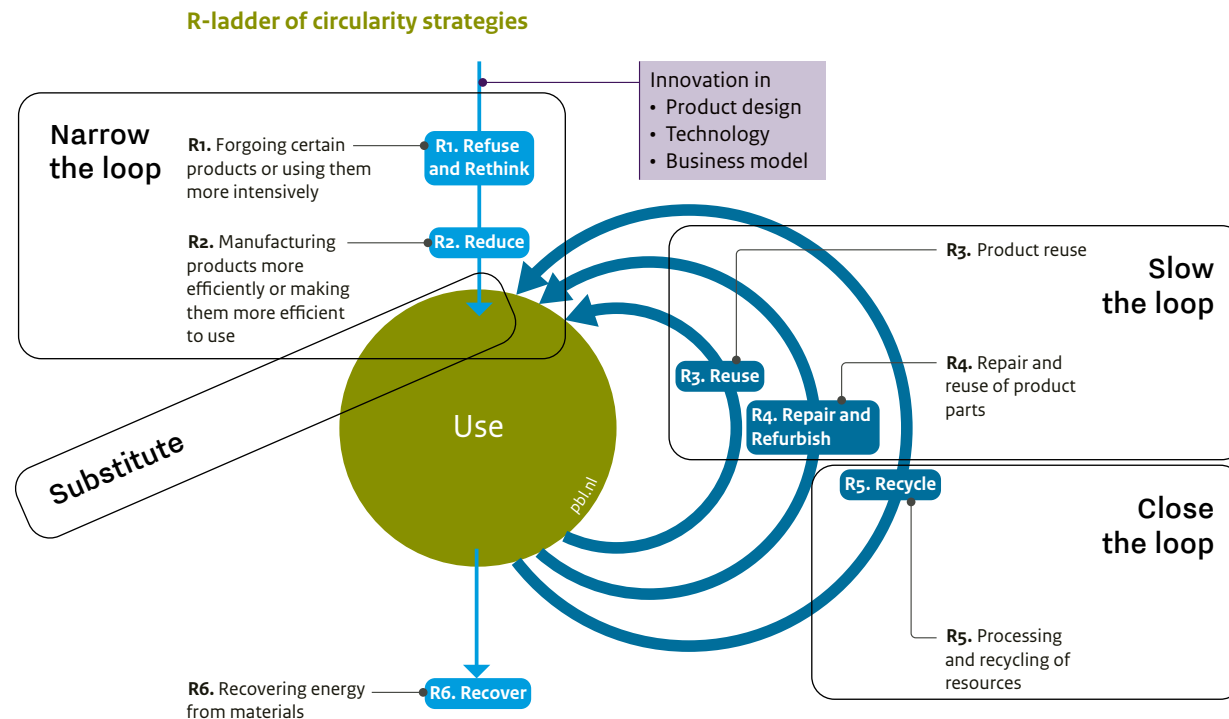
It's about much more than waste management ..

The term circular economy is often and mistakenly used interchangeably with terms such as “recycling” or “waste management”. As much as end-of-life processes play a fundamental role in the transition to a circular economy this misconception is far from accurate. Circular economy is about value retention along the whole supply chain and life cycle of a product or service and designing out waste and emissions from the beginning.

The circular strategies in figure 5 represent 4 main goals when it comes to material loops:

1. **Narrowing resource loops** (reducing the input of resources) by refusing the use of products (prevention) when possible, intensifying the use of products or reducing the use of materials through more efficient manufacturing or efficiency in using them;
2. **Slowing down or elongating resource loops** (longer and high value use of materials and products) by reuse, repair, and remanufacturing of products;
3. **Closing the loops** (reducing loss of materials through waste) by recycling and recovering energy from materials when all the previous options are no longer possible.
4. **Substitution where applicable**. This includes the use of biobased, renewable materials instead of primary abiotic materials.

Figure 6: Circular Economy Principles in the Construction Value Chain

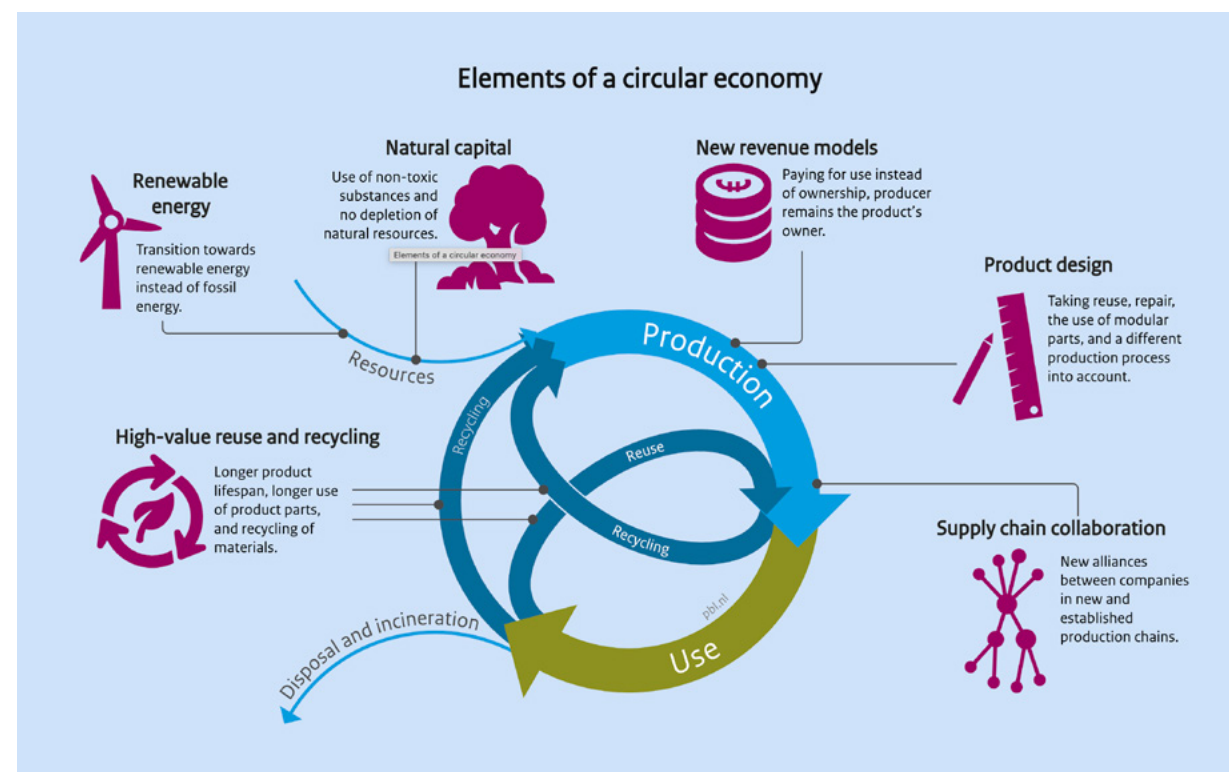


Source: PBL 2018, edited by the Ministry of Infrastructure and Water Management²¹

Circular Economy principles (figure 7) offer a holistic and realistic approach to facing the world's most pressing challenge: accommodating for a growing population's demand for products and services without exceeding earth's capacity and depleting its natural resources, all while keeping global temperature rise within the 1.5°C boundary

and without sacrificing the economic return from business practices. The circular economy approach makes this possible through innovative design principles and business models, value-chain collaborations and procurement schemes, making use of digital technologies and technical innovations, aiming at a complete system change.

Figure 7: Elements of a circular economy



Source: Source: Source: PBL 2017²²



Photo: Bouwdeel D, a fully demountable office building in Delft, constructed entirely from a prefabricated steel structure and prefabricated laminated wooden floors of Laminated Veneer Lumber (LVL) elements. Credits: cepezed

A circular buildings economy

Circular economy principles can help solve building sector challenges in several ways. **Circular design** pre-integrates lifespan considerations, and future reuse of materials and structures at every stage of the project.

Buildings are usually designed with a specific purpose in mind. However the use of buildings changes over time and the different parts of a building do not all last the same time, as clarified by the 6S model (see figure 8). Consciously thinking about the different lifespans of the different layers and separating the layers within the building ultimately allows the building to remain in use for longer.

Asset management is another very important aspect. By developing circular maintenance and renovation

strategies, asset managers can make choices to ensure that materials and structures from a built asset remain in use for as long as possible. A circular economy approach not only enables a higher residual value but above all a far better total costs of ownership. At the end of an asset's lifespan, **high-quality recycling** and **reuse** of materials can address the huge amounts of construction and demolition waste, resource scarcity, and environmental impact associated with material production. The increasing need to phase out the use of (scarce) primary resources can also drive the sector towards the use of **renewable** and **bio-based materials**, such as timber, hemp, and elephant grass. However, many **new solutions** and **innovations** still need to be developed for high-quality recycling and reuse of materials, sustainable production, and service-life extension of materials.

The different layers and their average lifespans are:

- Stuff 5-15 years
- Space plan 5-20 years
- Services 5-30 years
- Skin 30-60 years
- Structure 60-200 years
- Site > 200 years

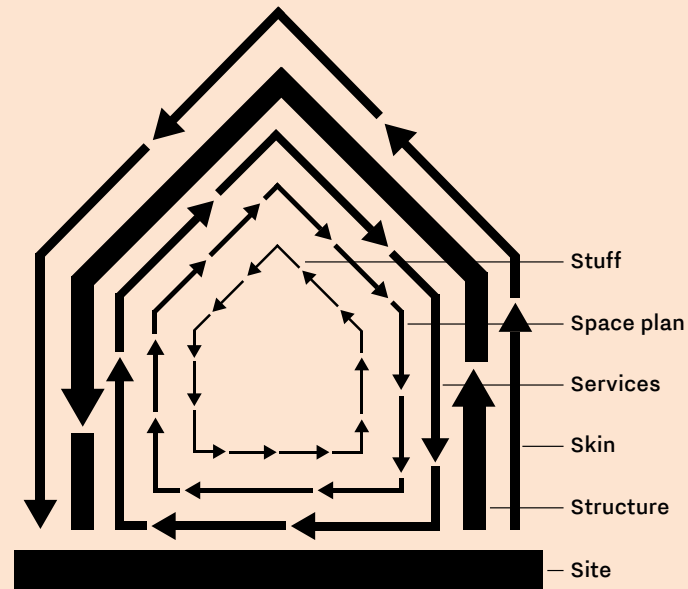


Figure 8: 6S-model

Source: Brand, 1994 in Circular Building Transition Team 2020²³

To achieve high-quality reuse, it is required to have insights into the quantity and quality of the materials and structures of a built asset and their availability for reuse. With this information, it becomes clear when parts of an old building can be reused for a new building. **Digital technologies** such as material passports or digital logbooks can track the journeys of products, components, and materials. Circular data strategies need to be developed to make the resulting data securely accessible over the full lifespan of the construction. Digital solutions and **sustainable business models and services** (e.g. products-as-service) will not only dematerialize our economies and make them less dependent on primary resources, but also create innovative jobs and upgrade knowledge and skills. In addition to data, developing **methods to measure circularity** is essential to make informed decisions. For instance, in the design phase and procurement, and to monitor progress.

