Circle House

— Denmark's first circular housing project

The declared objective is that 90% of the projects materials can be reused without loss of value.

— The main focus for Circle House

Preface

I often take questions about what circularity in architecture and construction actually involves. And among our residents and housing associations, this is often followed by a “What does it do for us? How will this housing be different?”.

The Circle House project and the present publication seek to answer these questions. Not only in relation to the social housing sector, which I very much hope will find the book inspiring and instructive, but equally all the building industry partners who will be needed to realise the circularity agenda.

Historically in Denmark, the not-for-profit housing sector has assumed a social and societal responsibility with respect to housing design. It is a source of pride for us to help to continue that legacy with a significant and high-profile initiative to create architecture that is eco-aware and resource-efficient – aligned with circularity.

In this book, however, the architecture itself is not in focus, but rather the process behind the ideation and implementation of circularity in social housing.

Our aim is to provide insights into the preconditions that inform the circularity of our approach, and to allow the book to reveal our work, present our observations and our objectives.

We want our ambition to be mainstreamed across the building industry. Only in that way can we succeed.

I hope that you will read this book with the same eagerness, curiosity and interest with which it was conceived, written and illustrated.

— Gerti Axelsen, Head of Construction & Development
Lejerbo housing association

Partners in Circle House

Main Partners
Lejerbo (Client), GXN Innovation, MT Højgaard, Danish Building Research Institute (SBi), The Danish Association for Responsible Construction.

Industrial Partners
Orbicon, Spæncom, Dansk Beton, Peikko, Velfac, Rockwool, Caverion, Gyproc, RGS Nordic, NCC Construction, Kingo Karlsen, Tscherning, Tarkett, Kalk, Dovista, Troldtekt, Fischer Lighting, Tåsinge Elementer, Thermocell, Aisol, InnoTherm, Papiruld Danmark, Derbigum, Kompro ment, Rheinzink, Convert, Haki, Kvadrat, Bewi Synbra Technology, Gutex, Isolenawolle, Scan Underlay, Thors Design, Kebony, Climate Recovery, CBI Danmark, Egetæpper, Metisse, ENKL, Amorim, Overtreders W, bureau SLA, KorkBYG, Hunton.

Consultants
Responsible Assets, Horten Advokatpartnerselskab, Lauritzen Advising, Hildebrandt & Brandi.

Collaboration Studio
3XN Architects, Lendager Group, Vandkunsten.

Educational Institutions
CINARK at the Royal Danish Academy of Fine Arts, Aarhus University School of Engineering.

Supported by
Realdania's Program for Innovation in Construction and The Danish Environmental Protection Agency's Development and Demonstration Pool (MUDP).

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Introduction to Circle House

Circle House is Denmark's first circular housing project, and its purpose is to disseminate knowledge and know-how about circularity principles to the entire construction sector, as a scalable lighthouse building project offered and constructed on market terms.

The Circle House project, with Lejerbo housing association as the client, is building Denmark's first social housing constructed according to the principles of circularity. This means, among other things, that the project's buildings are designed to be dismantlable so that its structural components can be reused with scarcely any loss of value.

Image © Tom Jersø

Interview

Circle House and the client

'Lejerbo decided to engage in the Circle House project because we see it as a great opportunity to test our ambitions for sustainable housing.
In terms of volume, we are also keen to be ahead of the game in something that will potentially be in high demand. But more than anything, we're expecting to end up with some amazing housing units.

At the same time we're also expecting our tenants to realise that a circular approach in architecture results in housing of a higher standard. For example, in the way it allows tenants to have influence on their home over time, and the fact that in terms of maintenance tenants will also perceive the housing to be different.

As a client, we stand to benefit both from the valuable learning points along the project's development process and from interaction with a number of interesting building industry partners. This will give credence to our decisions and our association, which is a real asset for us.

Lejerbo is a large-scale procurer of social housing, and as a client, we will be able to contribute to the process of development, for example by establish our requirements for the long term. What will our needs be one, two or five decades down the line? We will be helping to address that and other factors via Circle House'.

— Gerti Axelsen, Head of Construction & Development
Lejerbo housing association

'As a housing association, we value the opportunity to offer our tenants housing that does more and does it differently'.

What is Circle House?

The Circle House project consists of 60 social housing units in the expanding Lisbjerg Bakke district on the outskirts of Aarhus, Denmark, which are scheduled for completion by 2020. Besides providing housing, Circle House will serve as a scalable demonstration project that will bring new know-how about circularity in architecture and construction to the building industry.

Circle House in figures

— Circle House consists of 60 social housing units designed and built according to the principles of the circular economy.
— The objective is for 90% of the building materials to be reusable without appreciable loss of value.
— The project will run for 3 years, commencin in spring 2017.
— The building design is expected to be tradable on market terms by year-end 2018.
— Construction is schedule to commence in 2019 and be completed by 2020.
— The project involves more than 30 enterprises from the Danish construction sector across the value chain.
— Circle House has received DKK 9.9 million in funding. DKK 6.9 million from the Danish Environmental Protection Agency and DKK 3 million from the Realdania philanthropic association.

Partnership with the City of Aarhus

The Circle House project is sited in the new Lisbjerg Bakke district, a development zone focused on sustainability north of Aarhus, Denmark. The site is located south of the district's new main street, Lisbjerg Bygade, close to a rail stop.

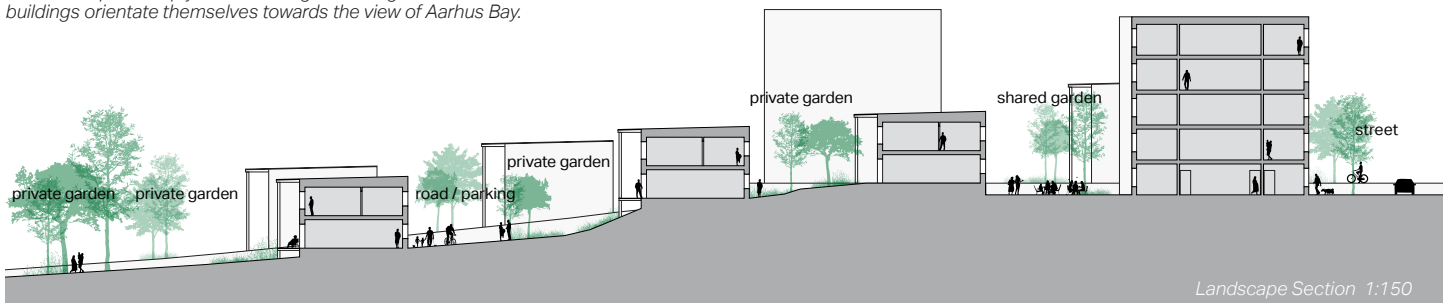
The site features a steep slope from the main street down to a wedge-shaped green area, and its highest point offers a scenic view of Aarhus. The building typologies are a mix of 2- and 3-storey terraced houses and 5-storey tower blocks.

The main street is defined by a single tower block and 3-storey terraced housing. The tower blocks are situated at the top of the hill so as not to overshadow the low-rise terraced housing.

All of the terraced housing has northeast-facing entrances and southwest-facing gardens. Extending the length of the entire estate, from the main street to the green wedge, is a green, recreational common area.

The project was mounted with funding from the Danish Environmental Protection Authority and the Realdania philanthropic association.

The site slopes sharply towards the green wedge and the buildings orientate themselves towards the view of Aarhus Bay.



Landscape Section 1:150

Circle House exhibition at Builing Green.

Image © GXN

What are the underlying principles?

The 15 principles have been developed as guidelines and strategies for implementing reuse and circular economy in the building industry.

Source: Building a Circular Future

Design for Disassembly

Materials
Select materials with properties that ensure their recyclability.

Service
The building must be designed with a focus on its entire life span.

Standards
Design a simple building that fits into a 'larger and coherent' system.

Connections
Design reversible connections that can be disassembled and reused several times.

Disassembly
A schedule for the disassembly is essentiel as well as a schedule for the assembly.

Material ID

Documentation
To secure the quality and value of the materials and ressources, documentation in all phases is essential.

Identification
Physical identification of the single element is important to gather the right information.

Maintenance
To secure the value of the material, correct maintenance is essential.

Safety
Maintenance of safety procedures through the entire lifespan of the building.

Transition
Gather the necessary information of how the different materials should be handled through transitions.

Circular Economy

New businessmodels
To complete the circle of circular economy new businessmodels must be developed.

Incentive
All parties in the supply chain must have a positive financial return.

New models
Instead of creating new products, business models must be based on offering customer service instead.

Partnership
Partnerships and cooperation agreements are necessary as no one can operate a circular economy alone.

Circulation
The value of the products in the biological and technical circuits must be maintained as long as possible.

Interview

Circle House and the climate

'Circularity as it applies to architecture and construction is about rethinking the built environment; its building materials, construction methods and liveability. In reality, you have to see it as if we are zooming in on it all from a metropolitan scale to a materials scale – right down to a molecular scale.

We don't have enough resources on the planet, but if we start rethinking the way we use resources – our materials – in everyday life, in the way we build, then we will see it as a man-made ecosystem, which I believe is the answer to a sustainable future.

Converting the industry to circularity in design and construction calls for new partnering models. It's all in the word.

We have to switch from a linear building process, in which we source and process materials, then install them in buildings, only to later downcycle or scrap them. Instead, we need to adopt a circular approach and actually plan for demolition from the outset, and we have to visualise new business models, but also look for new system solutions. Meaning, how can manufacturers supply modular components for buildings that can be disassembled, reassembled or upcycled as assets in future buildings?

In Circle House, we are asking how the circular economy is realised in architecture now. How far can we go, and how can we offer circular system solutions on market terms, so as to make Circle House the first large-scale showcase; a viable building project, constructed according to the principle that 90% of all the materials must be high-value reusables?'.

— Kasper Guldager Jensen,
Architect, 3XN Senior Partner, GXN Director

'Circle House will be a crucial proof of concept that circularity in architecture is achievable today'.

A collective design office

The aim of the Circle House project is to develop, disseminate and platform know-how and knowledge about circularity in architecture. To that end, its architecture is not designed by a single firm, but three.

For the Circle House project, a collective design office was therefore established and staffed by architects from the following practices: Vandkunsten, Lendager Arkitekter and 3XN Arkitekter, with design facilitation and coordination by GXN Innovation.

The four firms are all dedicated to implementing sustainability in their projects in different ways. This made the Collective Design Office an excellent forum for designing Circle House. The partners' many and varied approaches make the project multifaceted. Equally, the knowledge gained in the project is naturally platformed in the work of the individual practices.

The design phase also involved MT Højgaard (building contractor), Orbicon (engineering), Kingo Karlsen (demolition) and the City of Aarhus in a close partnership on design and solutions.

Vandkunsten

Vandkunsten is an architectural practice with a strong ethos. We only design what we believe in. But when the work is done, the architecture is not ours. It is communal. For 45 years, we have challenged the habitual practices of the building industry and continually sought to direct it at societal and sustainable goals.

LENDAGER ARKITEKTER

Lendager Arkitekter was founded with the aim of being Denmark's leading practice for sustainable architecture. As architects, urban planners and consulting engineers, we ensure that sustainability is an integral component of every project from the very first meeting and sketch.
We do so because we believe that circularity on construction sites, upcyclable materials and general awareness of resource efficiency is essential for the future of the built environment.

3XN

At 3XN we believe that buildings are more than the sum of their parts, and we seek constantly to achieve a synthesis of design, function and context. Our buildings are uniquely tailored to each project, but we always seek to combine aesthetic appeal and relevance through people-centred design. Designing buildings that are intuitive and connected ensures clarity and wellbeing for their occupants.

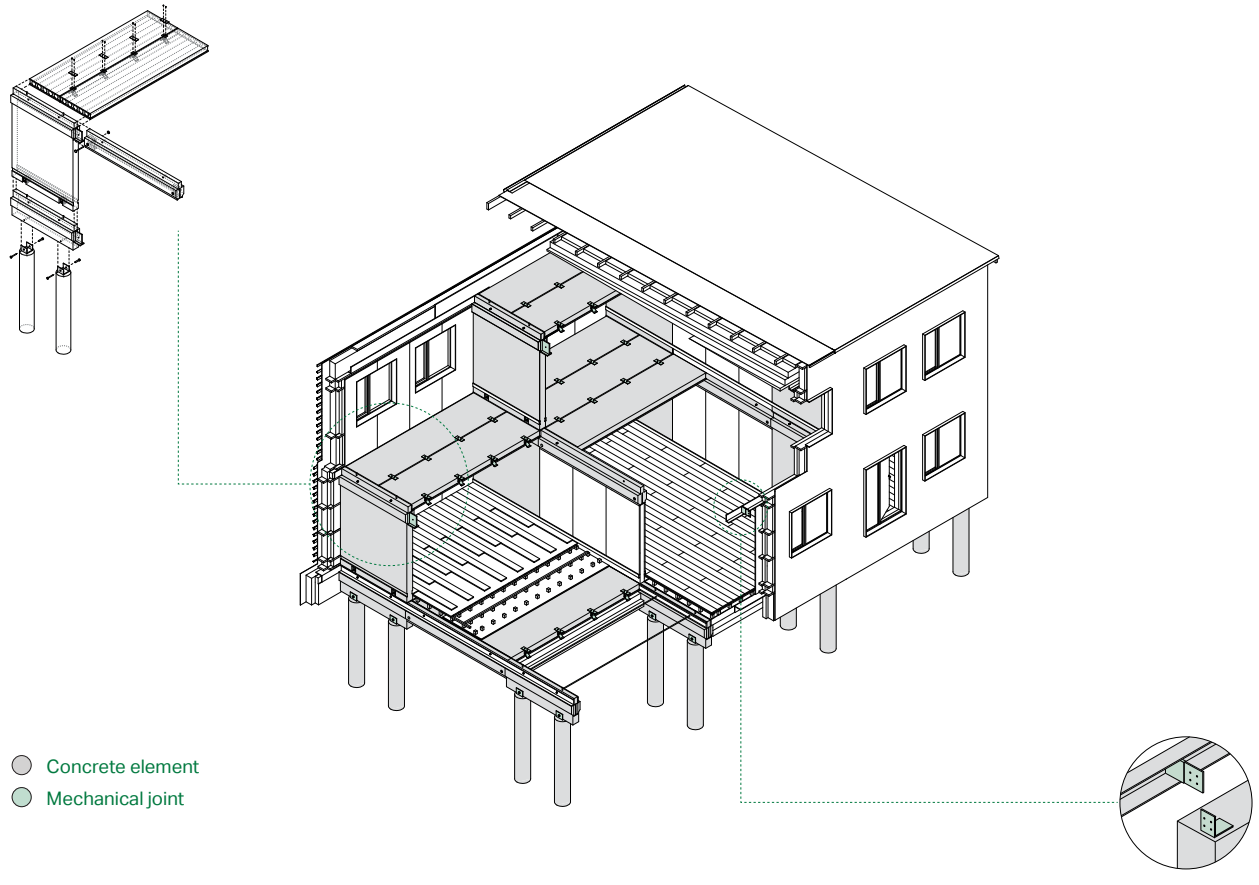
GXN

Since 2007, GXN has pursued architectural innovation in materials, behaviours and technologies. The 'G' stands for Green to highlight GXN's commitment to sustainable design. Our mission is to create people-centred design and to design buildings as man-made ecosystems.

Model of the Circle Houses construction system.

Circular building system

Circle House consists of several building systems that will be reusable for other buildings and thus retain their value.



Modular building system axonometry.

Circle House Demonstrator facade with upcycled plastic shingles.

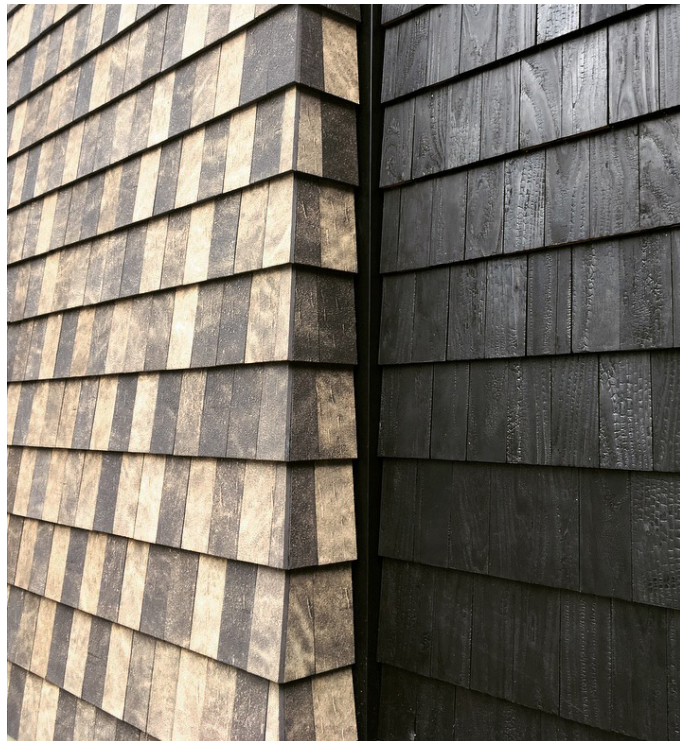
Image © Tom Jersø.

The demonstrator

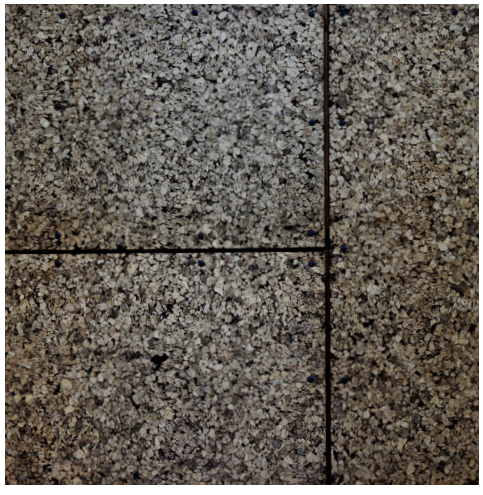
The Circle House Demonstrator is a 1:1 mock up and exhibition space, where all the building's layers, materials and products are exposed, displayed and described.

The demonstrator is a collection of already available solutions and products that in each it's own way an be part of creating a circular building.

The demonstrator aims to:
— Demonstrate in scale 1:1 that is possible to make a circular building.
— Educate the visitiors in circular economy principles.
— Debate how products can be developed and become more circular.
— Be a catalogue of available circular solutions for the industry and promote the companies circular products to a larger audience.

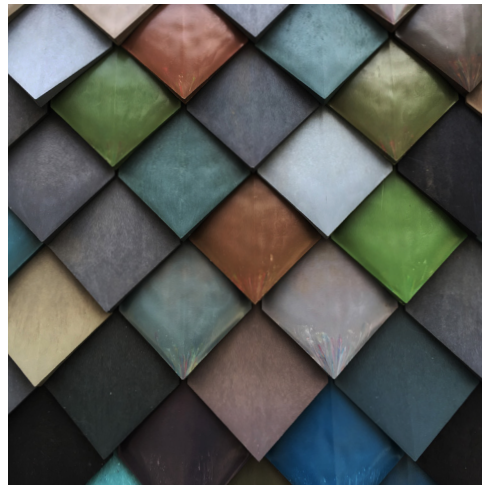


Facade of the Circle House Demonstrator showing the Komproment system.



Expanded cork boards.
By Amorim Isolamentos.

Tile and wood shingles, burned for natural impregnation.
By Komproment.



Shingles made from upcycled plastic waste.
By bureau SLA and Overtreders W.

Interior view of the demonstrator.

Image © Tom Jersø

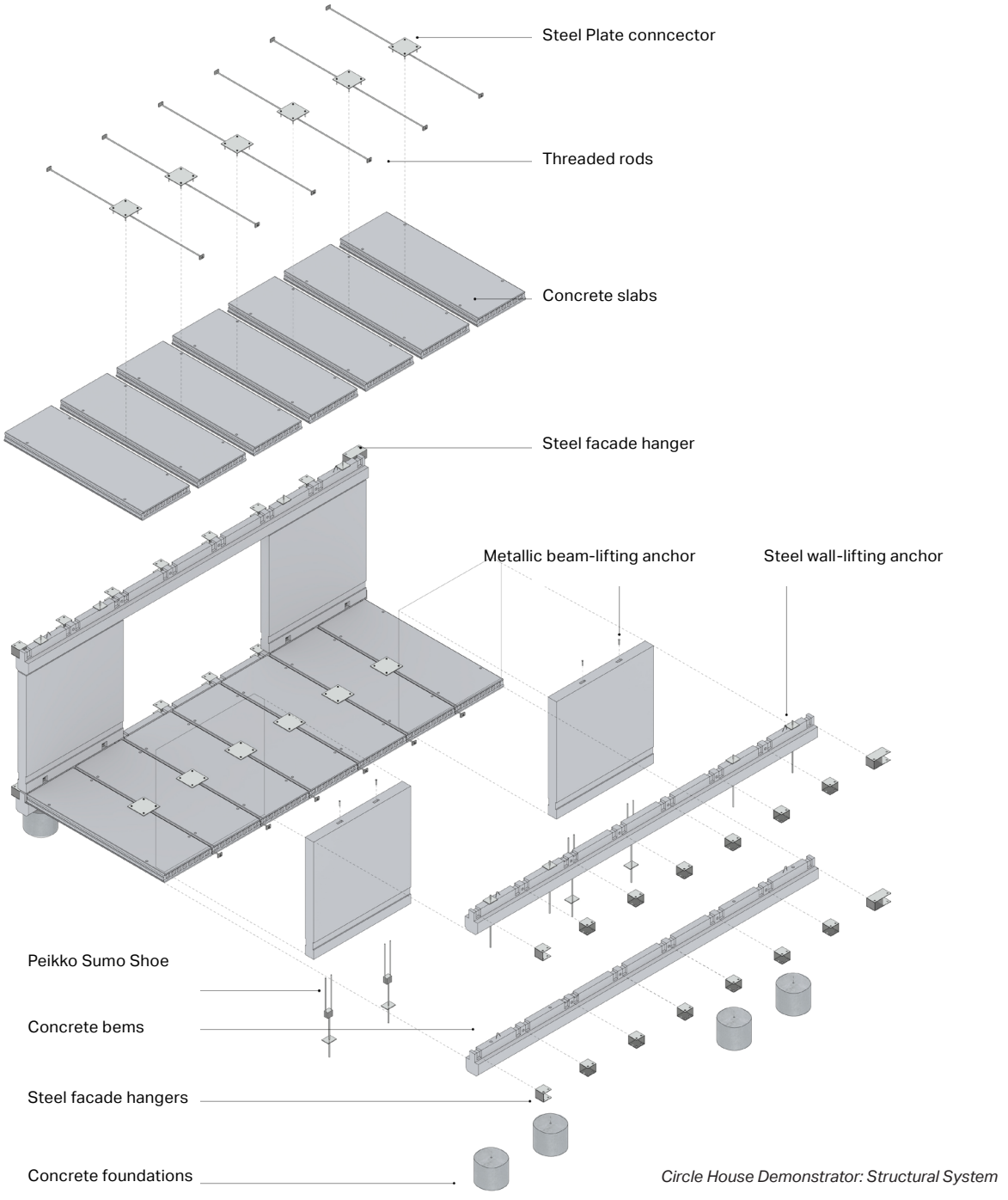
The demonstrator is placed by the client Lejerbo's headquarter in Valby, Copenhagen. Here it is being used as a meeting and event space to inspire collaborators, business partners and curious passers by.

The interior of the demonstrator is a curated of exhibition of circular materials, products and solutions. Everything features descriptions, contact informations and links to websites so it's easy to go from inspiration to implementation.

The demonstrator is an exhibition of circular solutions.

Images © Tom Jersø

Illustration of the superstucture and mechanical connections of the demonstrator.



Circle House Demonstrator: Structural System

The circular superstructure is based on already existing solutions from the Circle House partners: Precast concrete elements from Spæncom, mechanical joints from Peikko and the connections are cast with lime mortar from Kalk.

Images © GXN

Superstructure

The superstructure was erected very quickly onsite and the contractor was very pleased with the process. It took the one hour in total to erect the walls before they would have been ready to mount the next floor.

The concrete element of the demonstrator will be demounted and reused in the final Circle House project. In that way the circle will be closed already in this project.

Interview

Circle House and the aesthetics

Circle House and circular architecture in general are top topics right now because we're at a dead end in current sustainability strategies, since they basically boil down to energy-saving measures. Now, we also need to look at materials and processes, with a focus on how to avoid wastage in the demolition context.

This is what we are preparing for with Circle House. For us as architects, the prime goal is still permanence; that our buildings are built to last. We want the aesthetic appeal and functionality of our structures to ensure that no-one is going to tear them down, but if that does happen, and it does from time to time, then the assets will be dismantlable, and their constituent materials will be reusable or recyclable.

In that sense, circularity in architecture is how we conserve the energy content of building materials. Superficially, the architecture might strike people as unexceptional, but for the Circle House project, we will probably be taking the opportunity to showcase a slightly different design aesthetic too.

An example would be features like visible connections as opposed to hidden ones. And that kind of feature might well do double service as an architectural ornament and decorative element on the building.

But here in the early days, our main aim is to demonstrate that it has a specific architectural potential. I do think Scandinavians are ready for the return of decorative elements in architecture, as long as they are done elegantly, in an unfussy Scandinavian way."

— Søren Nielsen,
Architect, Partner, Vandkunsten

'Through architectural appeal and functionality we want to ensure that our buildings have permanence'.

Only six different precast concrete structures, including the foundations, are used. The facade is mounted on fixings to facilitate rapid assembly and the option of disassembly.

The facade design for Circle House is a lightweight facade mounted to the exterior of the structure. The facade material is fitted using screws or mountings in order to preserve its value for subsequent reuse.

The material could be all kinds, since the real focus is on how it is mounted on the building.

Because the system is what counts, we have a lot of architectural freedom in our choice of materials when it comes to circularity in the building concept. In the design proposals, the formats are either kept as large (full sheets) or as small (shingles or boards) as possible in order to maximise their potential reusability value.

Below are different studies of what the facades in a circular building project might look like. One of the benefits of facades designed for disassembly is that they are easier to maintain, personalise and reuse.

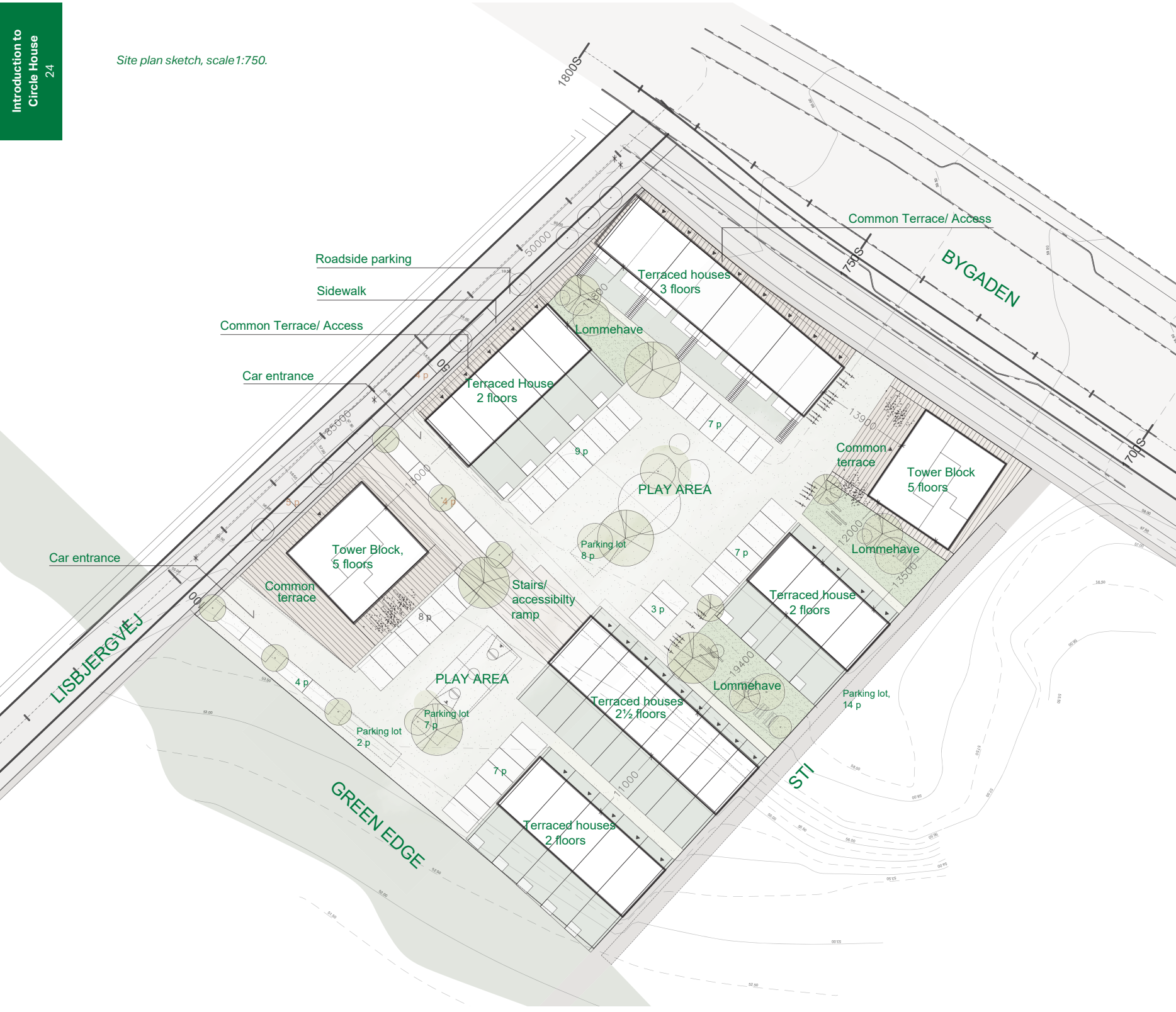
Facade study:
Wood and steel sheets.