Buildings are procured for a large part by the public sector and institutional organisations. The **procurement** can offer unique opportunities to lead the way towards an interesting market for stakeholders to develop climate neutral and circular solutions. **Circular procurement** can therefore offer additional opportunities to transition to circularity. Nevertheless, structural attention to public procurement and long-term policies are needed for the market to invest in circular innovation.

An integrated approach to maximize benefits

When speaking about circular buildings, it is important to keep in mind that the large construction sector including buildings and infrastructure is highly interdependent. Taking material flows for instance, a very high percentage of the construction and demolition waste from buildings is reused in the infrastructure. Both sub-sectors share many similarities such as digital logbooks, circular design

and measurement methods, and more. Therefore, the road to a circular construction sector needs to be better aligned and look at both buildings and infrastructure*. This also applies to the industry, which supplies materials for both sub sectors.

Installations, for example for heating and cooling, make up an integral part of buildings. Most of the footprint impact of buildings today, takes place during the usage phase. Circular strategies aimed at installations should be incorporated upfront during the design phase. Next to energy efficiency, these strategies should also focus on material resource impact. Strategies can focus on circular manufacturing, new business models like products as a service, digital innovations or lifetime extension by making installations easy to repair, refurbish or dismantle.

An integrated approach is required to maximise benefits. This is further elaborated in chapter 4.

Building a circular economy

The transition to a circular buildings industry is a complex issue, but also offers huge potential in implementing new business models and looking at the total cost of ownership instead of just the initial costs of a building. The larger the scale in which circular products and services are applied, the higher the cost reduction and cost effectiveness, and the faster learning experiences can be gained. On top of that, circularity also provides great opportunities on both the supply side and the demand side. Smart reuse and a lower energy demand in the production process offer cost benefits. There is a demand for a multitude of new products and services, each with their corresponding economic incentives. Through smart demolition or disassembly, demolition companies can retrieve entire construction parts from a building designated for demolition so that these can be reused. Wholesalers can also respond to the need for distribution of used construction materials.



Photo left and right: Van Gelder Groente & Fruit energy efficient office, designed by Kraaijvanger



The New University Building of VU Amsterdam by Team V Architecture. Sustainable and energy-efficient building made with renewable materials. Photo: ©Jannes Linders



Photo: The Green House accommodates a circular catering concept, housing a restaurant and meeting rooms. Credits: cepezed

Showcase

The creation of a circular building: the Green House

For the redevelopment of an area in the centre of Utrecht the Dutch Government Property Management Agency (Rijksvastgoed) decided to create a temporary project for a part that would otherwise remain unused for 15+ years. Main goal of the temporary project was to contribute to social liveliness and safety in the development area. The partnership R creators won the tender with the proposal to create a circular catering pavilion: The Green House.

The Green House is a collaborative project between Strukton, Ballast Nedam and Albron, who have entered into a partnership of at least 15 years for the realization including a circular business case and operation. Strukton and Ballast Nedam are involved as developer/building owner/energy supplier/maintenance party and Albron as concept developer, decorator and catering operator. Architectural firm cepezed was the designing party.

In addition, Strukton, Ballast Nedam and Albron put their available budgets together and looked at what they could best invest in, considering the entire life cycle of the building. Not only for the construction, but also integrally for the operation. The shared vision on circularity and shared core values - collaboration-oriented, inspiring, efficient and future-proof - are included in the partnership agreement.

Development in phases

Originally the Dutch Government Property Management Agency wanted to develop the entire 100,000 square meter site of the former Defense barracks De Knoop at once. However, because there was low demand for office space at that time it was decided to develop De Knoop in three phases. The first phase, 33,000 square meters, has been completed. In the second phase, another 40,000 square meters will be realized and in the third phase the remaining 22,000 square meters. At the same time as the first phase, The Green House was built on the site where the third phase is planned. It opened its doors in spring 2018.

'The main reason for realizing The Green House was that we did not want to create an urban development gap pending the third phase the area. In addition, we wanted a function that would provide social liveliness and safety.'

– Peter Eitjes, procesmanager integrated procurement at Dutch Government Property Management Agency.

For the conversion of De Knoop the Dutch Government Property Management Agency used a new approach that embraced social and sustainable values. Besides the three existing tender criteria for the building contract – experience value, utility value and future value – two new tender criteria added: sustainable partnership and hospitality.

The concept

The Green House accommodates a circular catering concept plus meeting facilities. The reusable pavilion was erected in three months. This rapid construction was possible by the use of remountable and prefabricated elements, and the use of recycled elements from the same site. In addition, the building can be completely dismantled according to the principles of circularity including the foundation of prefab concrete blocks. After use on this location, it can be easily taken apart and rebuilt elsewhere.

Taking up the challenge

How do you create a building that can stand for fifteen years, but then just as easily be demolished and can be built elsewhere? Or of which all materials can be reused in all kinds of ways become? The winning team of the tender formulated the best answers to these questions. They shared the goals to gain experience with this innovative way of building, to set an example for other construction projects and as a breeding ground for circularity. Because also the visitors to the catering establishment must be able to gain inspiration.

The two-storey pavilion is a 'building kit'. It has a detachable steel frame made of galvanized profiles. The dimensions are derived from the smoked-glass façade panels on the former Knoop barracks; these were reused



Photo: The facade is made from glass panels coming from De Knoop barracks. For the closed parts of the façade on the first floor, prefabricated, dismantable and recyclable timber-frame panels were used. Credits: cepezed

for the second skin and the pavilion's greenhouse. The floor consists of paving bricks from an old quay in Tiel. The storey floor has been constructed with pre-used wood.

Comfort and safety

The reusable underfloor heating on the ground floor is laid in a sand bed on top of a good insulation package, finished with the recycled paving bricks. Upstairs the removable underfloor heating system is placed on recycled concrete tiles, which are supported by a prefab wooden floor construction. Not only for a pleasant temperature, but also for less contact noise. The acoustically perforated roof sheets provide good acoustic comfort; an additional lowered ceiling is therefore not necessary.

100% recyclable

For the perforated roof, the architects chose a light steel sheet. With glass panels on the façade, coming from De Knoop barracks, the plinth of the pavilion is completely transparent. For the closed parts of the façade on the first floor, prefabricated timber-frame panels were used. These are 100% recyclable and (H) CFC-free and can be dismantled.

Vegetables from own greenhouse

The 80 m² vertical greenhouse is located on the first floor, next to the meeting rooms. Here, vegetables and

herbs are grown for the restaurant kitchen. Rainwater is used for irrigation. Thanks to a void in the pavilion, you can clearly see the freely accessible greenhouse from the restaurant below. The large greenery wall also contributes significantly to the experience of The Green House.

Energy neutral

The greenhouse not only functions as a buffer for a good climate in the building, but is also energy saving. By connecting The Green House to heat and cold generation, assuming a compact high-quality insulated design and the application of PV panels is energy neutral building.

Pioneering with partnerships and new business models

The Green House involves numerous cooperation partners in both construction and operation who participate in numerous sub-aspects. This created pioneering space for new ways of collaboration. For example, a contract has been concluded for the lighting supply for the next 15 years. The product is purchased as a service, a so-called pay-per-use agreement. The fixtures have not been purchased but remain the property of cooperation partner Trilux.

This business case is interesting for partners, because they can assume guaranteed income over 15 years. This allows them to make choices that pay for themselves in



Photo: In the 80 m² vertical greenhouse located on the first floor, vegetables and herbs are grown for the restaurant kitchen. Rainwater is used for irrigation. Credits: cepezed



Photo: Circular 'as-a-service' collaboration contracts are concluded for lighting, furniture and herbs and crops. Credits: cepezed

‘That element – social liveliness and safety – we will also include it in the final implementation of phase three. This may consist of housing only or a combination of housing with offices. That choice has yet to be made.’

– in F-Facts May 2019

the long run. The same form of cooperation has been entered into with furnishing supplier Maasdam and supplier of herbs and crops for the greenhouse, HRBS.

The collaborations provide new business models. These are based on feasibility, so that they can be performed (on a daily basis) and subsequently achieve a healthy return, which makes it possible to scale them up both operationally and financially. On site, for example, by composting organic waste and by using 'The Color Kitchen'.

Inspiration for De Knoop

The first phase of De Knoop development also contains elements that fit well with a circular approach but is not fully circular. Main reason for this is that the concept of circularity was not yet played when the development was started in 2012. Example of circularity is that the Dutch Government Property Management Agency has chosen deliberately to have the hull demolished as little as possible. At the end only a fifth has been demolished. Materials are also partly recycled. Façade material has not only been reused in The Green House but also in the landing of the temporary bridge from Knoopplein to the Forum.

Recognition

After opening The Green House has received awards and award nominations such as the Dutch Sustainable Building Award 2019. Moreover, The Green House has become a lively and popular meeting spot close to the Utrecht central station. According to Ernest van de Voort, director marketing & concepts at Albrion it remains a great showcase for people who want to see what is possible on the area of circularity and it attracts many interested parties. The connection that the building radiates speaks to people: it's a pleasant building to stay in. "We want to keep developing it and make it better, what we learn we use in future projects".



Photo: The Green House has become a lively and popular meeting spot close to the Utrecht central station. Credits: cepezeed

The Dutch approach and best practices

Circularity is becoming more and more common. In our language, but also in construction practice. Not surprisingly, because the principles behind circular construction are obvious. We stop depleting natural resources, emitting hazardous substances and polluting our living environment. Instead, we will reuse materials, reduce our waste stream and build sustainably and futureproof. However, the transition from a linear to a circular construction practice does not happen by itself. We have to abandon the way we worked for countless decades and look for new forms of collaboration, with different business models and new actors.