Facade study:
Fiber cement elements.

Facade study:
Wave plates and composite material.

Facades Study:
Corten colored wave sheets.

Site plan sketch, scale1:750.



Building typologies

The building typologies are a mix of 2- and 3-storey terraced houses and 5-storey tower blocks. The housing is laid out with 100 m² of communal facilities across three typologies.

The 60 housing units in Circle House are distributed as follows:
— 5 single-room (studio) units of 30-35 m².
— 5 two-room units of 70 m².
— 10 four-room units of 110 m².
— 40 three-room units of 90 m².

The building density on site is between 65% and 80%. The Circle House development will consist of 60 social housing units representing 3 typologies.

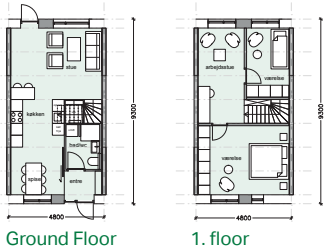
The terraced housing
The terraced housing units with 2 floors are laid out with an entrance, bathroom, dining area, kitchen and living room on the ground floor. The 1st floor has one large and one small bedroom and a small living room/study.

The interiors can also be laid out differently, e.g. as two small bedrooms and one large living room or two large bedrooms.

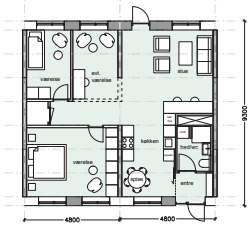
The one-floor terraced units have a similar layout for the entrance, bathroom, dining area, kitchen and living room. For the bedrooms, there is the freedom of making one large and one small room, two medium-sized rooms or four small ones.

The tower blocks
The tower blocks will incorporate all the alternative style flats and common facilities. All units will have access to a shared staircase.

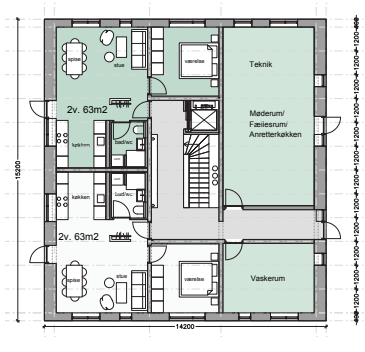
— Single-room, studio-style units are laid out with a small bathroom, kitchen, dining area and living room/sleeping niche.
— Two-room units are laid out with a bathroom, kitchen, dining area, living room and one bedroom, with the option of creating an extra room instead of a dining area.
— Three-room units are laid out with a bathroom, kitchen/ dining room and two rooms, with the option of making a small extra room.
— Four-room units are laid out with a bathroom, kitchen, dining area and a large bedroom and two small rooms.



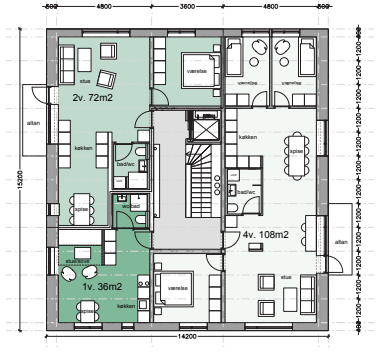
2-floors terraced house 90 m²



1-floor terraced house 90 m²



The tower block 2nd floor



The tower block groundfloor

Interview

What is the occupant experience of circularity in architecture?

' Lendager Group joined the Circle House project because we believe in partnership in the transition to the circular economy, and that it is imperative for the entire industry to make the transition and start looking for tools for solving the challenges faced in realising circularity in the building industry. This is why we need the entire value chain to be involved and committed to cross-sectoral partnerships in order to create innovative solutions.

The future occupants of Circle House dwellings will experience an architecture that is just a touch different. Suddenly, the interior of the building will be visible on the exterior. The observer understands what it is constructed from. Today people typically move into a new home where they can't tell what it is made of and how it is constructed.

That's one difference in Circle House. Basically, the structures, connections and installations will be on display as integral, aesthetic features of the architecture. The benefit for Circle House occupants is that the flexibility of each unit is designed to allow it to be varied in size, and for relative ease of access to the installations.

In other words, if the occupant wants to add an extra room to the unit, or the housing association wants to change the mix of units to make them larger or smaller, those options are open to them, as opposed to having to demolish the building or consigning it to disuse.

I don't believe there are any drawbacks, as such, to Circle House. The architecture is going to be different – a different experience in that you can see what the building is constructed from. That would be the only drawback, for people who don't go for that; who feel more at ease inside a secure, shut off and sealed living space. That aside, there are no drawbacks – on the contrary'

— Anders Lendager,
Architect MAA, CEO Lendager Group

'The advantage for Circle House occupants is that the architecture is geared to flexible, variable occupancy'.

Definitions of terms

The terms reuse, recycling and recovery denote the type of 're-utilisation' of waste or scrap.

Reuse
Reuse means that the same material or object is used for the same purpose more than once. Reuse entails direct re-utilisation of a product without any treatment to make that possible. This means that the raw materials and the energy that went into making the product are not wasted, but conserved.

Example: Bottles are collected, sorted, rinsed and refilled.

'It's time to act and rethink Denmark's business models and welfare state based on the following call to action: Reduce. Reuse. Recycle. Rethink'.

— Flemming Besenbacher, Chairman of the Advisory Board for the Circular Economy

Recycling
Recycling denotes the process by which waste is combined with virgin raw materials to either remanufacture the same product that originally generated the waste, or to manufacture an entirely different product.

Example: Glass cutter is used to manufacture new bottles (same product) or insulation material (new product).

Recovery
Recovery also recycles waste for new products, but to a lesser extent than recycling. Recovery means that waste is used in making a product, but the original properties of the waste are not fully utilised.

Example: Glass cuttings are used in conjunction with other waste products for combustion slag, which are used as a substitute for gravel and sand for ground protection in road construction.

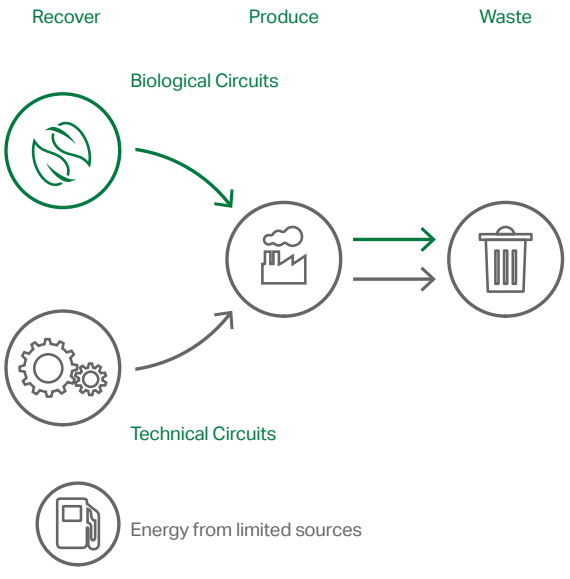

Post-it
FUN
> HVO
> HVIL
> BEB
> DRI
> PER

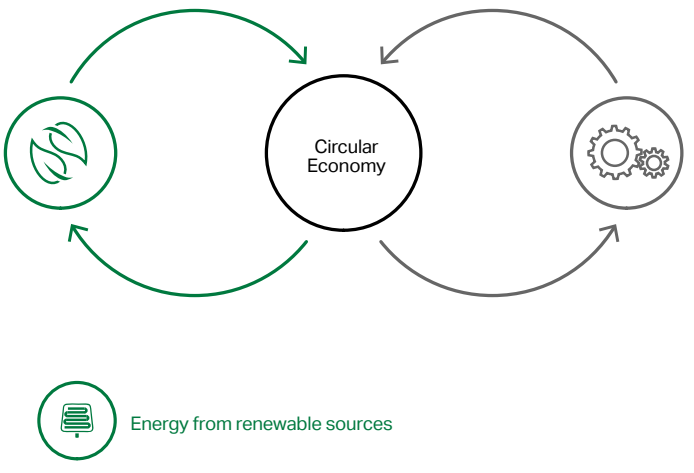
Business and legislation

A circular economy is all about common sense and smart design. If their design enables products to be disassembled and reused, then they have high economic potential.

In 2015 the Ellen MacArthur Foundation, McKinsey Center for Business and Environment and the Danish Environmental Protection Authority co-published '*Delivering the circular economy: a toolkit for policymakers*'.
The report takes Denmark as its pilot case study and its calculations indicate that one of the industries that stands to benefit most is the building industry.

From a linear economy to circular economy.





What is circular economy?

From a linear to a Circular Economy
In Denmark, the construction sector accounts for 1/3 of the total materials waste volume and globally for around 1/3 of carbon dioxide emissions. One of the reasons for this is that the economic model that prevails in the building industry today is linear. In real terms, this means that raw materials for construction are mined and excavated, building components are manufactured and subsequently used in buildings, and ultimately they end up as construction waste.

Given the rate at which we are using up the planet's resources, this means that in less than eight months, we have used the planet's renewable resources for a single year[1]. Over the next four decades, the global population is set to increase from 7 billion to around 10 billion[2]. This means that global consumption will require three times the volume of resources we are actually able to obtain, unless we reuse those resources.

One possible solution to this immense challenge is to switch from a linear economy to a circular economy. This means that instead of incinerating building materials or disposing of them in landfills after a single use, such as a floor, walls or ceilings, it must be easy to repurpose them without reducing their value. The transition to circularity in the built environment means, for example, that products must be manufactured so that their constituent materials can be separated out.

This is not only a technical challenge, but also calls for recirculation capabilities in the building industry value chain that do not as yet exist. In only a few instances do manufacturers take back their products for resale. Leasing schemes of the type offered in the car market, for example, have not yet made their appearance in the Danish building industry.

For circularity in the built environment to be mainstreamed in Denmark, there is thus a need to renew and rethink the traditional business models in the industry and ensure that the legislation supports reuse and recycling.

Circle House addresses these challenges by analysing a project in all its value chains; business models, case studies and framework conditions. All the findings and insights are shared in a wide-ranging debate on industry-wide circularity.

New business opportunities for Danish companies

One of the main advocates of adopting a circular economy is the Ellen MacArthur Foundation.
This foundation has conducted a comprehensive case study of the economic potentials for Denmark as a circular economy [3].

The calculations in the report indicate that the total economic potential for Denmark of implementing a circular economy in its building industry amounts to approximately € 7.75 billion per annum up to 2035.

— € 3.4 billion in industrialised production and 3D printing of building modules.

— € 1 billion in reuse and high-value recycling of components and materials.

— € 2.3 billion in sharing and multipurposing of buildings.

1 Global footprint network (footprintnetwork.org).
2 Population Reference Bureau (pbr.org).

3 Potential For Denmark As A Circular Economy - A Case Study From: Delivering The Circular Economy – A Toolkit For Policy Makers (ellenmacarthurfoundation.org).

Maersk Triple E Class container ship is manufactured from recycled materials.

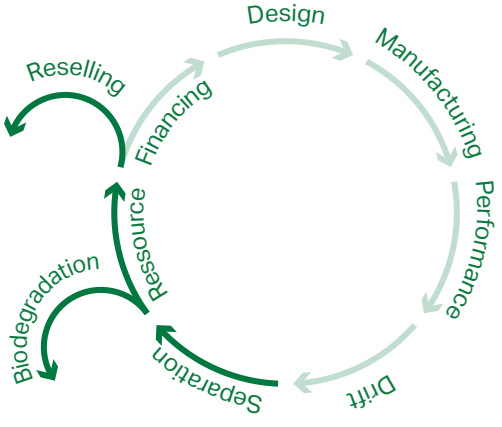
Image © Maersk Line

Five business models based on circular principles

Business model 1: Circular supply chain
In a business model based on a circular supply chain, all the components of the products are reusable resources. In other words, the individual parts of the products are disassemblable, traceable and reusable.

The circularity is not complete until the products, after initial use, enter a new cycle, either in intra-company manufacturing or in resale and recycling by other companies.

This circularity ensures that materials that would otherwise have been discarded as waste retain their value as tradable commodities or as cost-free materials in intra-company manufacturing.



Maersk Line

Maersk Line is one of the Danish companies that has started establishing a circular supply chain. For a new line of ships, the company has developed a digital Cradle to Cradle® material passport documenting 95% of the vessel's materials.

This means that the individual vessel components can easily be reused by Maersk or others when the vessel is eventually decommissioned. The Cradle to Cradle® label guarantees that the individual materials have the purity needed for the steel to be recyclable.

This has allowed Maersk to avert against rising steel prices. If we broaden our perspective beyond the building and construction industry, Maersk Line is a good example of a well-established company that is taking small steps in transitioning its business to a more sustainable course.

Maersk Line has committed to being a leader in sustainable shipping and is currently offering shipping with the lowest carbon footprint in the industry. The goal for 2020 is to reduce Maersk Lines' total greenhouse gas emissions per handled container by 60%.

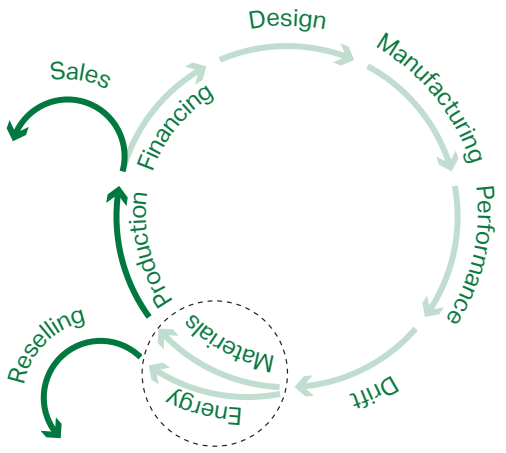
A significant move for Maersk Line on the sustainability agenda is better utilisation of raw materials, which is why Maersk Line is introducing a digital material passport in its production, as the first step towards a circular supply chain.

Business Model 2: Reuse and recycling
In a business model based on reuse or recycling, companies utilise their own or other companies' products or resources and resell them.

One example of this type of business is Gamle Mursten, which cleans used bricks (about 6,000/hour) so that they can be sold and reused. This company is the first in Denmark to obtain a CE marking for a reclaimed building material, and by that has documented its performance.

All new bricks must be CE marked, but until now, this was not an option for reclaimed bricks, hence a standard and methodology did not exist. That, however, is no longer the case. In 2016, Gamle Mursten achieved a net profit ratio of 28%.

Calculations from the Ministry of Environment and Food of Denmark indicate that the annual market potential for reclaimed bricks is 47 million bricks or 12% of the total market.



Gamle Mursten collects, cleans and resells used bricks. The company has created a business based on reuse of building materials and has developed the brick cleaning technology in-house.

Gamle Mursten

Gamle Mursten is based on the principle that scrapping used bricks is needless wastage. Asked about how the company got started, CEO of Gamle Mursten, Claus Juul Nielsen, says that he threw himself headlong into the project on a hunch without analysing the market potential, profitability, scalability etc.

The biggest barrier to building up a market for reuse of bricks is the certification to guarantee the quality of the bricks. This is because used building materials, unlike new ones, are not subject to the rules on CE marking. Gamle Mursten was the first company in Europe to gain ETA certification in order to be able to CE mark their goods.

A number of tests demonstrate that the quality of Gamle Mursten's reclaimed bricks is identical to that of newly fired bricks; and the company's commercial advantage is that it can create value for customers through sustainable solutions that meet today's environmental challenges.

Test results from the Danish Technological Institute demonstrate that the reclaimed bricks can withstand brick-laying and demolition several times. In fact, the reusability rate is as high as between 61% and 82%, depending on the strength of the mortar.

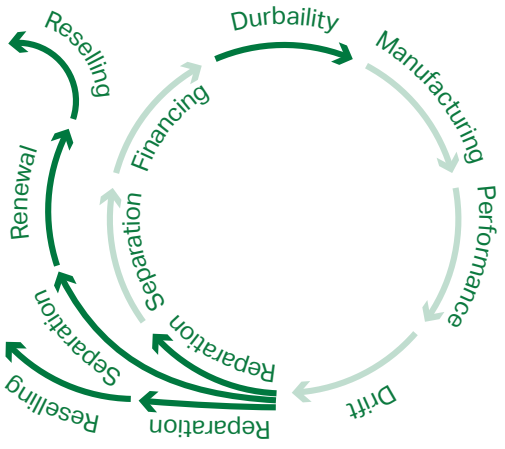
'We started Gamle Mursten with the sound and rational premise that reusability has been practised for more than 100 years, and that not simply scrapping used bricks ticks all the value boxes'.

— Claus Juul Nielsen,CEO, Gamle Mursten

Business Model 3: Product life extension
A business model based on extending the lifespan of a product and which focuses on preserving the product's original economic value for as long as possible. This might, for example, consist in:

— Renovating used products for resale.
— Taking back products with a view to resale.
— Upgrading already-manufactured materials.
— Repairing products.

Examples of this business model typically exist for high-price products in which services, checks and repairs are part of what the consumer pays for. This business model is based on the value of the add-on services the company can sell in order to get the product to function in its original form with maximum value for as long as possible.



Brummen Town Hall in the Netherlands is designed for disassembly. The concept behind the town hall is for 90% of all the materials in the extension building from 2013 to be reusable when it is dismantled.

Brummen Town Hall

The Netherlands was one of the first countries to introduce regional-level regulations to encourage a more circular construction sector. Brummen Town Hall is an example of buildings designed and constructed for subsequent disassembly and reuse of their constituent building materials.

The Town Hall in the Dutch town of Brummen has gained world renown as a shining example of design-for-disassembly circularity. The concept behind the town hall is for 90% of all the materials in the extension building from 2013 to be reusable when it is dismantled.

Brummen Town Hall was erected with robust wooden beams in the load-bearing structure. And instead of casting the foundations in concrete, they were constructed from rubble retained by a metal grid. This makes it possible to keep iron and stone apart during demolition, and the materials are easier to reuse.

The process of coming up with materials that can be disassembled and used directly one-to-one in new buildings without needing to be processed and without significant loss of value before their reuse called for a transparent design approach. At Brakel, one of the material manufacturers in the project, they have found that sustainable projects are good for business, and that design-for-disassembly and the sustainable profile are the perfect fit for the business Brakel aspires to be.

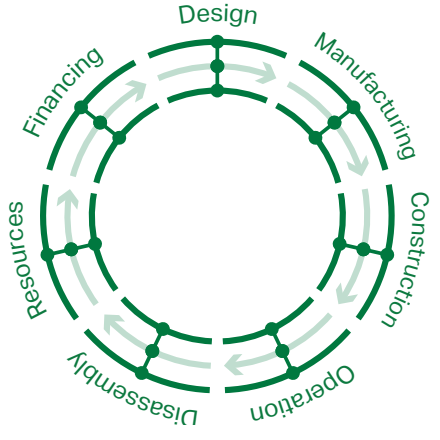
'Projects like Brummen Town Hall require a close partnership between us, the architect and the consulting engineer to ensure that the solutions are designed for subsequent reusability'.

— Mark Giller, Country Manager, Brakel

Business Model 4: Shared platform
The special aspect of this business model is that it consists of sharing products and activities. The model is based on peer-to-peer renting, swapping or exchanging of goods and activities so that more benefit from the same resource, which is also put to more intensive use.

The shared platform connects the product owner with businesses or private individuals who wish to make use of the products. This business model is known outside the building industry from services such as Uber and Airbnb, and within the building industry, Loop Rocks is an example. The platform, developed by NCC, allows businesses to exchange secondary building materials via an app.

The platform connects more than 1,500 construction sites in Denmark and Sweden. In Denmark, just three months after the launch, NCC had 600 customers on the platform, while Sweden is attracting 100 new customers a day. The app is free, and NCC's business model is to sell services linked to exchange of the building materials, such as transportation.



Loop Rocks has established a shared platform in the form of a virtual marketplace for purchase and sale of secondary (used) building materials. Loop Rocks was initiated by NCC Sweden, who founded their circular start-up as an independent offshoot.

NCC Loop Rocks

As part of their updated corporate strategy, NCC laid down a number of business concepts to improve their business. In the top 10 of these concepts was the creation of a shared platform for handling secondary building materials.

This saw the start of Loop Rocks, which is now set up as an offshoot business within NCC, and which will be helping NCC and the rest of the industry towards a more sustainable and efficient building and construction industry in the future.

The aim of operating Loop Rocks outside of the NCC core business is to respond to structural challenges in recognition of the fact that agility and radical innovation call for a special business culture and management paradigm.

The virtual marketplace is designed to match availability with demand and thereby achieve more sustainable and efficient handling of used building materials in the industry generally.

This means that the concept holds evident value creation; companies will naturally reduce the costs of materials, transportation etc. and in that way reduce their environmental impacts through reduced greenhouse gas emissions and raw materials depletion, while customers benefit from lower prices and a more efficient market.

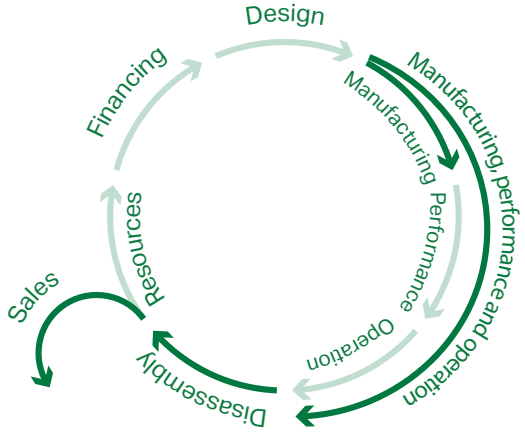
'We spotted obvious opportunities for improving the building industry's materials handling and making it more efficient, and then all the statistics told us that demand for sustainable solutions was only set to increase in the future'.

— Carl Zide, Head of Loop Rocks

Business Model 5: Product as a Service
An example of this business model is Philips Lighting, where customers buy lighting instead of buying lamps. Philips owns the product and the lamps and supplies a contract performance to the customer, measured in lighting hours and quality.

This model will be encouraging Philips to extend product lifespan, boost efficiency and thereby reduce its drain on resources. The model enables the manufacturer to extend the product's useful life, alter its purpose over time or tailor it to new target groups, all of which optimises resource consumption. Product-as-service covers:

— Pay-per-use, where the customer pays only for how much they use the product, rather than blanket payment.
— Leasing, where the consumer signs up for the right to use the product for a defined term.
— Renting, where the consumer has the right to the product for what is typically only a short term.
— Performance scheme, where the consumer purchases a specific level of product capability.



Atlas offers industrial enterprises pressurised air for manufacturing. Under this scheme, Atlas Copco supplies all the requisite equipment and deals with all the installation, maintenance and replacement for the term of the contract.

Philips Lightning

In the lighting industry, the linear business model means that a customer buys a lamp, and when it breaks, it is thrown away and replaced with a new one. This waste, compounded by the fact that lighting accounts for no less than 40% of industrial energy consumption, prompted Philips Lighting to set itself the ambition of making the original, linear business model smarter.

Philips Lighting introduced their Circular Lighting concept in 2012. The design is based on the principle that the business model is to reduce energy consumption while facilitating reinstallation and maintenance of the lighting system and the materials.

The Philips Circular Lighting business model is distinct from those of competitors in that it is based on leasing. Philips offer lighting in a product/service combination comprising manufacturing, installation, maintenance and reuse of lighting equipment, in other words: the entire lighting value chain.

Interview

Circle House economics

'Circularity in architecture and construction is part of the circular economy. Both entail thinking reuse and resources into the design and manufacturing from the outset. Don't melt down a steel girder if it can be reused intact as it is. Don't crush a concrete pillar if it can be reused intact as it is.

This is the upshot of the circular economy. Circle House is important as a one-to-one demonstration project that buildings can actually be constructed from components destined for a second and third useful life without degenerating. But in this project, we're also aiming to demonstrate that a Circle House unit will offer more flexibility than other housing.

It will be easier for the housing association to convert flats that are designed for disassembly, in the sense that their components can be taken apart and reused. Circularity in architecture and construction will also be a profitable business in the long term.

It may not be profitable right now, but ultimately it will be, because as resources become more scarce they will be increasingly costly, which means that those companies that best understand how to boost resource productivity, as it were – meaning how much you can get out of the resources relative to how much you put in – will be those that gain a competitive advantage going forward.

The building industry consumes 40% of global materials and generates 35% of global waste, so we're fairly confident that if we don't come up with the solutions ourselves, they will be imposed on us from political quarters. And if industry comes up with the solutions unprompted, we believe that will be one of the drivers because we actually have proof of the profitability of circularity. We also believe that there will be increasing political pressure to do things differently, so that will be another key driver´.

— John Sommer,
Director of Strategy and Business Development
MT Højgaard

'The circular economy is not only about reusing volume, but also reusing value'.

Trends and scenarios

A number of emergent trends and likely scenarios in the building industry are expected to greatly influence the potentials open to circularity in construction as a distinct business area in the future.

Prefabrication, new partnering models and digitisation have been identified as three of the most significant trends for the building industry.

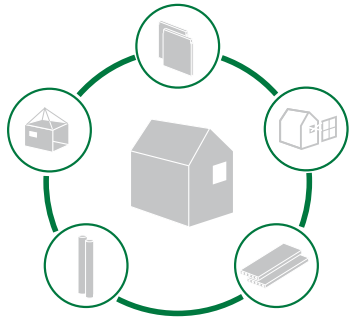
Meanwhile, legislation, new players and sectoral shifts are scenarios that might drive the industry's transition to circularity.

Digitisation
For some years now, digitisation has been a megatrend globally, including for the building industry. For the tools and data side of the industry, a number of key changes are anticipated. Three technologies in particular: Building Information Modelling (BIM), Big Data and the Internet of Things (IoT) are expected to have substantial influence in the short term.

Prefabrication
Modular construction entails prefabrication of large precast structures; typically entire rooms are constructed off-site in modules for subsequent on-site assembly.

Prefabricated modular buildings are also increasingly envisaged as structures that permit adjustments over time so that buildings can be tailored over their lifespan to altered needs and living conditions for their occupants.

This also influences the options open to a circular construction sector, since modules with suitable functional features will ultimately be reusable in conversions or newbuilds. This will allow a far greater fraction of the value of the original prefabricated module to be conserved.



New partnership models
Forming partnerships with other building industry players from the start of a project enables early-phase assimilation of innovations and improvement potentials. In a circular context, this can lead to solutions involving more extensive reuse of building materials, and also ensures the integration of a material passport and modularity.

The transition to a circular construction sector is only a question of time, and of whether the impetus will come from the sector itself, from external requirements or from new competitors.

A number of cold facts indicate that in any event we will have to abandon our linear production practices.

— Today, it takes nature 18 months to produce what we consume globally in 12 months. If everyone on the planet consumed as much as the average European citizen, three Earths would be needed.

— The global middle class currently amounts to two billion people. By 2050, that class is predicted to number five billion spending consumers.

— This causes waste volumes to increase. The construction sector already accounts for a high proportion of global waste production. The sector's share in Denmark is 35%.

— And construction is set to increase: forecasts for the construction sector suggest that 60% of the building stock expected to exist in 2050 has not yet been built.

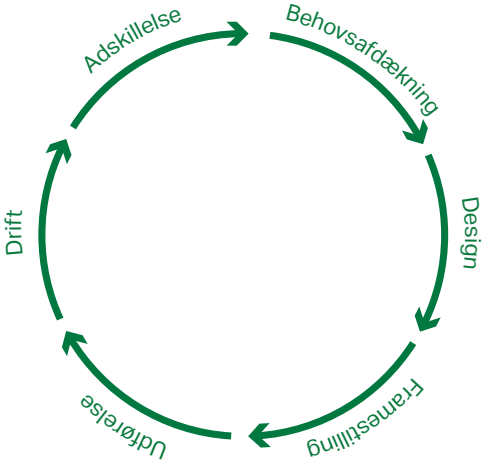
In other words, we cannot continue to consume resources and generate waste at the present rates. Essentially, the transition to a more circular construction sector could take place in three ways:

— Scenario 1: Legislation forces the sector to make the transition.

— Scenario 2: New players challenge and disrupt the market.

— Scenario 3: The sector's companies make the transition before the other two scenarios force them to do so.

In fact, a combination of all three scenarios is the most likely. Companies' room for manoeuvre will be determined by how fast they transition, and hence how well prepared they are for stricter legislation and new types of competitors.



General circular value chain for construction.

Scenario 1
Legislation forces the sector to make the transition
The circular economy is integrated in many policy areas in both Denmark and the EU. Carrot-and-stick measures in the form of growth strategies, waste management plans and resource optimisation are devised to spur private and public sector enterprises to reuse materials and extend product lifespans.

In 2014, the Danish Parliament adopted a resource plan for waste management. In 2015, the European Commission adopted an action plan with the purpose of putting a regulatory framework in place for the development of the circular economy.

The Danish Government has incorporated circular economy principles in its national economic growth proposal, and in 2016 appointed an Advisory Board for Circular Economy, which in 2017 submitted an action plan that included a proposal to bring the national building code into line with a circular economy.

There is every indication that requirements for reuse and resource optimisation will become increasingly more stringent in regulation of the Danish construction sector over the next five to ten years. In countries such as Finland and the Netherlands, the national legislation is already far stricter than in Denmark; advancing a circular economy is a strategic objective for both of these nations.

Scenario 2
New players challenge and disrupt the market

It is difficult to make reliable predictions as to the types of players that might be able to challenge the existing construction companies with circular solutions. But in many other markets, new players have managed to rapidly disrupt the established order.