This chapter showcases some of the best practices that apply circular economy principles along the buildings value chain. Through the Dutch triple helix approach of collaboration between the public sector, private sector, and academia, circular innovations are continuously emerging (figure 6). The perfect circular project does not exist, so it is certainly not our intention to make a sum of the best circular projects in the Netherlands. However, it is our intention to give a series of good examples of how clients and contractors implement the theme in practice.

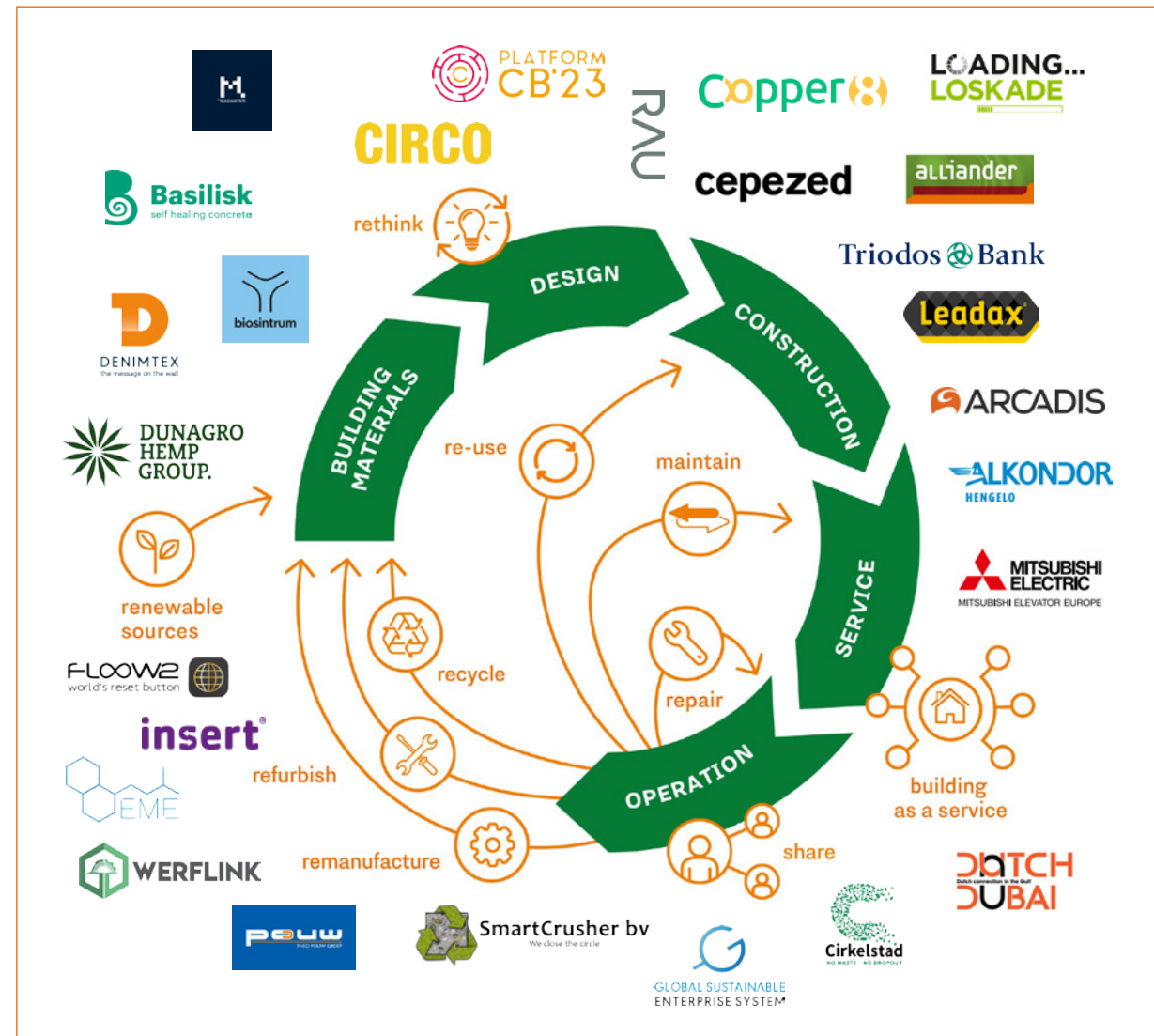
In this chapter we have sub-divided the best practices into the following categories:

- circular policies and practices
- circular procurement
- measuring circularity
- circular design strategies
- technical and material innovations
- material passports and data strategies
- circular business models
- circular marketplaces
- supply chain collaboration, platforms and regional initiatives

Value chain of buildings

The best practices in this chapter can close the value chain of buildings when working together. In figure 9, all mentioned best practices are plotted against the several phases in the value chain to illustrate a closed loop for buildings.

Figure 9: Closing the loop for buildings



Source: Holland Circular Hotspot

Circular policies and strategies

In 2016, the Dutch government published a governmentwide programme titled 'A Circular Economy in the Netherlands by 2050'. This programme introduces an ambitious target for the country, which is for The Netherlands to be fully circular by 2050. It defines five priority themes, which includes the construction sector. Separate transition agendas have been developed for each theme and are currently being carried out through yearly implementation programmes.

The transition agenda 'Circular Construction Economy', which was drawn up by a number of public and private stakeholders, describes the Dutch strategy of making the entire built environment circular by 2050. This

includes residential and non-residential buildings, as well as infrastructure. The strategy sets an agenda for the period from 2018 to 2023 and a detailed description of the first steps to be taken in 2023, known as 'the basecamp'. A transition team, consisting of experts from different organizations and disciplines, leads the implementation of the transition agenda. They do so by working closely with other initiatives and organizations to achieve the goals set by giving solicited and unsolicited advice to the government, and by facilitating the transition. In order to monitor and evaluate the progress towards a circular economy by 2050, a 'Work Programme on Monitoring and Evaluation Circular Economy 2019–2023' has been set up. One of the important outcomes of the programme is the bi-annual monitoring report, ICER.

Circular Construction Economy Transition Agenda

For the period 2018 to 2023, the Dutch Transition Agenda contains 4 focal points and 10 action points:

1. Market development

- Action point 1: first series of innovative products and services for circular construction
- Action point 2: a concrete demand for circular products and services, for example in public procurement
- Action point 3: accurate knowledge and an action plan to halve CO₂ emissions in construction by 2030 and to eliminate them completely by 2050
- Action point 4: a plan to make the existing housing stock plus one million extra homes as circular as possible in ten years
- Action point 5: sufficient incentives for R&D, experiments, prototypes and concrete projects

2. Measuring

- Action point 6: common language and tools to interpret and measure circularity in projects

3. Policy, legislation and regulations

- Action point 7: no inhibiting, but stimulating legislation and regulations
- Action point 8: international positioning and collaboration

4. Knowledge & awareness

- Action point 9: knowledge, experience and tools with enough people and the right people in the total construction chain
- Action point 10: understanding, support, recognizable benefits, awareness

Circular procurement

Circular procurement indicates the usage of the right purchasing instruments to drive the circular economy. For each circular solution, it is important to evaluate the most suitable contract form, award criteria, and contract requirements. A powerful tool used for circular procurement in the Netherlands is the environmental cost indicator (ECI). This is an indicator based on the European norm EN15804, which monetizes environmental costs on the basis of shadow-prices. By awarding a virtual reduction for offers with a better (lower) ECI, the market is encouraged to develop and offer alternatives that are more circular. DuboCalc is an example of a software tool that is used by infra providers and (potential) contractors to calculate the environmental impact of a material, structure, or construction method. With this tool, the entire life cycle, from material extraction to demolition is taken into account. Another similar tool is the Dutch National Environmental Database Foundation (Stichting NMD), which is an independent environmental database that stores environmental data about building materials and installations, and maintains and guarantees the quality of the determination method. This determines the environmental performance of buildings and infrastructure projects.

Buyer groups

In a buyer group, contracting authorities in the public and private sectors work together to develop a shared market vision and strategy for a specific product category to make the market more sustainable. This gives a clear signal to the market and encourages it to develop sustainable solutions that respond to a clear and common need. The members of the buyer group aim to implement this vision and strategy in their procurement practice within two years.

For example, participants engage in market dialogues, learn from each other's experiences and work together to develop specifications and reward criteria. Other commissioning parties can join and apply the strategy themselves when they are ready. This enhances the collective impact. Within the Dutch infrastructure-sector, following successful initiatives in Sweden, Norway and the EU, buyer groups have been appointed for:

- New construction and/or renovation of schools
- Renovation of social houses
- Circular new-build housing
- Timber construction/renovation
- Circular building materials
- Biobased building materials

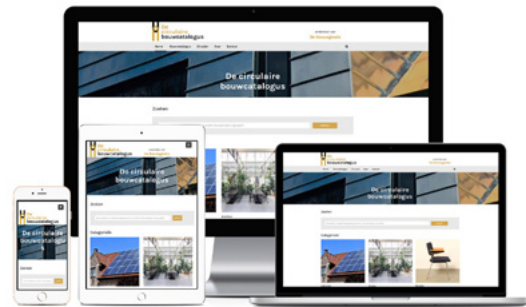
For more information: Buyer groups for sustainability PIANOo - Dutch Public Procurement Expertise Centre



Copper 8 - Guidelines Circular Procurement

Circular Procurement in 8 Steps is a generic guideline by Copper8 to facilitate organizations in circular procurement. A specific version 'circular procurement in 8 steps guideline for Residential and Non-Residential Construction' has been developed for the transition team circular construction economy and focuses on buildings.





Circular building catalogue

Several overviews of circular products and materials on offer have been made for procurers and builders to have easy access to information, thus stimulating both offer and demand. An interesting example is The Circular Building Catalogue (De Circulaire Bouwcatalogus) that contains inspiring examples of circular products and services that can be used in construction practice. It offers interior products to construction elements and complete buildings as well as product as a service concepts.

www.decirculairebouwcatalogus.nl



Measuring circularity

Measuring circularity is important for many decision-making processes. For example, it can play a role in tenders or in monitoring the circularity performance of a country. To provide insight into the degree of circularity of a material, product, structure, or area, a uniform and effective measurement method is indispensable. The CB'23 Platform (Circular Construction in 2023 Platform) has worked on a core method for measuring circularity; harmonising and expanding on existing methods. The core method is based on the three key goals of circular construction: 1) to protect stocks of materials, 2) environmental protection, and 3) value retention. This is described in the guideline 'Measuring circularity in the construction sector'. The measurement methods for the first two goals are established and ready for use, while the third is being developed. The method will be implemented in the national environmental database (described in the 'circular procurement' segment above), and has already been tested in projects. It is currently being improved upon and made more accessible for use. The development of a method to determine the third goal, value retention, is the main focus of the action team in 2021-22.