The hotel industry saw Airbnb's facilitation of tourists' access to private residences reduce demand rates of hotel rooms in a large number of European cities. In the taxi service segment, where Uber facilitates private cars for personal transportation, the traditional companies are under pressure. In both cases, an entirely new breed of player has challenged a sector by offering solutions that tap into existing resources for new commercial ventures via user-friendly digital platforms.

Scenario 3
The sector's companies make the transition before the other two scenarios force them to do so

No companies want to be caught off-guard by stricter regulatory requirements or new competitors. Businesses in the Danish construction sector are still in time to develop new products and business models.

The Circle House project is one example of how a large number of Danish companies are updating their products, developing their business and getting up to speed on the new requirements and opportunities a circular construction sector spells for them.

In this third scenario we will see many more of this type of collaborative projects in which businesses in the sector and across sectors join forces to test new solutions for forwarding used building materials for use in new products and cycles.

Interview

How do we develop the industry?

'The principal aim of Circle House is to mount a Danish building project based on the principles of the circular economy. We are pursuing that aim with a housing project that is the first of its kind, and by sharing the know-how and knowledge generated by the project with industry associations, companies and policy makers.

A project like Circle House is important in order to address and define what building according to circular principles entails. The hope is that the project can help to concretize both the Danish Government's and the EU's action plans for a circular economy. In the project we examined how we should be building differently in order for construction elements and materials to be reusable with maximum value retention.

We studied what the transition to circularity will require from the regulatory frameworks, and how the construction sector's business models will have to be adjusted. Circle House has so far involved around 30 companies from along the entire value chain, representing architects, engineers, contractors and materials manufacturers. The value of the project lies, not least, in this wide circle of enterprises and their involvement.

Because good solutions tend to be found in partnerships between several businesses, and because those businesses are each, individually, incentivised to decide that from tomorrow they too will be offering circular solutions. And in that way, the industry is taking the next step. The Circle House project is not presenting ready-made solutions; we are offering suggestions with the hope of bringing Denmark a few steps closer to a circular economy'.

— Tine Lange
Founder, Responsible Assets

' Partnerships between many companies are crucial because the best solutions are often found in an interaction between different companies'.

Legislation

Danish legislation holds no real barriers to circularity in the construction sector. This is the conclusion of a study carried out by the legal firm of Horten Advokatselskab and consulting engineers Lauritzen Advising for the Circle House project.

The Danish public procurement and construction acts both permit construction using reclaimed building materials and the disassembly of building products and dismantling of buildings. The study does, however, conclude that a number of de facto barriers exist in the current regulations, due primarily to the fact that the legislation does not actively encourage circular economy principles in the construction sector.

The main de facto barriers are:

— That life-cycle cost is not a prominent concern in building procurements. The legislation permits life-cycle costing but does not require it.
— The difficulties of issuing declarations as to used building material performance, content and durability.
— The low number of requirements for resource optimisation in the legislation.

The study reviews relevant statutes to determine how they inhibit the development of a circular construction sector, and how they might be amended so as to encourage the adoption of circularity.

Legislation	Barriers	Solutions
Legislation of supply	- Criteria often favors the lowest price.	- Demands for holistic economic considerations.
Legislation of general housing	- Construction fees can not be raised even though circular solutions can make the final result cheaper.	- Potentials of raising a budget for installations when savings on operation through circular solutions can be documented.
Building Act	- Needs requirements for limiting resource consumption and waste, as well as recycled building materials.	- Requirements for documentation of resource consumption and use of recycled resources.
Building Regulations 2015	- Needs requirements for limiting resource consumption and waste, as well as recycled building materials.	- Requirements for the use of recycled resources. - Requirements for mapping of materials as well as a plan for dismantling and Design-for-Disassembly.
Construction Products Regulation	- Recycled materials are difficult to CE declare - or declare otherwise.	- Ease the possibility of CE declaring used building materials - or declaring otherwise.
AB92, ABT93, ABR89	- Liability of future recycling of the building materials is difficult to place.	- Specification of explicit obsolete rules for circular constructions. - Improvement of new insurance systems.
Waste Decree and residual production Order	- Uncertainty about the future recycling of circular building materials.	- Requirements for optimal use of building materials.

Cycles of use

This chapter presents a large number of circular products and initiatives that are viable for implementation in buildings at the present time.

The chapter is structured around a building's cycles of use. One fundamental aspect is to ensure that the different layers of the building do not overlap and thereby prevent disassembly and reuse.

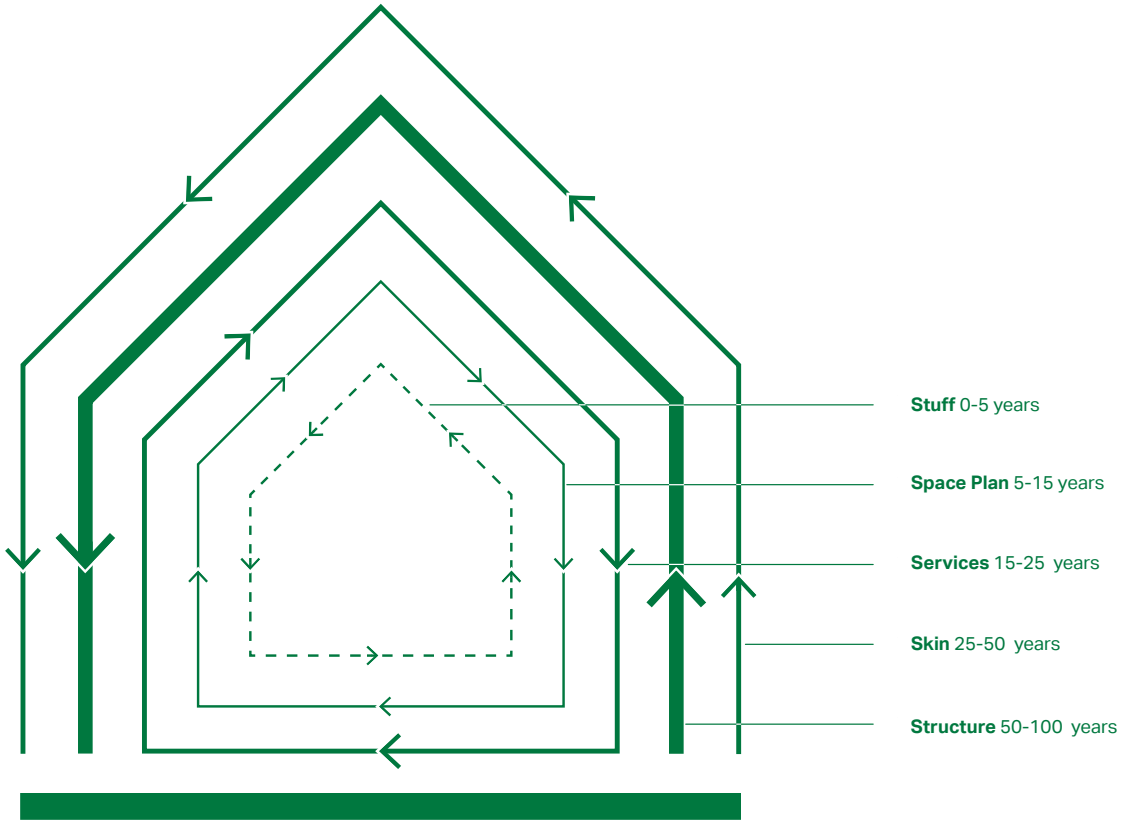
— Stuff 0-5 years.
— Space Plan 5-15 years.
— Services 15-25 years.
— Skin 25-50 years.
— Structure 50-100 years.

Image © GXN

Circle House Exhibition at Building Green

Image © GXN

What does this **chapter cover?**



Environmental benefit

66% CO_2

— Carpet Tiles

EXAMPLE By laying reusable Mosa carpet tiles, a carbon dioxide saving of 66% was achieved (on the assumption that 100% of the carpeting materials are reusable).

HOW The calculation is based on a single reuse of the product. In the event of further reuse, the environmental benefit rate increases.

The result is based on Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD) data. The calculation was carried out by SBi, the Danish national building research institute.

Cycle of use

0-5

years

— Stuff

The movable objects in our buildings – furniture, curtains, lamps etc. – have a very short life cycle and are regularly replaced so as to match seasonal colours for example. Stuff should thus be considered in relation to the building's total resource consumption, embody maximum circularity and not prevent flexibility and reuse.

Interview

Flooring as part of a circular process

'Tarkett is the third-largest flooring manufacturer in the world, and we produce all types of flooring except ceramic tile. For Circle House, the solution consisted of wooden flooring, carpet tiles and wall-to-wall carpeting. The carpeting we supply today (named DESSO) is made at our plants in the Netherlands and Belgium. A carpet manufactured according to circular principles is carpeting that can be returned and the yarn regenerated as new yarn, while the backing goes straight back into our production and is turned into new backing.

The reason we joined the Circle House project is naturally because it is a crucial project in redirecting focus at the circular mindset in the building industry, but also because it's not just an architectural draft on paper, but an actual project at the other end. A building that will be built based on what we develop and decide on throughout the entire project.

What we get out of our involvement in Circle House is things like partnerships across the construction sector, and learning more about other sectors that overlap in their business with our sector. Today, we are seeing that one of our main carpet backing suppliers is the Dutch water industry, which we obviously never imagined as a subcontractor.

A circular approach and circular manufacturing is clearly good for business. For us, the circular economy has meant that there is now demand for reusable products.

Cradle to Cradle® certification of our products entails reuse, but also positively defined content criteria, which contributes to a healthier indoor climate and also means that demand for our products is growing'.

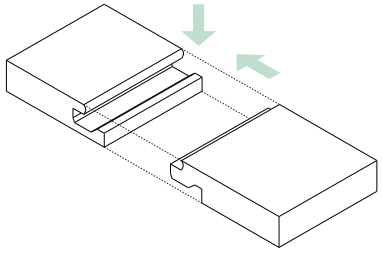
— Michael Aastrup,
CEO, Tarkett

'For us, the circular economy has meant that there is now demand for reusable products'.

What if your **floors were like LEGO bricks?**

Imagine if your floors were constructed by means of a simple click-in-place system that would allow you to easily replace parts of the floor, reuse it or take it with you if you move house.

Non-adhesive solution that makes sense
One of the world's leading flooring makers, Tarkett, uses a 'click system' for its flooring systems in wood, laminate and LVT. A unique but very simple assembly solution makes it easy for consumers to assemble and disassemble their flooring. A system which is increasingly used for flooring solutions. Assembly requires neither adhesive nor other fixings and can easily be reused when the floor eventually needs replacing.



Click-in system.

'The use of floating, rather than glue-down systems makes it easy to reuse the floors'.

— Jørgen Baden, Techical Manager, Tarkett

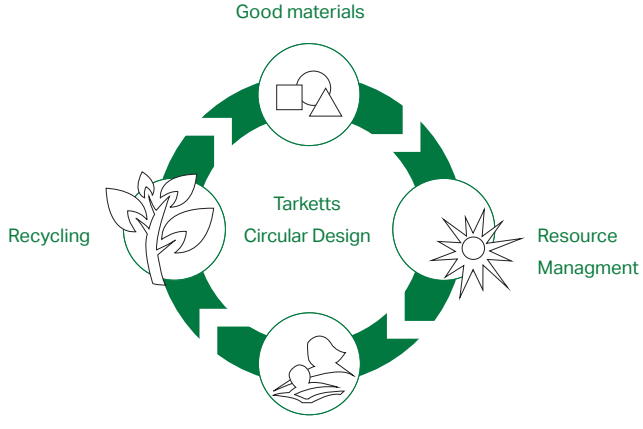
Case supplier
Tarkett
Contact: Jørgen Baden, Techical Manager, Tarkett
Mail: jorgen.baden@tarkett.com

New business models
The whole basis for Tarkett's products and innovation is turn over the linear economy. This is why Tarkett implemented a circular system with a cyclical life.

One example of this is Tarkett's DESSO carpets. The carpets are manufactured from end-of-life materials and are constructed in such a way that Tarkett can separate out the carpet constituents for recycling in new carpets.

Circular economy in every stage of the manufacturing
Tarkett's products are manufactured from materials that are 95% conformant with the Cradle to Cradle® standards, while 68% of the raw materials are mineral-rich, readily renewable or pre-reused materials. Tarkett uses a total of 80,000 tonnes of recovered materials in its production annually.

In addition, 60% of its production plants run on closed-loop or zero-water systems. Post-use materials are returned to Tarkett via their take-back ReStart® programme, which has so far collected 99,000 tonnes of flooring. These products then re-enter the Tarkett production cycle, where they are separated out into their individual constituents and used as new raw materials. ReStart® comprises.



Tarkett´s circular economy.

Cradle to Cradle® is a registered trademark of MBDC, LLC.

Ege Rugs uses water bottles in the production of their Ecotrust blanket

Imagine your carpets were made of water bottles and worn fishing nets. Then imagine that even carpets could be cleaned up so they stood as new, and then used by others.

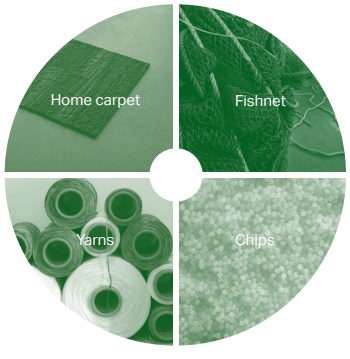
What if your carpets was on a **subscription service?**

From regenerated fishing net to carpet face
Abandoned fishing nets make up 10% of marine waste and drift in the oceans for months or years, posing a major threat to marine life. At egetæpper, the carpets are made from Aquafil's ECONYL® yarn, which is manufactured from used fishing nets that are collected, cleaned and broken down physically and chemically for regeneration as hard-wearing carpet yarn that is 100% endlessly regenerable.

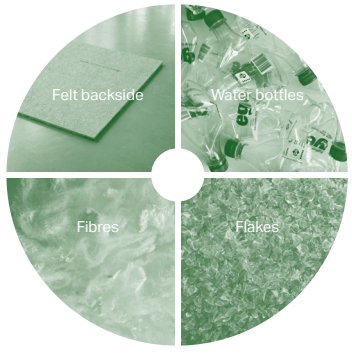
Aquafil collect the fishing nets via their reclaiming programme, where initiatives in large parts of the world allow them to source enough materials for their regenerated raw materials. These raw materials are then shipped to the manufacturing facilities in Slovenia for sorting before they enter the next stage of the manufacturing cycle to result in carpet yarns or textile yarns, used in swimwear, for example.

From used PET bottles to carpet backing
Used PET bottles are ordinary household waste items, and as waste products they are not attributed much value. But in the hands of ege, this post-consumer waste gains a new and unique function. This is because ege uses post-consumer PET bottles in the production of their patented Ecotrust felt backing for their carpet tiles.

This is achieved through an innovative manufacturing technique, which transforms the bottles into a soft but incredibly strong PET-felt that has extended durability and excellent acoustic properties. This PET-felt is then used as the base component for the hard-wearing carpet tile backing, which is recyclable. The PET-felt can be recycled again and again.