An important aspect of circularity is also whether parts and components (or structures as a whole) can be disassembled with ease and without damage. The better the de-mountability, or detachability, the higher the chances are for high-value re-use. A method to establish de-mountability has been developed for buildings: 'Circular Buildings - a measurement methodology for detachability v2.0' (Dutch).



The Global Sustainable Enterprise System

The Global Sustainable Enterprise System - GSES, is an overarching, international, and leading one stop sustainability platform based on internationally accepted standards and frameworks. The GSES aligned over 550 ecolabels, certificates and frameworks (incl. PEF, EPD, LCA) into 1 ESG reporting system. GSES is measuring and rating on buyer level, organisation level and product and project level, setting the international standard for ESG and Sustainability.

A database on organisation level and one on product/project level, consisting of standardised rating cards with independent verified data, are openly available at its platform. In the product database you can search on the Infrastructure, Building and Construction category, and find the data behind the products and suppliers.

The GSES offers various services, including product lifecycle management, supply chain management & dashboarding, supply chain ESG and risk monitoring.

For more information: www.gses-system.com



Circular design strategies

Circular design is about carefully considering the entire life cycle of an object from the beginning until the end. It takes into consideration aspects such as the desired lifespan, the future (re)use of all parts and materials, and the usage of various types of (sustainable) materials. Circular design also takes into account maintenance and potential (functional) changes in the future of the structure. CB'23 Platform has published a guideline on circular design (in Dutch). It underlines the fact that there is no "one size fits all" circular strategy, and that a customised approach is needed for each design challenge. The guideline identifies 6 main strategies, which, in varying composition, form a sort of methodology for approaching specific design challenges.

- Design for prevention
- Design for Life Cycle Impact Reduction
- Design for future-proofing
- Design with recycled objects
- Design with secondary raw materials
- Design with renewable raw materials

In the last few years many circular design strategies have been put into practice.



Photo: Netherlands Pavilion at World Expo 2020 in Dubai. Credits: Jeroen Mush



Netherlands pavilion Dubai Expo 2022

The Netherlands pavilion, designed as a biotope where the climate is controlled naturally, was a living example of circular economy. It was built and designed by Expomobilia, V8 Architects, exhibition designers Kossmanndejong and engineering firm Witteveen+Bos.

As all the pavilions on the Expo grounds were temporary, the design team opted for a circular design with naturally controlled climate, in which recycling and reusing materials is key.

Some of the companies that contributed to the pavilion:

- **Leadax** waterproofed the iconic cone with their flat roofing made from laminated glass, such as car windows.
- **Signify** supplied its high quality, energy-efficient LED lighting and control systems, as a service..
- **Mogu** supplied bio-based floor tiles and acoustic wall modules, produced using mycelium, the vegetative part of mushrooms.

Furthermore, the pavilion's ecological footprint was aimed to be as small as possible. where possible local materials were used, reducing the need for transportation. After the Expo, the building materials were repurposed or recycled locally. As for the interior of the pavilion: all materials used were either biobased and biodegradable or were reused elsewhere.

www.dutchdubai.com/designed-as-a-biotope





Photo: Completely remountable temporary courthouse by cepezed

Completely remountable temporary courthouse, cepezed

Via a Design, Build, Maintain & Remove (DBMR) assignment, the Dutch Government Property Management Agency created the Temporary Court in Amsterdam in 2016. The temporary character of the building doesn't take anything away from its representativeness and quality when it comes to matters such as equipment, complex logistics, acoustics, comfort and safety.

The building assignment has focused on preventing waste and maximising the residual value after this initial period of use. The building designed by cepezed is therefore easily adaptable and offers possibilities for varying purposes and users.

In 2022/2023 proof of concept was delivered as the building was dismantled and reassembled for use elsewhere in the Netherlands. The contractors, cepezed projects and Du Prie, remained the owners of the materials and are responsible for relocating the entire building.

cepezed



Loskade living lab residential area

Loskade is a project on the former sugar factory site in Groningen. It is a breeding ground for circularity and has 46 houses in which people live. Until 2030, this pop-up residential area serves as a living lab for revolutionary solutions. Van Wijnen uses the site to look for innovative solutions for external wall and roof finish, installation solutions and energy generation and storage.

Loskade is detachable, movable, demountable, and benefits from a smart grid. A new type of coating has been applied to the wooden walls, developed using biomimicry. The attractive part of this biocoating is its self-repairing capacity. In the event of damage, the living biocoating will regrow in the exposed areas.

www.decirculairebouwcatalogus.nl

**LOADING...
LOSKADE**

Biosintrum, the circular knowledge centre

Biosintrum is based on the bio-based economy that does not use fossil fuels as a raw material, but biomass. Biosintrum, with a GFA of 1,000 m², includes offices, classrooms, a restaurant and a theatre. The energy-neutral building uses 80% recyclable bio-based materials, including a laminated wood structure made from larch trees from local forests, grass slabs for the ceilings, HSB frontages, Accoya wall frames and a floor in which elephant grass has been processed. Toilets are flushed with rainwater.

A de-centralised treatment plant of Afmitech Friesland from Joure purifies the wastewater. The municipality engaged local entrepreneurs in the realisation of the building. Installation contractors Bakker took on the complete mechanical and electrical engineering concept. Finding economical, circular and sustainable systems took some extra effort. Recyclable plastic and steel pipes and a water-carrying VRF system allowing to regulate the temperature per room contribute to the building's outstanding BREEAM score.



Photo: Biosintrum, the circular knowledge centre.
Source: Circular buildings; strategies and case studies



Circular construction gives energy, Alliander

In November 2015, grid operator Alliander opened a fully circular renovated office in Duiven. The building supplies more energy than it consumes and more than 80% of the materials have been recycled. The circular renovation merged several buildings into a single office for 1,550 employees, more than twice as many people as before. The Atrium is an interplay of light and space. A total of 20,800 plants grow in the green walls that purify the air in the interior space. The materials passport lists, among other things, the rubble of the old concrete wall that has been finely ground into granulate for the concrete floor. Furthermore, the wood for the inner wall is internal waste wood. Insulation of the walls is partly made from recycled cotton, from old work clothing. The toilet bowls and sinks have been refurbished and reinstalled.

VolkerWessels Vastgoed was awarded the contract and entered into a DBMO (Design Build Maintain Operate) contract for 15 years. They guarantee the building will deliver the promised energy performance.

alliander



Photo: Holland Casino Venlo, self sufficient and future-proof building by Arcadis

Holland Casino Venlo self-sufficient and future-proof

Located on a major road near the German border, the new Holland Casino acts as a gateway to the country for its many German and Belgian guests. Accessible and iconic, the building's flower-inspired form—symbolic of the Netherlands— attracts attention from afar. A multidisciplinary team including MVSA Architects and Arcadis developed the concept, resulting in a holistic approach to architecture and sustainability. There are two starting points for this design: maximum sustainability and an optimal user experience. A natural coherence between landscape, architecture, and interior is felt everywhere in the self-sufficient building. Some materials are biodegradable, natural, or reused. Being self-sufficient in energy terms, the casino fits seamlessly with circular economy thinking. A materials passport in BIM facilitates maintenance and repairs, and respect for the total cost of ownership forms the basis of the holistic design. The outdoor space and building form one entity and absorb air, water, and energy like an organism. The building has a skin, skeleton, brain, and an excellent metabolism. Meanwhile, the visitors experience magic everywhere, from the façade deep in the building's heart (Source: leaflet Arcadis).

For more information: www.arcadis.com/en/about-us/sustainability



Technical and material innovations

Circular innovations along the value chain of construction are the on-ground manifestation of circular design methods, policies, strategies, and the cooperation between the stakeholders involved. In The Netherlands, innovations in materials, products, components, and processes are changing the landscape of the industry and playing an important role in achieving the country's ambitious circularity goals.



Concrete recovery, SmartCrusher

SmartCrusher has developed a technique for recovering sand, gravel and cement from concrete. The concrete industry on a global scale is 3 times more polluting than the aviation industry. This is mainly due to the production of cement from CaCO₃, whereby for every kilogram of cement, one kilogram of CO₂ is released. The SmartCrusher can decompose concrete rubble into its constituent parts and the cement fraction can also be removed. The recovered sand and gravel can be reused immediately and give even better results. The recovered cement can serve as a CO₂-free raw material to make new cement and can also be used as a concrete improver.

For more information: www.slimbreker.nl/smartcrusher.html



Prefab hemp panels, Dun Agro

With the production capacity of the world's first factory that produces prefab hemp panels, 500 homes can be built per year. The hemp house is made out of timber skeleton elements filled with a hemp mixture that are used for the walls and roof of the house. The factory mixes hemp wood with slate lime and water. After three months of natural drying, these very light panels can be assembled directly at the construction site. Thanks to its advantageous properties, the hemp mixture can be used in a multifunctional way. It represents bearing capacity with strong thermal and acoustic insulating properties. It is vapour-permeable, making use of plastic foils superfluous. Facilities such as pipes for gas, water and electricity are incorporated in the elements.



Waterproofing buildings, Leadax

Leadax is an Award-winning Dutch SME with a working & sustainable business model in the circular economy. Leadax uses high-tech material & production knowledge for developing and manufacturing 100% circular materials out of waste for waterproofing buildings, such as flat roofing, flashing and waterproofing basements. Leadax operates on a global scale and is ready to accelerate its impact.

The products are made of discarded PVB waste (polyvinyl butyral), a plastic foil used in laminated glass (e.g., car windows and safety glass). Leadax designed its products to be easily dismantled, recycled and used again as raw material for new products at the end of their lifecycle. With the production of waterproofing materials Leadax tries to solve a problem of 1,5 billion kg of unusable plastic waste annually, only in Europe.

For more information: www.leadax.com/en



Theo Pouw Group

Since its foundation in 1981, Theo Pouw Group has been convinced that raw materials are infinitely recyclable. This leading supplier in civil engineering takes rubble, construction and demolition waste, asphalt and (contaminated) soil and processes them into high-quality secondary building materials using various techniques. The Theo Pouw Group is one of the few that produces high-quality concrete granulate, cleaned ballast gravel and thermally cleaned sand, cement substitute, granulate and gravel and also uses this for high quality application.

The concrete plants mainly produce green concrete that consists of at least 30 to 50% recycled material as a replacement for primary sand and gravel. Research into how cement can be replaced is currently underway and it is expected that by 2030 concrete will be provided with 100% recycled material. For the Floriade Expo 2022 in Almere, cementless geopolymer concrete was used constructively for two circular bridges for the first time, a revolutionary milestone.

For more information: www.theopouw.nl/en



Photo: Waterproofing buildings, Leadax

Basilisk Self-Healing Concrete

Basilisk Self-Healing Concrete repairs cracks autonomously with the help of micro-organisms (bacteria). When the bacteria come into contact with oxygen and water, they convert nutrients to calcium carbonate (limestone). By reinventing concrete through this bio-based technology, less maintenance is required and the environmental impact of concrete can be reduced. Basilisk offers different products which can be used for both new and existing concrete structures.

For more information: www.basiliskconcrete.com/en/



Circular business models

A long-term perspective and clear responsibility for products and materials is essential in a circular economy. Because the durations of contracts in construction are quite short – only a fraction of the lifespan of the assets concerned – short term agreements are mainstream. This hinders the development of circular solutions. Therefore, it seems worthwhile to explore whether these barriers can be removed by offering product as a service (PAAS): a concept in which the manufacturer of construction elements assumes (part of the) responsibility and is stimulated to make long term considerations about design, construction, maintenance and replacement. PAAS concepts have been developed in recent years for varied products. Applying products as a service is a complex process due to the combination of a long life span of the assets and the relation between the building owner and a competitive field of suppliers. Being able to determine residual lifespan and residual value is very important. The shift in roles between owners and contractors can also be a challenge.

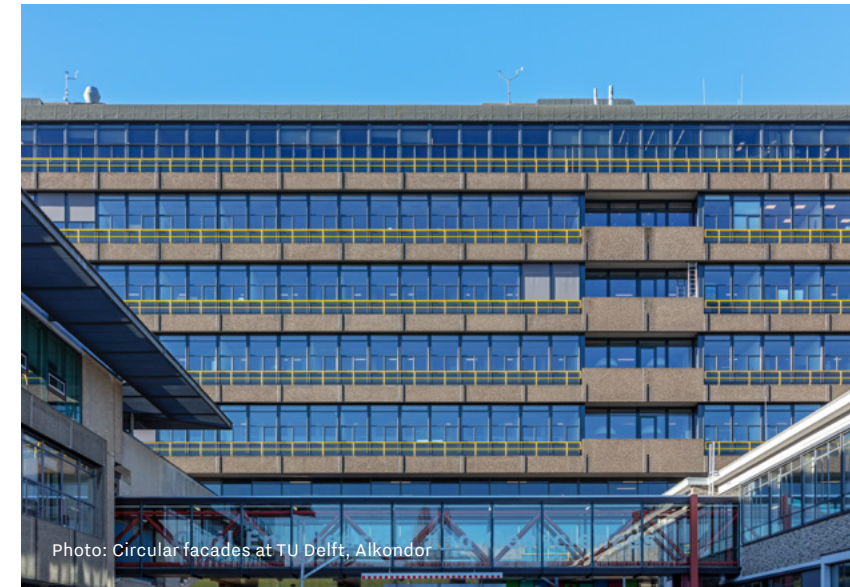


Photo: Circular facades at TU Delft, Alkondor

Circular facades, Alkondor

Alkondor developed the concept of the integral circular façade as a service in collaboration with Delft University of Technology (TU Delft). After the first pilot in 2016 Alkondor started a full scale project (3.000 m²) with CRE (Campus Real Estate TU Delft). The project resulted in a smart façade which is offered as a service: automatic night cooling and sunlight and sun warmth protection. In addition the smart façade enables four other benefits that lower environmental impact and improve user experience : 1. Comfort measure and control if possible, 2. Energy efficiency by smart control, 3. Predictive maintenance by counting use cycles, 4. Grip on end of life scenarios to stimulate reuse by having data about the products individually.



What information is needed to enable and safeguard circular decisions? Is this information different for structures at different stages of their life cycle, i.e., new construction, maintenance or demolition? In addition to these questions concerning the right information to incorporate in a materials passport, there are also questions regarding how data should be collected and stored. For instance, should it be stored in a central database and/or at the source using linked data? Which formats should be used? How to make sure this happens in a secure manner that guarantees availability and continuity to those who have access? To answer these questions, a sector wide strategy is called for.



Cadastre of materials, Madaster

Madaster, the 'Cadastre of Material' is a platform which facilitates the central standardized, web-based registration of materials and products applied in the built environment. The Madaster platform automatically generates material passports for buildings and infrastructure, providing a detailed inventory with information about qualities, and locations of all materials, components and products used. In addition, the platform automatically calculates environmental impact including embodied carbon, detachability and circularity using specific and generic data sets including EPD and circular data. It also provides a financial valuation of registered objects (current and future expected residual value of materials) and includes a product proposition that facilitates product passports for manufacturers. Besides the specific registration of buildings and infrastructure, the Madaster platform offers an area register that provides public insights in materials and products used in specific areas.

For more information: www.madaster.com



Discarded clothing as wall covering, Denimtex

Denimtex turns discarded jeans into circular wall decorations with unraveling jeans into textile fibers, using the method of mechanical recycling. With a bio-based glue, Denimtex ultimately processes the fibers into a textile stucco that can be applied to walls and ceilings. By means of water, the product can be removed from the wall after at least ten years of life. What makes it unique is that this process can be repeated ten times without losing any properties or adding new ingredients. The product is not only circular but also functional. It is sound-absorbing, fire-retardant, moisture-regulating and suitable for almost every surface.

For more information: <https://en.denimtex.nl>



Mitsubishi Elevator Europe - Selling performance

With M-Use® Mitsubishi Elevator Europe offers the use of elevators instead of ownership. The customer closes a contract based on the expected performance: minimum outage and maximum availability, far above market standard and against contractual penalties if this Service Level is not achieved. By providing additional contractual insurance, Mitsubishi can provide the necessary service and collateral is provided for their investment, there is no initial payment for installation. The M-Use® elevator remains in the maintenance portfolio for at least 40 years, supported by life-extending capabilities through innovation, sensors and remote monitoring. This results in extremely low operating costs, so that the costs for the building owner are not higher, despite the financing component. After the usage period, based on the enclosed material passport, customers will be offered money for the components / materials in the shaft to enable high-quality re-use and when a higher level is not applicable: ultimately recycling. In order to gain more insight into the social added value, KPMG has calculated the M-Use® service model. This shows that in addition to financial benefit, there is also a clear added value on environmental as well as social impact.



Materials passports and data strategy

A materials passport is a digital database recording the objects in buildings. It documents what they consist of in both qualitative and quantitative terms, how they were built, where they are located, and the ownership of the entire object and/or its parts. Materials passports are an important means for achieving circularity in the construction sector since they promote high-value reuse at the material, product, element, and building levels. In the Netherlands, practical experiences concerning buildings have been gained from the Dutch Materials Expedition (Materialenexpeditie) and Madaster. However, collecting the needed data raises many questions and challenges on several levels. These questions include:



Photo: Circular office building Triodos Bank, by RAU architects

Circular office building, Triodos Bank / Rau architects

The headquarters of Triodos Bank is the world's first fully circular, demountable office building with a structure made entirely from wood, including its core. Due to the choice of wood, the building captured more CO2 than it had emitted during its fabrication and construction, making it one of the first carbon-negative office buildings of its size in the world.

138 standardized wooden elements, wooden floors, wooden shafts and wooden columns are held together with 165,312 screws to form three towers of up to five storeys. The building and landscape are designed to enhance the biodiversity of the area. A green roof captures rainwater for flushing toilets, cools the building in the summer and provides space for insects and birds.

The building has a Madaster account with a material passport, which facilitates the mobility of materials that are now temporarily stored in the building, designed as a temporary deposit. Because the values of the materials are also constantly monitored through the Madaster platform they can be made liquid in the financial statements. Everything remains valuable as it is recorded, documented and evaluated, which means reducing future waste by 100%, also eliminating long-term disposal costs.



For more information:
thomasrau.eu/en/



Aeres University Almere, BDG Architecten

This circular, sustainable and climate resistant university building works as a living lab and is a prominent icon of the city of Almere. It consists of, among others, a demountable steel structure, scrap wood, old ship's timber, and a bio-composite facade, which is guaranteed to be recycled by the supplier when the building is demolished. The building is designed for multifunctional use and achieving an optimal living environment: improving concentration, the ability to learn, well-being and a positive experience for its users. 'The lung' refers to the greenery which is the central element from the ground level to the roof, bringing the outside world inside.

For more information: www.bdgarchitecten.nl/projecten/aeres-hogeschool-almere



Circular marketplaces

Coordination and cooperation within the chain is crucial for good infrastructure and construction logistics. Conditions for the successful execution of logistics for infrastructure and construction include insights into the integral chain costs, joint tactical and operational plans based on shared information, sufficient scale in circular marketplaces to reduce costs, a well-thought-out location of the marketplaces, insights into the operational logistics performance, and an active role of local government in tendering and licensing. Typical activities in circular marketplaces include:

- Supply of bulk raw materials
- Production of bulk building materials
- Storage of bulk building materials
- Distribution of bulk building materials
- Demolition & waste separation
- Processing / reprocessing of construction and demolition waste into secondary construction material



Sharing construction equipment and materials, Werflink

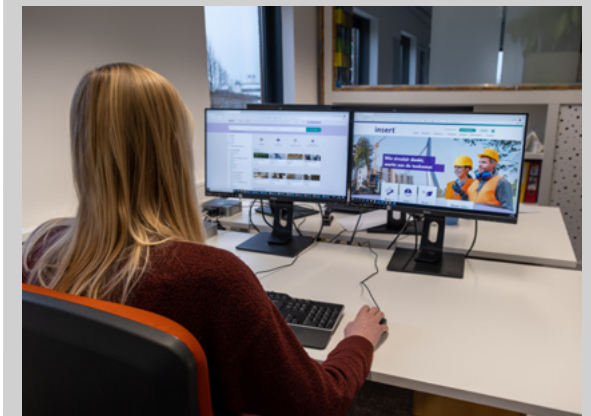
Werflink enabled construction (and related) companies within The Netherlands and Belgium to swap, sell and share construction equipment, building materials, storage and freight space with each other. These activities result in: reduced waste, greater reuse of materials, collaboration between companies, cost savings and additional turnover. The basic idea of this project was to match supply and demand between construction companies and sites from the same region to avoid unnecessary transport. The sharing platform had 675 companies using it in Belgium and The Netherlands. Over 200 items have been shared through Werflink but this amount is probably higher as not all transactions flow through the platform itself. Werflink was powered by FLOW2, the Dutch expert in digital B2B marketplace solutions.