Manifacture of the carpets frontside.



Manifacture of the carpets backside

Case supplier
ege
COntact: Johannes Nørgaard, District Manager, egetæpper
Mail: jn@ege.dk

'We take back used carpet tiles and clean them and then resell them at a favourable price'.

— Johannes Nørgaard, District Manager, egetæpper

'Think' chair in all its parts and components

What if your furniture was **a resource for other consumers?**

Imagine a piece of furniture that can be disassembled into its component parts, which can then be replaced, upcycled or recycled as new products.

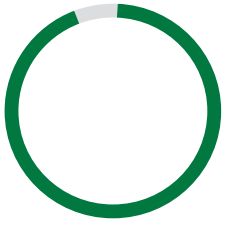
From a whole to element and back again
The 'Think' chair developed by Steelcase boasts unique circularity properties. The chair can easily be disassembled by hand using ordinary tools, making it easy to replace damaged parts or reuse specific components of the chair.

Reusability
The chair was designed on the basis of Steelcase's ambition to create a product that positively benefits the consumer and the environment throughout its use. The chair is made of 28% recycled materials, while a full 95% (by weight) is recyclable after its service life.

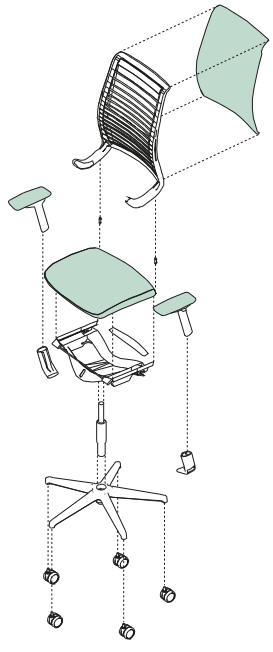
	Kg
Reused material before use	*3,3*
Reused material after use	*1,0*
Total	*4,3*

- Pre-consumer recycled material
- Post-consumer recyclde material
- New materials

The material composition of theThink Chair.



95% recyclability with today's waste management.



5. Backpost
4. Seat
3. Armrests
2. Swivel
1. Wheels

Concept of the ´ Think Chair.´

Case supplier
Steelcase
Contact: Christian Nørbæk, Sales Director, Movement
Mail: christian@movement.dk

Really's acoustic blankets.

Image © Really

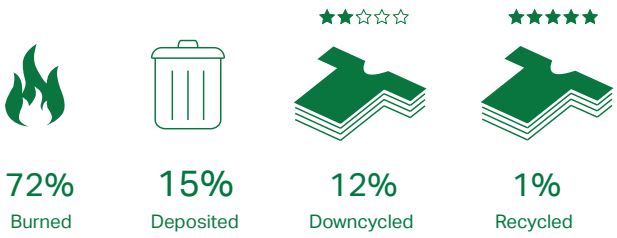
Suppose your used textiles could be used to make unique products that nudge our mindset and notions of resource streams.

What if your **dishcloths and towels were transformed into building materials?**

The textile industry as a supplier of raw materials
Denmark's industrial laundries dispose 1,000 tonnes of textiles annually. The company Really has addressed this paradox and is committed to raising consumer and corporate awareness of circularity.

Really develops materials that offer an eco-friendly and sustainable alternative to conventional materials used in wall coverings for example. The products are generated from upcycled textile waste through a close partnership with state-of-the-art material innovators, and result in unique, multi-use solutions.

The materials are sustainable and facilitate new product service systems in that they are fully reusable. Some of the products also contribute to a better indoor climate through their sound absorption qualities. By combining conventional processes from diverse industries, Really is able to manufacture textile matting consisting of 70% textiles and 30% plastic bonding medium. Their production is based on non-toxic materials, low-energy and water-free manufacturing.

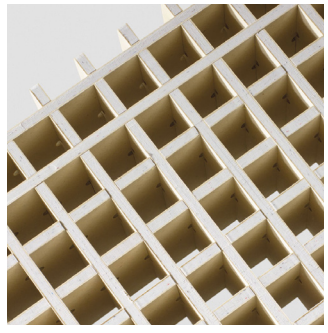


Distribution of textile waste today.

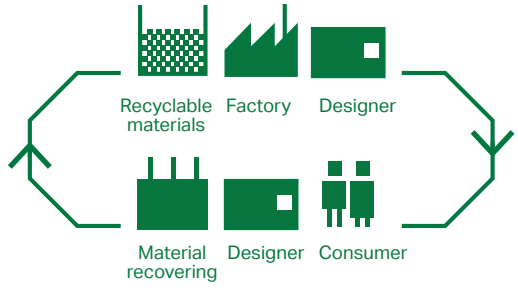
Case supplier
Really.
Contact: Troels Theilby, Production Manager, Really
Mail: troels@reallycph.com

Circular contributions to the building industry
The Ellen MacArthur Foundation estimates that Denmark is effectively tying up around EUR 100-150 million through its inconsistent recycling efforts. These are funds that could be freed up over time by using design for disassembly, innovative business models and establishing an efficient logistical ecosystem.

Acoustic blankets.



Solid textile plates.



Really's value chain og circularity.

Really's acoustic textile felt is their latest initiative for this agenda. A new product embodying the above-stated values, and which realises a vision for a new green product. A product which gives the building industry an eco-friendly, cost-competitive, functional and aesthetic alternative to existing materials.

Waste fibers can be used in the production of new furniture.

Image © GXN

Imagine a piece of furniture consisting of household waste, which at the end of the use-cycle can be taken back and recycled to make new products.

What if your **plastic bottles were your future armchair?**

From waste to upcyclable furniture
Upcycling Scandinavia is a Danish firm that sells sustainable office furniture, consisting of 100% reused waste, at competitive prices.

By means of a technique involving pressurised cold and hot water, this company makes furniture resembling equivalents from conventional manufacturers, the difference being that Upcycling Scandinavia uses 100% green chemistry in its manufacturing process.

Green chemistry means reducing or eliminating the use of harmful substances in formulating, manufacturing or using chemical products. In addition, Upcycling Scandinavia takes back its products post-use, as they can be upcycled as fibrous materials in the production of new furniture.

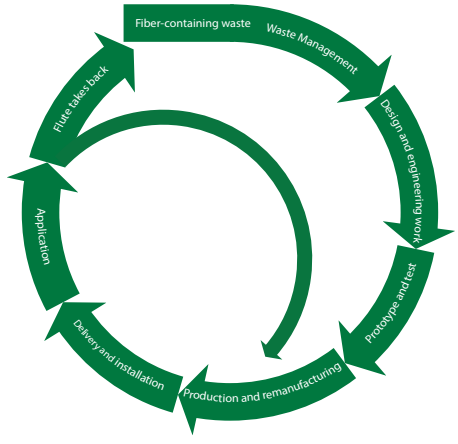
Upcycling Scandinavia - Production diagram

'It's about not seeing waste as an end product, but as a resource'.

— Erik Jørgensen, CEO, Upcycling Scandinavia

Case supplier
UPCYCLING SCANDINAVIA
Contact: Erik Jørgensen, CEO, Upcycling Scandinavia
Mail: erik@upcyclingscandinavia.com

Value-adding
According to the Danish Environmental Protection Authority, Denmark produces 600 kg of waste per capita per annum. When commercial waste is added to the figure, it rises to just under three tonnes of waste per capita per annum. This is needless wastage, since much of the waste can be reused.



Upcycling Scandinavia's circular business model

Upcycling Scandinavia's vision is to reduce wastage and create economic, environmental and societal value in partnership with their customers, by producing sustainable furniture. To that end, they use a circular development model designed to reduce wastage by upcycling waste as a resource in their furniture production.

Upcycling Scandinavia´s table and chair

Environmental benefit

45% CO_2

— Plasterboard walls

EXAMPLE The use of Gyproc Ergolite system walling saves 45% CO_2 compared with a conventional plasterboard wall. The reason for this saving is that the system allows the plasterboard to be taken down and 90% of the boards is reused directly without first having to crush them and recycle them into new boards. In addition, the boards are lighter, which makes them easier to install.

HOW The reusability value is based on a single reuse of the product. In the event of further reuse, the environmental benefit rate increases. The result is based on Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD) data. The calculation was carried out by SBi, the Danish national building research institute.

Cycle of use

5-15

years

— Space plan

The spaces inside our buildings are defined, in terms of both spatiality and surfaces, by the interior walls. This is then also the component that undergoes the most replacement in order for buildings to be adapted to changing occupant requirements. It is therefore a question of optimising the versatility and adaptability without affecting the remaining building layers.

Interview

Circular plasterboard walls

' There is no doubt that for Gyproc, and its parent company Saint-Gobain, sustainability is a corporate mission, which is why we are involved in projects such as Circle House.

Our contribution to Circle House and to a circular economy in this context is our plasterboard expertise. Circular plasterboard walling means screwing the wall together in the right way. Meaning so that it can be taken down again without being damaged, and then be reused. The solutions envisaged for Circle House are not so different from those for conventional builds.

The only difference is the approach to the actual installation. The advantage for my customers in using circular solutions in their dry walls is that this allows them to contribute to the sustainability account.

After all, ultimately, we are directing change; and it's imperative that we do so. There is no doubt that if we can facilitate installation of dry walls that are deinstallable and reinstallable we will be saving natural resources too. In the sense that the natural gypsum that usually goes into plasterboard is saved if we can use it as walling once, twice or three times over and more.´

— Søren Rasmussen,
Consulting, Gyproc

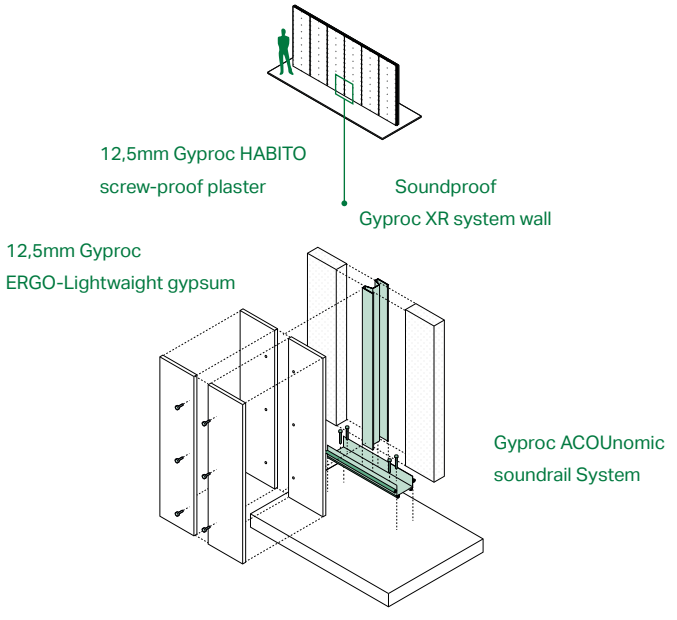
'When we create a product that can be disassembled and reinstalled, we save natural resources'.

What if you could **move your walls during the weekend?**

The materials, the system and the component
For years, plasterboard walls as the raw material have been integral to circular production and a circular economy.

Plasterboard manufacturer Gyproc is currently using up to 40% recycled materials and by-products in its plasterboard, and recovery of gypsum has become a systematised symbiosis between industries. The processing of the pure gypsum, from residual product to raw material, is energy-intensive at the plants, and the value of the product declines.

If, instead of demolishing the plasterboard for recycling of the raw material, the gypsum component or the entire system wall is reused, then energy is saved while the value of the gypsum is conserved.



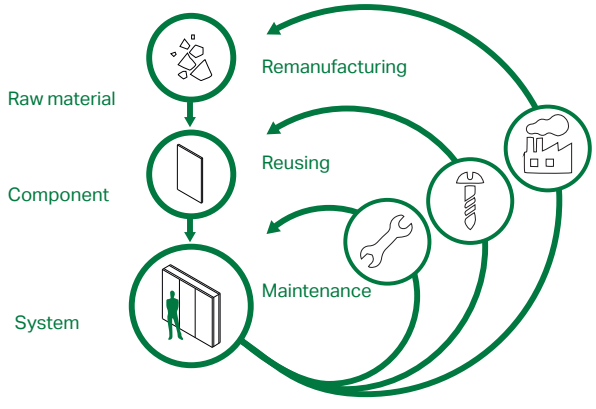
System Wall section

Case supplier
Gyproc SAINT-GOBAIN
Contact : Søren Rasmussen, Cunsulting, Gyproc
Mail: soeren.rasmussen@gyproc.com

A plasterboard wall designed for disassembly
With GYPROC performance plasterboard and steel profiles, it is easier than ever to install a dry wall. ACOUnomic acoustic rails and XR acoustic battens ensure sound-proofed walls and maximum ambient sound insulation.

HABITO™ as the inner layer of board results in secure screw fastening at any point on the walling. ERGOlite™ is the lightest-weight plasterboard in Denmark, weighing 25% less than standard plasterboard, and is just as impact-resistant. The weight makes it possible to produce plasterboard in full floor-to-ceiling lengths, which is a real advantage when it is used as the outermost layer of board. This eliminates the need to deal with untapered (short-edge) butt joints. Gyproc steel profiles and plasterboard are assembled using screw fixings.

The acoustic profile's EPDM rubber seals ensure mechanical sound proofing. All of the components in the plasterboard wall are designed to be demountable, and can be demounted and re-mounted without the conventional taping and plastering.



In material circuits, the least circuit is the cheapest and the most sustainable.

Detail of Reform kitchen front.

Image © GXN

What if you could **swap kitchen with your neighbour?**

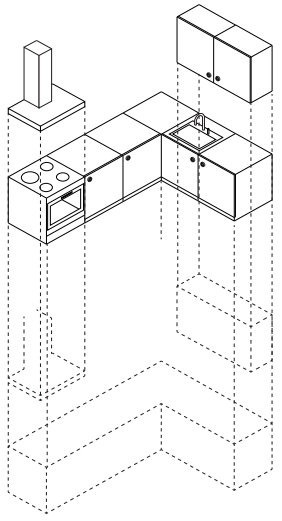
Take your kitchen with you when you move house
In Denmark, leaving the kitchen units in place is a given when we move house. It is then up to the new occupants to decide whether they want to keep the kitchen or install a new one. But not so in Germany, where the new occupants move in with everything from their cooker to their kitchen cabinets and reinstall them in their new home.

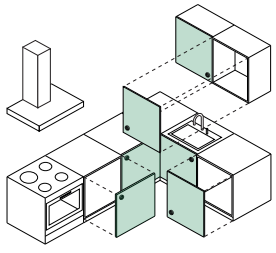
The kitchen is something replaced for aesthetic rather than functional reasons, and many kitchen units end up being incinerated. Based on the German practice, Danish kitchens can be designed so that their materials and aesthetic have a far longer life span.

Replace your kitchen in a day
Kitchen-units maker Reform with their kitchen unit fronts have invented a new way of replacing and using kitchens. Using IKEA kitchen units as the base structure, Reform adds designer fronts, plinths, end-pieces and counters to offer affordable and personalised updates to both new and pre-installed kitchens.