For more information about FLOW2:
www.floow2.com



Excess Material Exchange (EME)

EME is a young and innovative company offering a digital match-making platform that enables companies to find new high-value reuse options for materials or (waste) products. As a pilot, they explored the viability of the Excess Materials Exchange as a 'dating site' for secondary materials. Using technologies like AI, Machine learning and Blockchain to make it easier for these materials to find a high value next use. By creating a scalable market (including a market price) for secondary materials, EME wants to help companies transition to a circular economy.



INSERT

Insert was founded in 2018. Together with 12 demolition companies, they started building an online marketplace with the aim of providing insight into reusable buildings and raw materials. This goal has been expanded to also give visibility to circular opportunities in the green and civil sector. Together with partners, they work on sustainability, reducing waste, preservation of primary raw materials, and reducing CO2 emissions. In demolition and renovation projects for buildings and public spaces, such as roads, streets, neighbourhoods and parks, enormous amounts of materials are often replaced. Many of these materials are still easily reusable, either one-on-one, or with small adjustments. Reusing them can save primary raw materials and reduce the emission of harmful substances such as CO2 and nitrogen.



Supply-chain collaboration, platforms, and regional initiatives

It goes without saying that collaboration is essential for the transition to a circular construction economy. In the Netherlands, supply - or value - chain initiatives – such as the Concrete Agreement (Betonakkoord) are examples of how stakeholders in the supply-chain work together to make materials more sustainable. The wood value chain coalition for infrastructure has the ambition to make wood an equal alternative for steel, concrete, and plastic in the materials mix for infrastructure. Another example is the recently launched National Steel-Agreement.

In addition, there are platforms to create awareness, promote and share knowledge developments, provide tools and practical insights, such as Cirkelstad.

A third important type of initiative is that of regional collaboration, since the regional level is very important



Creating business through circular design, CIRCO

With support from the Dutch government, CIRCO activates entrepreneurs and creative professionals to (re)design products, services and business models in order to subsequently conduct business in a circular way. In 3 day CIRCO-Tracks, entrepreneurs and industry professionals are challenged to use circular design strategies to redesign their own propositions, products, services and business models, and identify business opportunities. This results in a concrete implementation roadmap.

In the Netherlands more than 1000 companies participated in a CIRCO Track. Internationally CIRCO has partnered up with Hubs in a number of countries, expanding its reach and impact globally. Research shows that 66% of the CIRCO participants have implemented their new circular propositions.

For more information:
www.circonl.nl/international

CIRCO

for circular strategies such as closing material loops. The MRA (Amsterdam Metropolitan Area), consisting of 32 municipalities, two provinces (North Holland and Flevoland) and the Amsterdam Transport Authority, is an example that shows the power of regional cooperation. It works on 3 program lines: circular procurement, material flows, and circular area development. This resulted in, among other things, the roadmap circular procurement, which is a practical guideline that enables MRA stakeholders to reach their circular procurement ambitions. Another example is Friesland Circulair, which is an active and open network started by local businesses and expanded to over 100 organisations. As a result, all Friesian public bodies and large knowledge institutions have joined forces.



The Concrete Agreement (Betonakkoord)

In response to the alarming environmental problems, frontrunners in the concrete sector have joined forces with the government, as well as with the building and recycling sectors and research institutes to formulate the 'Dutch Concrete Agreement in 2018'. The aim was to reach ambitious environmental and social goals and steer the concrete sector into a sustainable direction. A network of partners has jointly managed to develop roadmaps on CO2 reduction, net positive value of biodiversity, circular design and 100% circular use of concrete being demolished. To accelerate the introduction of more sustainable solutions, the frontrunner approach is leading. This means that the sustainability results gained by frontrunners (expressed in the Environmental Cost Indicator) will be the standard for the peloton in due time. The Environmental Cost indicator will be integrated in the procurement guidelines and become stricter in the course of time. The challenge ahead is to mobilise the whole concrete sector in the scale up phase to act according to the Concrete Agreement.

For more information:
www.betonakkoord.nl

BETONAKKOORD

Bringing together frontrunners, Cirkelstad

Cirkelstad ('Circular City') is a cooperative organisation, organised in Circle-cities and bringing together frontrunners in the circular and inclusive building sector. Cirkelstad partners meet to exchange knowledge, discuss cases, best practices, and support each other in Communities of Practice. These Communities of Practice are organised 4 times yearly in various Circle-cities, each of which is coordinated by a 'spinner'. In addition, several overall activities are undertaken:

- A bi-weekly City newspaper is published
- The Cirkelstad Academy offers tools and knowledge on circular construction
- A product database offers an overview of circular products

Accelerate together

The national and regional programme 'Accelerate together' aims to reach a covenant in 2023 that describes 'circular construction, the new normal'. To set up the covenant, participants audited each other's (100+) projects, contributing to a better understanding of circular construction, setting the bar, and disseminating tools and tips over the course of 3 years.

For more information:
www.cirkelstad.nl



Circular Construction in 2023 Platform, CB'23

Platform CB'23, a collaboration for Circular Construction in 2023, aims at making unambiguous agreements to anchor circular thinking and actions in the daily construction practice. Platform CB'23 is committed to drafting these agreements for the entire Dutch construction sector, which includes both residential and non-residential construction as well as civil engineering. Teams of professionals from the entire sector have laid a solid basis with a Lexicon Circular Construction and guidelines for Measuring circularity in the construction sector and Passports for the construction sector. Two guides about Circular design and Circular tendering are drawn up in Dutch and guidelines for Future re-use are in production.

For more information:
www.platformcb23.nl



Standard for new supermarkets, LIDL

The energy bill of the Lidl supermarket in Woerden remains zero euros thanks to the innovative linking of climate technology, product cooling, energy storage and solar panels.

The circular character of the Lidl outlet is particularly apparent in its energy system. The building has 1,766 solar panels on the roof and carports of the car park. Innovative piles serve as heat and cold storage and the residual heat from the cooling systems establish the right in-store climate.

The supermarket chain has expressed the ambition to make its construction projects completely carbon neutral by 2022. Lidl has already installed a total of

more than 88.000 m² of solar panels on its buildings. Since December 2018, all stores are natural gas-free and new stores are delivered with an A++++ energy label.

For more information: www.lidl.com





Photo: The NIOO-KNAW office building in Wageningen has been a testing ground for the latest ecotechnology since 2011



Photo: Guillaume Meurice, Pexels

Chapter 4

Proposal for an international action plan

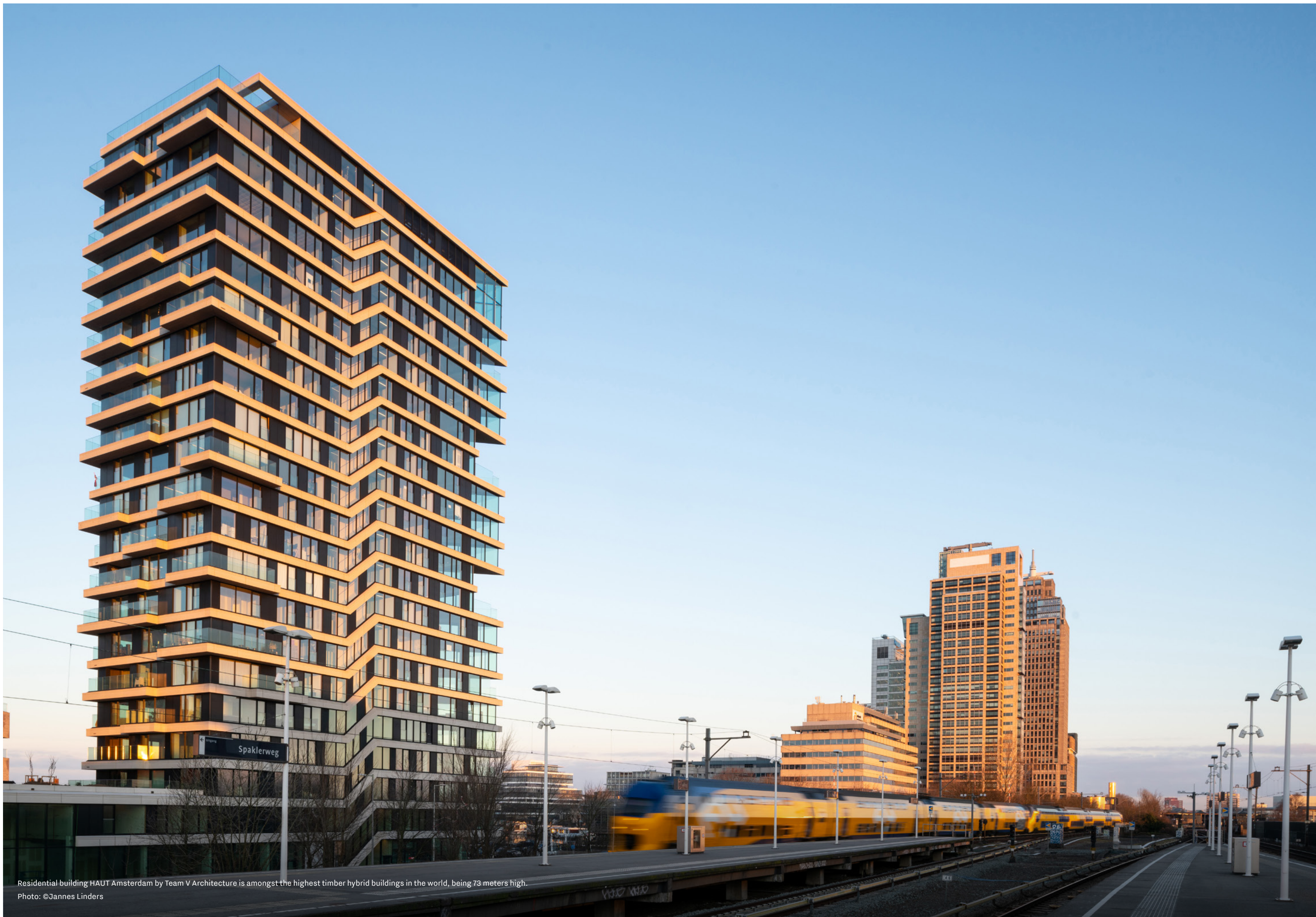
The momentum to act is now

The World Resources Institute states that by 2030, cities will account for nearly three-quarters of world energy use. In most cities, buildings account for more than half of this consumption. But 75% of the urban infrastructure that will exist in 2050 has yet to be built, presenting a huge opportunity to shape more resource-efficient, healthy, low-carbon cities through better buildings.

If we can't make the built environment more sustainable, we cannot reach the climate goals and we will run into unsurmountable resource challenges. But no government nor business can take this action alone. As primary and secondary resources flow over borders, we need to align cross-border as well. There is action happening in the policy field, on local, regional, national, and European level with policies that are impacting materials, products, and waste and/or are related to environmental goals like climate goals at large.

A lot of the policies and regulations that will shape the future of the built environment are being set as we speak. Slowly but irreversibly a circular economy will become a regulatory reality.

In the following section, we propose a multi-stakeholder Action Plan that calls for international cooperation to accelerate the transition to circular buildings, in the global run towards a climate neutral and circular economy. This proposal explores what is needed to realise the transition across borders and acknowledges that many actors will need to play a role in deploying a circular buildings sector: from private- and financial-, to public- and knowledge actors. While many of the proposed actions focus on Europe, most are also worldwide applicable.



Residential building HAUT Amsterdam by Team V Architecture is amongst the highest timber hybrid buildings in the world, being 73 meters high.

Photo: ©Jannes Linders



The New University Building of VU Amsterdam by Team V Architecture. Photo: ©Jannes Linders

Action agenda: how can circular potential in buildings be unlocked?

We need to go circular together

International cooperation is paramount to unlock the potential for achieving climate neutrality and a circular economy in buildings and utilities. Cooperation across international supply chains of raw materials but also across value chains of building products and installations, will help the construction industry achieve climate and circular economy goals.

National governments, the EU and other relevant inter- and transnational organisations and forums, such as the United Nations Environment Program (UNEP), Organization for Economic Co-operation and

Development (OECD), the G7 and G20 should increase efforts to promote and support international collaboration for circular buildings and the (climate) installations inside.

Bilateral and/or regional collaboration between countries and (similar) organisations should be further promoted and supported. In Europe, such partnerships already exist. For example, the European Environmental Agency and the Environmental Coalition on Standards are pushing for the delivery of the EU Strategy for a Sustainable Built Environment. There are many ways bilateral and regional support can be fostered to encourage uptake of circular economy principles in the construction sector. Some ideas include:

- **Setting up dedicated value chain collaboration programmes** (e.g., programmes that focus on closing material loops that are handled at an international level, like concrete or steel) and materials agreements (e.g., similar to the Dutch Concrete Agreement or 'Betonakkoord'). In addition, cross-border collaboration programmes for circular climate installations should be set up as they play a crucial role in green renovation and their value chains are international and complex.
- **Setting up common knowledge & innovation development projects**, such as the European project Building As Material Banks (BAMB2020) for the built environment.
- **Connecting stakeholders** in the building and utilities sector with climate neutral or circular economy platforms, such as the European Circular Economy Stakeholder Platform with its Leadership Group on Buildings and Infrastructure, or individual circular hubs in countries and cities.

Set the right frameworks for climate neutral and circular infrastructure

In addition to international cooperation, policy can support unlocking the potential of circular construction. In Europe, for example, the proposed Strategy for a Sustainable Built Environment is meant to accelerate the development of the circular buildings sector.

A joint integrated approach for circular buildings that looks at broad environmental aspects is needed to develop an ambitious European standard and inter-European performance measurement.

The European Commission introduced the voluntary **LEVELS framework** as an answer to the lack of a standardized, global standard to measure the sustainability of buildings. In addition, the Environmental Cost Indicator (ECI) for construction works, that is currently being used in the Netherlands provides a good starting point for a European database and ambitious measurement system that goes beyond CO2 emissions. This uniform method calculates a wide range of 19 relevant environmental effects, such as depletion, CO2 emissions, pollution and biodiversity loss and is based on the European norm EN15804.

With regards to measuring circularity, the **Construction Products Regulation** should be at the forefront of product information to ensure coherence. The CPR is currently under review and the new version should take into account that the environmental performance of construction products and materials cannot be assessed stand-alone, but in the context of an entire construction project. In the CPR, the EU should stimulate the use of Environmental Product Declarations (EPD) for life cycle assessments of construction works, based on existing CEN standards.

Set-up a 'coalition of the willing' and of the 'doing' for a common circularity framework

To create a common circularity framework for the buildings sector, relevant stakeholders should **mobilize setting up a 'coalition of the willing'** through existing platforms and networks specifically focused on circular construction, such as CB23 in the Netherlands. It could consist of a number of Member States, market parties and other international organizations, such as the UNEP with its Sustainable Buildings working group. The coalition should work on innovations and technologies like high-quality recycling, renewable materials, data management, or on how to make specific criteria for procurement of circular buildings.

In addition, **'coalitions of the doing'** could be set-up by various stakeholders (individual Member States, relevant NGOs, knowledge institutes, etc.) and at different levels (local, regional, national, and international). They can take immediate action by learning from each other, making specific transition pathways at an international level (e.g., use of biobased materials) and aligning specific sub-sectors or product categories in buildings (e.g., facades, climate installations). These coalitions of the doing can work on and adopt cutting edge practices like materials passports.

Develop and align circular international public procurement

Structural financial change is needed to make the transition to circular buildings as this requires significant investments. Public and private circular procurement can be an impactful instrument for positive, systemic change by promoting circularity. Various actions can be taken by all stakeholders involved to make circular tendering the norm:

- Make and promote the use of a standard international tendering method, a type of framework with common protocols, norms and standards that procurers can use and customize.
- Use common sustainability assessment tools and circular indicators applicable for both buildings and infrastructure as mentioned in 2.2.
- Specific coalitions could be set up for procurement, such as the existing **Big Buyers Group** 'Biobased Building materials', can work out and apply the same strategies on an international level.

Integrate circular economy actions within the Climate and Energy, and sustainability related actions

Europe wants to broaden and expand its energy efficiency and renewable energy policies to resource efficiency. It wants to decouple economic growth from the use of raw materials and their environmental impact and become a climate neutral continent.

We invite public and private stakeholders, the knowledge community and civil society to join the discussion and help to set up an action agenda that integrates circular economy in other current policies

and actions. [The Circular Economy Action Plan](#) (CEAP) is one of the building blocks of the European Green Deal. Construction and buildings are identified as one of the key sectors in the CEAP. Below an overview is provided of several initiatives in EU perspective that could also support the development of a cross-border circular buildings sector.

- With the European Green Deal the EU wants to reform its economy to achieve net-zero emissions and resource-free economic growth by 2050. A resource-efficient Europe is one of seven flagship initiatives as part of the Europe 2020 strategy aiming to deliver smart, sustainable and inclusive growth²⁴.
- CO2 related regulation will impact the construction sector. An example is the Emission Trading Scheme (ETS), which largely covers the supply industry for construction. The emission ceiling decreases annually, which means that the CO2 price for emission certificates generally rises. Therefore, industry will have to deal with stricter emission limits. Circular strategies like the use of biobased materials open the way to materials and building products with a reduced CO2 impact.
- In 2020 the European Commission published a new strategy to boost renovation called 'A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives'. It aims to double annual energy renovation rates in the next ten years. A refurbished and improved building stock in the European Union will help pave the way for a decarbonised and clean energy system. This offers huge opportunities to minimise the CO2 footprint of buildings, introducing healthy and renewable materials.
- More recently, the Fit for 55 package has been published, charting the way towards a more carbon neutral Europe. It sees both new buildings as well as major renovations as important supporting topics to achieve this. Circular materials and products can play a major role in these goals.
- REPowerEU (2022) is the European Commission's plan to make Europe independent from Russian fossil fuels well before 2030, in light of Russia's invasion of Ukraine. There is a huge opportunity to integrate circular economy actions within Repower EU similar to the integration in Renovation Wave, and Fit for 55.
- In 2020 the European Commission (EC) committed itself to develop a Strategy for the Sustainable Built Environment in the CEAP and Industrial Strategy.
- The Construction Products Regulation (CPR), currently under review, promotes open markets for building materials within the EU. Part of the CPR are Environmental Product Declarations, which are transparent, objective reports that communicate

what a product is made of and how it impacts the environment across its entire life cycle.

- The Waste Framework Directive includes measures to reduce the negative impact of waste generation. The new Waste Framework Directive sets a minimum level for construction and demolition waste target of 70% recycling (including reuse). Future developments are expected in the field of End-of-Waste status bridging the world of waste and the world of chemicals (REACH).
- Transborder flows of waste and circular resources are not without issues. The amended regulation for the cross-border transport of waste (Waste Shipment Regulation) regulates the imports of important flows such as soils, but also other sandy materials that are used as building materials.
- The European Green Deal is also our lifeline out of the COVID-19 pandemic. One third of the 1.8 trillion-euro investments from the NextGenerationEU Recovery Plan, and the EU's seven-year budget will finance the European Green Deal. The EC has also developed a policy agenda on sustainable finance, including the Action Plan on Financing Sustainable Growth. Reorienting capital flows towards a more sustainable economy is part of it and it includes establishing a clear and detailed EU taxonomy, a classification system for sustainable activities.

All these developments can help to unlock the potential of constructing and renovating buildings in a circular way.

An integrated approach to circular construction is needed to maximize the benefits for the broader sector.

In the Netherlands both the infrastructure and buildings sectors work on common circular economy approaches, such as: measurement methods for circularity; materials passports, circular use of materials, etc. By tackling the transition in an integral way, the combined volumes become a strong incentive for the industry to innovate and switch to circularity.



Photo: Elina Fairytale, Pexels



Photo left and right: The Netherlands pavilion at Expo 2020 in Dubai. A biotope that generates water and food. After the expo all of the building materials could be reused or returned to the earth, and the plot returned to its original state. Credits: V8 Architects/Jeroen Musch

Closing remarks: what's next?

To work on these actions, we can start now, drawing on existing knowledge, best practices and lessons learned about how to make buildings circular and climate neutral. The Netherlands is happy to share and is looking for partners in Europe and beyond, who have the same vision and ambition. We look forward to engaging with the world to make that happen!

Want to work together with us? Be sure to send your ideas, thoughts and proposal(s) to info@hollandcircularhotspot.nl.