Aside from the financial and design-oriented perspective, Reform is also committed to keeping the kitchen installation process simple. All Reform's cabinet doors and drawer fronts are made ready for mounting, and hinges are all that need to be fitted, since the fronts can then simply be clicked on and off the cabinets. Older IKEA kitchens can also be fitted with the new fronts.

The German kitchen concept: Stoves, appliances and kitchen items are taken with you when you move.





The circular solution: The kitchen cabinet will stand, but the front and table top will be changed if needed.

Case supplier
Reform
Kontakt: Jeppe Christensen and Michael Andersen
Mail: hej@reformcph.dk

'Reform's kitchen solutions can be disassembled and reinstalled, resold or swapped with your neighbour – all in the space of a day'.

— Jeppe Christensen, owner of Reform

Close up of color samples.

Image © GXN

What if your paint was **healthy for you and the environment?**

Bringing lime wash back into conventional building projects
Lime wash has been used for centuries to whitewash Danish farm buildings, churches and stately homes. The obvious advantages of the lime in this wall treatment are its porosity and versatility. It lets out moisture, which is good for both the building and its occupants.

Lime is also a very elastic material that withstands the motion of the building. 30% of the total waste produced by Denmark comes from the built environment, but with lime in both mortar and a lime wash, it is possible to separate the constituent materials from each other after use and reuse the lime without loss of value.

A paint for occupant and house health
REN Vægmaling from KALK is an eco-labelled premium quality lime wash for indoor use. Its applications match those of acrylic and silicate paints, but it is free from VOC and formaldehyde emissions.

In addition, the paint contains no organic solvents, preserving agents, heavy metals or microplastics, which means that it can safely enter a biological cycle and be returned to the natural environment without causing pollution.

'Danish homes have become so airtight that it is often difficult to maintain a sound indoor climate. Our paint is an active remedy for this problem'.

— Rasmus Jørgensen, CEO, KALK

'The vision is for all products used in brick buildings in 2030 to be reusable'.

— Rasmus Jørgensen, CEO, KALK

Close-up of KALK paint.

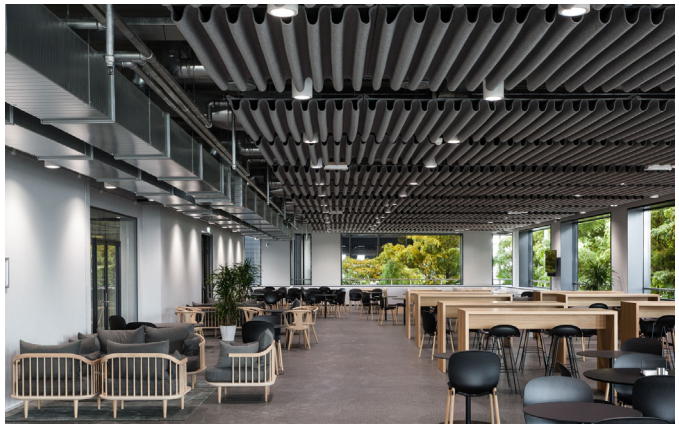
Case supplier
KALK®
Contact: Rasmus Jørgensen, CEO, KALK
Mail: rasmus@kalk.dk

Close-up of ceiling panel made felt from PET bottles.

What if your **ceiling was made of PET bottles?**

Plastics damaging the environment
Denmark incinerates up to 80% of its waste, and 12% of the total waste volume consists of plastic.

Plastic is environmentally harmful, as plastic incineration produces large volumes of CO_2 and toxic chemicals. In addition, far too much plastic ends up in the oceans, where it harms marine life and ultimately ourselves.



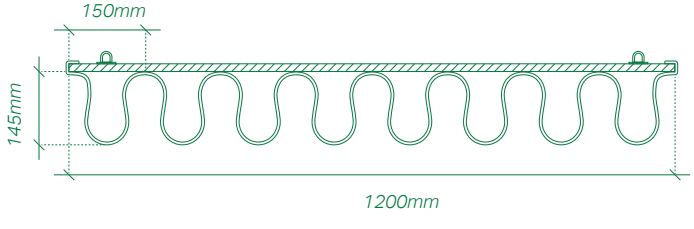
Ceiling panes.
Image © Lendager Group

PET plastic in ceiling components
For the Copenhagen Towers II project, Lendager Group developed and designed acoustic ceiling panels made of PET plastic in the form of a PET felt. PET plastic is the hard plastic used in plastic bottles, packaging trays and the synthetic filling in quilted jackets. Reuse of this plastic makes the most of an abundant resource and reduces carbon emissions.

With their innovative ceiling panels, Lendager Group have demonstrated that plastic waste can be used in an intelligent and aesthetically appealing way.

'For every kilogramme of plastic we reuse, the environment is spared of 1.5 kg of carbon dioxide'.

— Lendager Group



Section thorugh the ceiling panel.

Case supplier
LENDAGER GROUP
Contact: Nanna Lee Thusgaard, Innovation & development
Mail: nt@lendager.com

A finished wall built with recycled materials.

Image © Torben Eskerod

What if **your floor could be sold back to the manufacturer?**

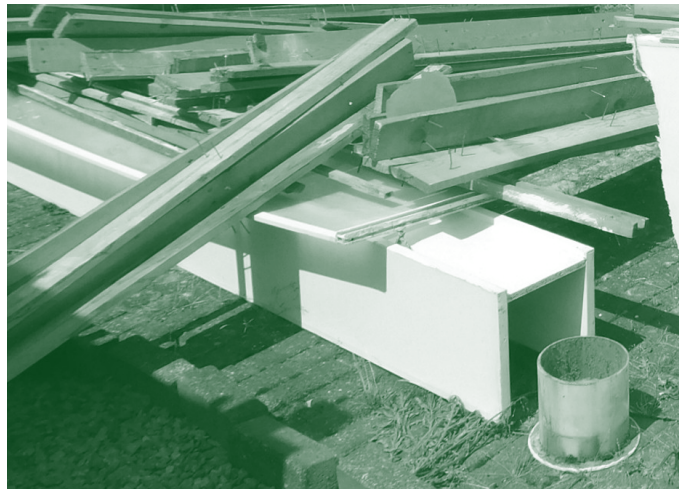
A new mindset
Floorboards constitute a resource, but when buildings are demolished or refurbished, the floorboards are often scrapped and sent for incineration. In connection with the refurbishment of the Albertslund South estate, 80,000 m^2 of beech parquet flooring had to be removed from the property so that new foundations could be laid.

Vandkunsten, the architectural practice behind the refurbishment, saw the value of reusing the floorboards instead of incinerating them and worked on concepts for how the wood could be given a new lease of life in the upgraded units.

The project started a new thought wave in relation to the circular system. The 80,000 m^2 parquet flooring were returned to the original manufacturer, Junckers, where they were milled and then upcycled as wall panels.

Systematising reuse
Albertslund South is an example of how small-scale visions can blaze a trail for a new mindset and new practices. The reuse of building components must be systematised in order to create value for the manufacturer and the occupant.

In just a few years perhaps, we will be able to lease our flooring, swap it with our neighbour or sell it back to the manufacturer we purchased it from.



The construction process in Albertslund Syd.

Case supplier
Vandkunsten
Contact: Katrine West Kristensen, Architect MAA
Mail: kwk@vandkunsten.dk

Environmental benefit

65% CO_2

— Acoustic ceiling

EXAMPLE The installation of a Troldtekt acoustic ceiling reduces carbon emissions by 65% as compared with conventional acoustic ceilings. The saving is achieved in that the acoustic panels are easily demountable, and the materials can be recycled to produce new panels. The assumption is that 90% of the panels can be reused directly.

HOW The calculation is based on a single reuse of the product. In the event of further reuse, the environmental benefit rate increases. The result is based on Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD) data. The calculation was carried out by SBi, the Danish national building research institute.

Cycle of use

15-25

years

— Services

The services in our buildings tend to be taken for granted and regarded as permanent because they are hidden away and fully integrated. However, in the lifecycle of a building, they require inspection, maintenance and replacement. By making them readily accessible and deinstallable, it is possible to optimise the operating costs and facilitate the replacement of a bathroom, for example.

Interview

Circularity in acoustic ceilings

'Troldtekt makes its renowned acoustic ceilings from Norwayspruce sourced from certified local Danish plantations and cement based on raw materials extracted from the Danish bedrock, mixed with water to achieve a premium finish.

Our commitment to circularity started in earnest back in 2009-2010, and the move was borne out by the financial strength of the business. This has been a productive venture for us, so we are open to the idea of circularity being good for business, which it certainly has been in our case.

The Circle House project, which we were invited to join as partners, means that we come into contact with many other players in the value chain. It also demonstrates that the vision of economising on scarce resources is not one we can realise as a single business. We have pioneered many initiatives, but we are only a medium-sized Danish enterprise, so if the entire value chain does not come on board to address this industry-wide issue, we're going to be facing some tall challenges.

There is a general focus in society on the need for businesses to take responsibility, and the fact that we openly demonstrate that we have taken responsibility, and that we have committed to a circular economy, has resulted in demand for these circular products, not only on the Danish market, but also on the 20+ markets we export to. Meaning, it's not just a Danish or Scandinavian trend. It's very much a trend we are seeing in many of our near markets in Europe'.

— Peer Leth,
CEO, Troldtekt

'The entire value chain has to come on board to address this industry-wide issue'..

What if your ceilings contributed to a **naturally healthier indoor climate?**

The majority of Danes spend most of their time indoors. That makes it essential for Denmark's buildings to have a sound indoor climate, and for the component building materials to be designed for the circular economy so that they can serve as a resource down the line. Troldtekt's vision is to be a trendsetter in acoustic solutions for a healthy and sustainable indoor climate. Accordingly, the company's business strategy is based on the circular Cradle to Cradle® design concept®.

Materials
Troldtekt products are 100% natural cement-bonded wood wool panels. The wood is Danish-sourced Norwayspruce, and it is PEFC™- or FSC®-certified, which guarantees that it can be traced back to responsible forestry operations. The cement supplier, Aalborg Portland A/S, extracts its raw materials from the Danish bedrock with minimal environmental impact.

Troldtekt wood concrete board

Troldtekt life cycle

Manufacturing
Troldtekt acoustic panels are made in Denmark under state-of-the-art conditions in a closed-loop system without discharge of waste water. Around 95% of the energy used to heat the timber drying kiln at the production plant is generated from carbon-neutral wood fuel. Equally, all the electricity used in production comes from wind power.

Case supplier
Troldtekt®
Contact : Tina Kristensen, Head of Communication
Mail: tkr@troldtekt.dk

Transport
Troldtekt products are manufactured from locally sourced raw materials, which minimises the company's environmental footprint from transportation. In Denmark, Troldtekt products are sold at builders' merchants and DIY centres. This makes it possible to optimise transportation to the end user. The company has a similar distribution network in its export markets.

Use
The use of Troldtekt guarantees good acoustics in all types of buildings. The company has developed a number of specialist solutions, such as ventilation ceilings for diffuse ventilation to provide enhanced air quality and comfort in schools and offices.

The acoustic panels contain no hazardous substances or allergens and are labelled in the top category according to the Danish Indoor Climate Label. In a new test, the Danish Technological Institute estimates that a Troldtekt acoustic panel in the use phase balances so much CO_2 that its total carbon footprint after 10 years is reduced by 35%.

Reuse
With a service life of at least 75 years, a single panel can enter into multiple use cycles based on smart mounting systems. At end-of-life, the cement-bonded wood wool panels can be composted and revert to their natural state as a soil improvement treatment.

This also applies to production waste and direct Troldtekt waste from construction sites. Troldtekt has launched a take-back system so that offcuts and other construction site waste can be collected and composted. Demolition waste can also be used in making new cement, where the wood content of the acoustic panels aids the incineration process, while the cement component is used as a raw material in new cement.

VELFAC window is designed for disassembly.

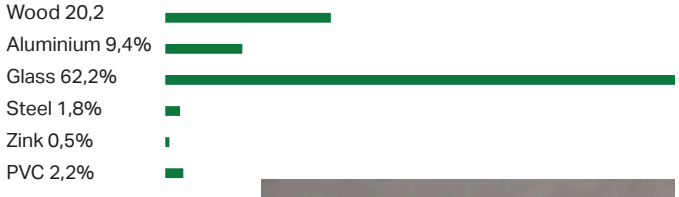
Image © GXN

What if your **windows could be replaced with just a click?**

A focus on the materials
VELFAC 200 Energy consists of 93% recyclable components, manufactured from natural materials. The window is designed for full and easy disassembly into pure material fractions with a purpose of reuse.

The ease of disassembly means that by far the majority of the materials can enter a lifecycle if they are fit for recycling at end-of-life. With a focus on recycling the materials, the company continuously increases the fraction of materials that can be reused.

Materials composition in VELFAC 200 Energy



Design for disassembly
VELFAC 200 ENERGY windows are designed to be deinstalled from a building facade with relative ease and reused directly. In future, the process may be further facilitated by a click system, which will allow the windows to be readily reinstalled in more buildings over their lifespan and without loss of value.

At the end of their life, the windows are easily disassembled into their individual components, which can then be recycled to make new products. The only specialist tool required is a round saw for removing the thermal bridge in the aluminium frame.