THE FUTURE OF THE EUROPEAN BUILT ENVIRONMENT

What will the European built environment look like in 2050? It is shaped by the effects of climate change, resource scarcity, changes in population, urbanization, and focus on health and wellbeing. Buildings integrate a vast amount of technology that connect buildings to information management and sharing platforms. Buildings have evolved into temporary storage of circular materials and products and have become datahubs that support optimal (energy) efficiency and wellbeing.



BUILDINGS FOCUS ON PERFORMANCE

The sustainability performance, energy performance, and other performances are central drivers for comfortable living and working, and also determine the value of a building.



ENABLING WORKING AND LIVING IN A 24-HOUR ECONOMY

In our 24-hour global economy buildings will provide combined working and living space. Leisure, sports, shops and other amenities are combined in buildings that provide 24-hour connectivity.



CIRCULAR BUILDINGS

Buildings are circular: built with reused materials and/or biobased materials, are modular and deconstructable. They have become a temporary storage of materials and products.



ENERGY POSITIVE

Buildings create energy through photovoltaic solutions and are highly energy efficient and independent of fossil fuels. Buildings are connected to a smart grid to share and store electricity and heat.



SUPPORT A HEALTHY LIFESTYLE

Buildings provide a healthy environment: healthy noise management, optimal temperature management, clean air and daylight. The design fully supports the wellbeing of its users.



CLIMATE RESILIENT

Buildings are entirely climate resilient: green, energy neutral buildings that are designed to withstand floods and heat stress and that are part of climate resilient cities and urban areas.



FLEXIBLE BUILDINGS

Buildings will facilitate flexible use. They are adapted for changes in use on the short term, while being constructed for the long term. Smaller and flexible units will provide living spaces for the growing urban population.



COGNITIVE BUILDINGS

Buildings will be able to autonomously manage its internal climate (light, temperature, air) and efficiently adjust e.g. energy use by themselves. Cognitive buildings are connected to smart grids and are part of the IoT.

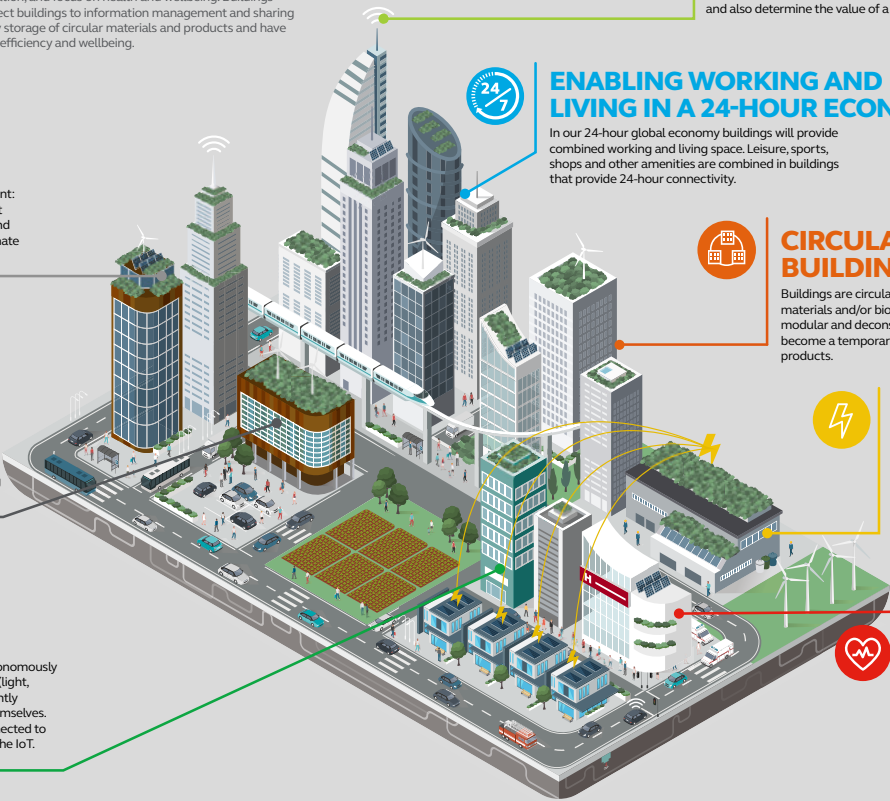


Figure 10: The future of the European built environment, source: Arcadis ²⁵

Future visions on the buildings sector

Throughout the brochure we discussed the relevance and urgency, but also the opportunities of transitioning towards a standard of circular buildings in Europe and beyond. Chapter 3 showed how in the Netherlands we approach a circular buildings sector. To round it up we share two independent visions on the future of circular buildings from different perspectives: one by the Transition Team Circular Construction Economy and one by Arcadis, a Dutch company that delivers sustainable design, engineering, and consultancy solutions for natural and built assets at a national and international level.

“In 2050 the European Built Environment will be circular and deconstructable”

In 2050 buildings have become a series of business models that are based on value creation instead of ownership. For example, many elements of a building can be part of a leasing contract and not owned by the primary owner: lighting, elevators, façades, waste management, furniture, plants, etc.

Buildings are seen as a vehicle for CO2 storage. Extending the lifetime of materials and building elements reduces the amount of CO2 that is needed to realize a building. If addition of new materials is needed there is a preference for biobased materials because this adds to the CO2 storage capacity of a building, contributing to reducing the impact and over time moving toward CO2 positive buildings.

All new buildings will be deconstructable. Buildings are no longer linear in terms of end of life, but circular in terms of end of use. The materials that are used in buildings are registered in material libraries. At end of use these materials can be repurposed. In these material databases, the quality and availability are registered, which stimulates effective re-use in construction. The materials used in the built environment are connected to an ‘internet of materials’. Large databases provide information about LCA information of the majority of used materials and transactions can be transparently followed in the Blockchain or similar mechanisms. Buildings will be modular to the extent that an entire building can be relocated. Modularity may relate to walls, entire floors, elements of the façade, etc.

Moving toward a circular (building) practice also requires moving toward circular financial models. We talk about value cases instead of business cases and choose circular strategies that are in line with the performance requests of the building. E.g., using a deconstructable façade solution with integrated heating and ventilation systems for an educational building that needs an update for an extended use phase of 10 to 15 years, or focusing on maximizing usage of recovered materials in a ‘new’ build.

But how do we get there?

In 2030 we start to adapt to the increased volatility of construction material prices. The percentage of recycled content will increase, e.g. secondary granulates, sand replacers and metals. Biobased or renewable materials will benefit from increased focus on circularity, although traditional materials will still form the majority of the used building materials. Legal provisions will stimulate



Photo: Dingena Verkerk, Program Lead Circular Construction at Arcadis

the application of secondary or alternative materials, e.g. through inclusion in standard specifications or in green public procurement. Nevertheless, these developments are not yet reflected in the market, as market prices for traditional bulk materials are still lower than those of circular materials.

Stock taking of materials used in buildings, as pioneered today by Madaster in The Netherlands, will be increasingly common practice in construction. Building Information Management enables big data storage in as-built models that will accompany the commissioning of new buildings. The total life cycle of materials will be increasingly monitored but is not fully feasible yet as it continues to be complex and costly in the next decade.

Inventories of old buildings will not only focus on presence of hazards but also on the presence of marketable materials. Deconstruction will increasingly become a mining activity for which deconstruction companies will have to pay.

New buildings will be designed to increase their suitability for future uses and recycling. Older buildings will increasingly be preserved rather than demolished and will adapt new functions. Also, late 20th century buildings will gain a certain heritage value. Because construction materials may already become more expensive due to increasing resource scarcity, refurbishing older buildings will be an attractive economic alternative to building new buildings.





Photo: Transition Team Circular Construction Economy in the Netherlands

“In 2050 we will have a construction economy that is fully circular”

This means that we will then succeed in meeting the socio-economic needs for housing and infrastructure without exceeding our planetary boundaries in the form of depletion, GHG emissions, pollution, biodiversity loss and other environmental damage.

“In 2030 we will have taken significant steps towards a circular construction economy”

And this will be evident by the way in which we narrow, slow down and close our resource loops.

Narrow

In 2030, circularity is an important point of attention in all decision-making processes, at all levels within policy, but also among chain partners in the construction industry. There is a critical focus on climate targets and reducing the environmental impact of construction in relation to available CO2 budgets. Capacity challenges the sector faces are approached differently: e.g. by promoting working from home and transforming commercial buildings to create new living space.

Slow

Much attention is paid to extending the lifespan of existing buildings, through new forms of (predictive) maintenance and repair and adapting to new uses. Where a building can no longer fulfill its function, efforts are made to reuse the entire structure or elements. The necessary regulations, by then, have been developed, and 'harvesting' of building components is common business. Physical repositories and virtual marketplaces to facilitate this are widely available.

In new projects, much attention is paid to extending the technical and functional lifespan,

and future reapplication. Circular design strategies such as adaptivity, modularity, standardization and detachability are common practice. A large share of the housing construction is carried out with a significantly lower environmental impact, as is the production of 'traditional' materials such as concrete and steel.

Close

Where reuse is not feasible, materials are recycled to a high standard and mostly used in equivalent applications. To this end, material flows are separated on the construction site and recycling methods for the most impactful flows are commonly used. Closing the loop is also achieved by using plenty of renewable biobased building materials, such as wood and timber, bamboo, flax and bio composites. The Dutch Environmental Cost Indicator measures a wide range of relevant environmental impacts of new construction, such as depletion, GHG emissions, pollution and biodiversity loss. In 2030 this method is also the standard for renovations such as energy conservation of buildings, so that the environmental impact of construction and renovation activities is reduced throughout the entire production, use and reuse cycle.

New chains and new ways

In 2030 the transition will be at full speed. Various new chains of construction partners have emerged, who work together in a circular way – employing new contract forms and business models. Due to the prominent place for sustainability and circularity in procurement processes and building regulations, the choice for circularity has become self-evident, thus providing the foundation to a full circular construction economy in 2050.



Schoonschip, the floating neighbourhood by Space & Matter Credits: Isabel Nabuurs



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Colophon



This publication is the result of a collaboration between Holland Circular Hotspot, the Transition Team Circular Construction Economy, Arcadis and the Netherlands' ministries of the Interior and Kingdom Relations, and Infrastructure and Water Management.

We would like to thank all contributors, editors, reviewers, businesses, programmes and organisations that provided best practices, and any individual or organisation that took part in the production of this publication.

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May 2022

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