93% of the window components can be recycled

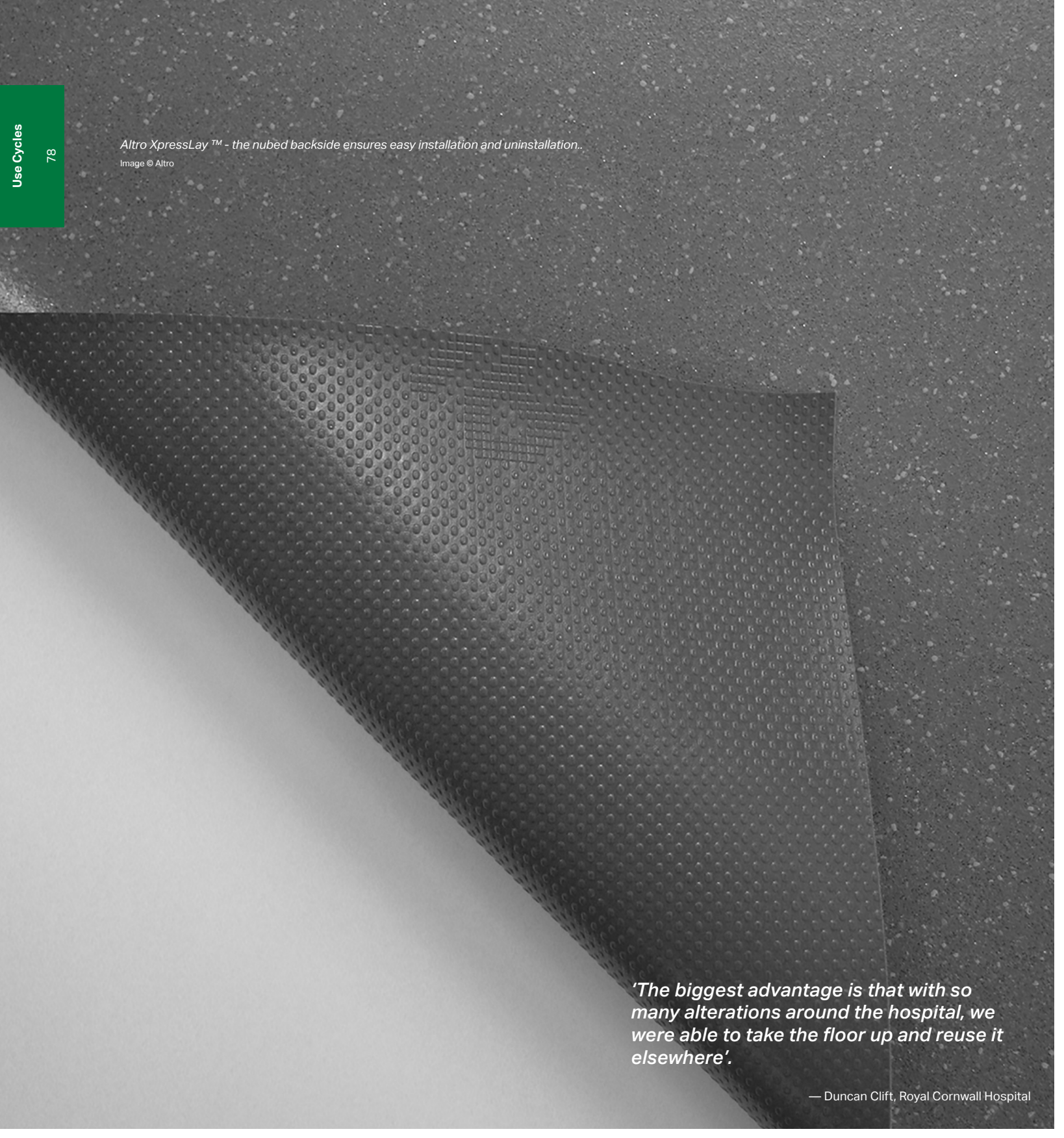
VELFAC 200 ENERGY being collected.

VELFAC 200 ENERGY separated into material fractions.

Case supplier
VELFAC
Contact : René Lohmann-Jørgensen, Consulent Arch.
Mail: rlj@VELFAC.dk

'At VELFAC, we are committed to avoiding needless waste of valuable resources through our products lifecycle'.

— Finn Jespersen, Administrative Director, Velfac



Altro XpressLay ™ - the nubed backside ensures easy installation and uninstallation..

Image © Altro

'The biggest advantage is that with so many alterations around the hospital, we were able to take the floor up and reuse it elsewhere'.

— Duncan Clift, Royal Cornwall Hospital

What if you could **replace your floors in a single day?**

Altro XpressLay™ and Altro Cantata™ adhesive-free flooring is made for designed-for-disassembly projects. The flooring can be reused after deinstallation and is, on average, twice as fast to install as traditional glue-down floors.

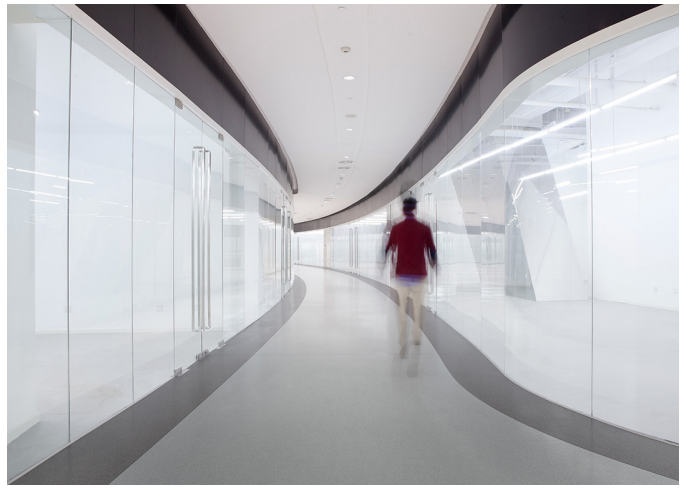
The adhesive-free floor
The nubbed backing guarantees fully functional and durable floor surfaces immediately after installation. And after deinstallation, the floors can either be reused in other interiors or recycled without any wastage in the production of new flooring. At the same time, the installer avoids having to deal with time-consuming adhesive residues and floor-covering remnants on the floor.

The flooring is suitable for use in hospitals, nursing homes, schools and other institutions that require a robust solution that is easy to clean, low-cost to maintain and rapidly installable and deinstallable, in that the floors can be laid directly on top of existing parquet, lino or vinyl. If the original flooring needs to be reinstated, the non-adhesive flooring on top can easily be removed to reveal the original floor in the same state.

> *'This is the first safety floor that can be fully reused, thereby benefiting both users and the environment´.*
>
> — Michael Persson, area Manager, Altro

Recirculation via take-back
Since 2009, Altro has collected vinyl offcuts for flooring production via its Recofloor take-back scheme in the UK, and the company reuses upwards of 500 tonnes of vinyl annually.

Between 2009 and 2017, it reused 3,300 tonnes of vinyl offcuts, corresponding to more than 1 million m^2 of flooring. All the floors are manufactured from up to 20 recycled materials.



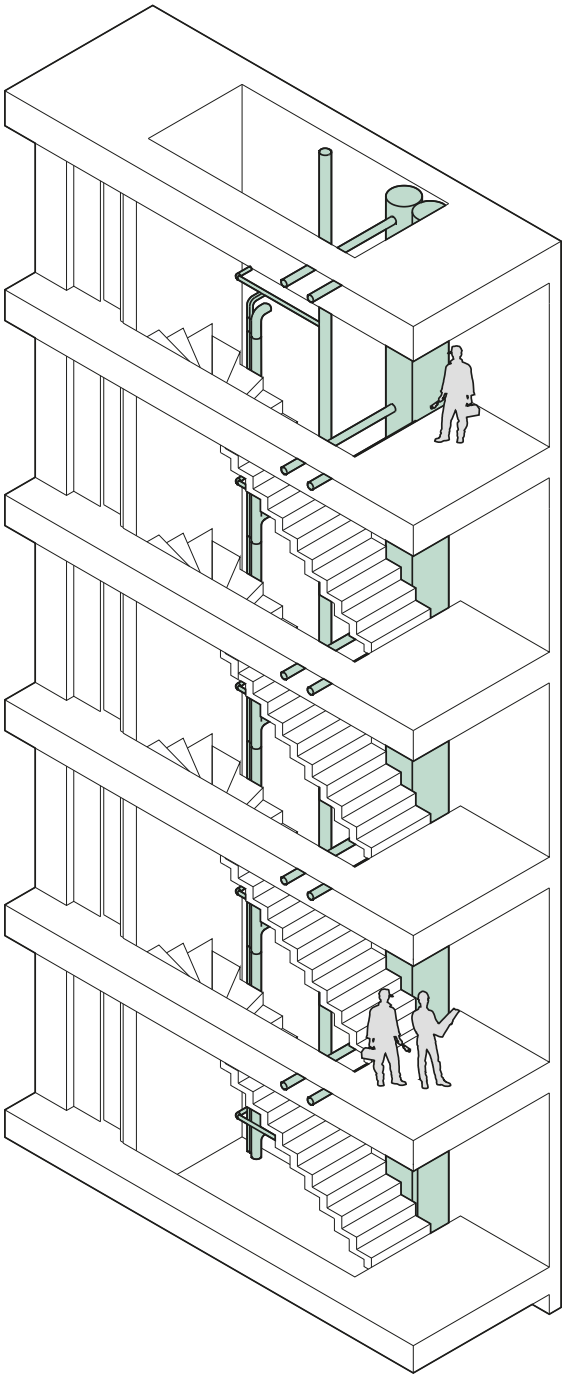
Royal Cornwall Hospital - Altro Cantata™.

Case supplier

altro

Contact: Benny Pedersen, Consulent
Mail: benny.pedersen@altro.dk

Circle House facilities are accessible by the stairs.



What if you **don't need to be at home when your utilities systems are serviced?**

Based on a reverse Centre Pompidou, service pipes are ducted openly inside stairwells, making them accessible and part of the interior design.

To accommodate the pipework, the skylit stairwell has no solid central column, thereby offering an unobstructed view up and down the stairs.

This both provides daylighting and enhances the sense of spaciousness of the stairwell. In addition, the daylighting allows plants to grow in the stairwell, which enhances the indoor climate. Though design-for-disassembly and by planning services installations from the outset, they are both decorative elements and value-adding for occupants and administrators alike.

Planning for circularity
The solution frees up extra floorage for the housing units and makes it possible to perform repairs, replacements and service without having to gain access to the flats.

From construction waste to building decoration
At the end of their life, the pipes can easily be dismantled, replaced by new pipes and upcycled, for example, by cutting them up, flattening them and using them as facade cladding. Learn more about this upcycling project on the display: What if your old ventilation ducts could be used for a new facade?

Centre Pompidou in Paris.

Image © Corbis

Case supplier
Caverion
Contact : Erik L. Olsen, Head of Operational Development
Mail: kebi@bestgreen.dk

Heat pump on existing building.

Image ©Jesper Balleby

What if the space **heating in your home was something you leased?**

A circular business model
Best Greens has created a circular business model to provide a sustainable and maintenance-free heating solution in which Best Green takes care of the practical sides of the service. The consumer pays for the heating used in a monthly subscription. Best Green calls this solution "local heating" to differentiate it from conventional district heating.

Instead of buying a heating product, the home owner only leases a heating service. Best Green then takes care of all the practical sides of the service and subsequently ensures that the heat pump materials are reused. Best Green purchases and installs a state-of-the-art heat pump system and then takes care of its operation and ongoing maintenance.

Thanks to the circular business model and subscriber scheme, home owners benefit from an eco-friendly heating solution.

The benefits of local heating
The system ensures high reliability of supply. The system is monitored 24/7 to guarantee stable performance. In this way, users are guaranteed a fixed monthly per KWh heating charge. Best Green also covers the cost of the electricity used by the heat pump, which comes from renewable energy sources. This means that the consumer no longer has to think about either performance or price.

Heath distribution system.

Better for the environment
By leasing a heating solution, you are contributing to the circular economy both during use and when the pump is no longer used. Over its service life, the pump supplies sustainable heat, and when the pump is decommissioned, Best Green ensures that the materials are reused.

Case supplier
Best Green
Part of the Ineero Group
Contact: Kent Bisgaard, Business Development
Mail: kebi@bestgreen.dk

Environmental benefit

45% CO_2

— Clay shingles

EXAMPLE The use of Kompro ment Clay Shingles as a facade system provides a carbon saving of 45%. The reason for the saving is in the mounting system, which involves screw-fixing the facade tiles to an underlying aluminium rail. This allows the tiles to be easily disassembled and reused, without any loss of value. The assumption is that 90% of the clay shingles can be reused directly.

HOW The calculation is based on a single reuse of the product. In the event of further reuse, the environmental benefit rate increases. The result is based on Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD) data. The calculation was carried out by SBi, the Danish national building research institute.

Cycle of use

25-50

years

— Skin

Given its exposure to the elements during the building's lifespan, the building skin (facade) is expected to be replaced or at the least undergo extensive renovation. This makes it imperative for the facade to be easily disassembled without loss of value.

Interview

Cirkular Facade

'Komproment makes different types of facade materials. We also have a roof tile division, but our facade tile division offering natural slate and clay shingle facade tiles is our main venture at present. Komproment has made a strategic decision to Cradle to Cradle®-certify our facade division. This means that we know what goes into our facades.

We know what goes into every fitting, and we have contracted others to validate our claims. That means we know for certain that our facades are reusable, and make no false claims. Going circular means being a first mover, which we can rightly claim to be in the facades industry. There has definitely been som effects in our in-house communication in that we had to use new terminology to reflect our circularity.

We have proof of concept in that our suppliers have had to join the game. They have provided inputs on all the aspects, and we have duly altered some of the materials in our facades because they didn't fit in with the circular mindset.

We have great expectations of the Circle House project in terms of spreading the word, because the project is an example of how things can be done. The power of example is worth far more than fire and brimstone preaching. Hopefully, another benefit is that it broadens our outreach, so we get clients, contracting authorities and others to understand what circular building means. In that sense, there's a lot to be gained now, and even more in the long run.

Many of our clients currently base their decisions about building materials on the criteria of function, design and cost. These are the primary factors in choosing our facade products. The fact that their circularity ranks only 7th or 8th in the criteria doesn't matter. But as we see it here and now, a circular commitment doesn't cost more if it's there from the design phase. And that's what we have done in our facades'.

— Niels Heidtmann,
R&D Director, Komproment

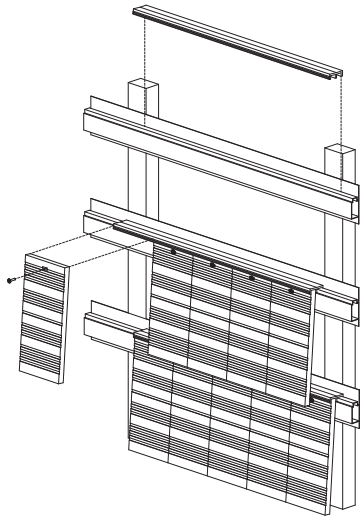
'A circular commitment doesn't cost more if it's there from the design phase'.

What if **your facade had a passport for the future?**

Komproment has developed a lightweight, ventilated facade solution based on clay shingle in which the entire system is reusable.

Komproment has developed a lightweight, ventilated facade solution based on clay shingle in which the entire system is reusable. The Clay Shingle facade system is manufactured exclusively from inorganic materials and is based on circularity. All components of the mounting system have been fully tested and documented as sustainable.

This was done in association with the client KAB, the module manufacturer Scandibyg and the architectural firms of ONV Arkitekter and JaJa Architects. The entire system can be deinstalled and reinstalled elsewhere, since both clay shingle and the underlying aluminium battens are fixed in place using stainless steel screws. These are concealed and protected behind the hard-fired tiles, which are maintenance-free and can be reversed when reinstalled to extend their life even further.



Teglspån monitoring system.

Manchester rustic.

Westerwald fluted.

Chelsea fluted

An alternative tiled facade
Komproment's Clay Shingle comes in nine shades and two different finishes. The hard firing of the clay shingle creates colour variations for a more vibrant look to the tilework.

The shingle is extremely lightweight, and therefore requires no additional battening. The resulting facade is maintenance free, which means that it entails no servicing costs in its lifetime.

Practical mounting system
As a lightweight facade system, Clay Shingle can be used in both newbuild and refurbishment projects. The system consists of aluminium battens, a system assembly rail and plastic windboard, and the shingles are mounted to the assembly rail using stainless steel screws. All the component parts can be handled by one installer, and therefore mount rapidly and with ease, as the entire system is designed for on-site assembly and easy adjustment to the substrate.

Comes with a material passport
With its silver-grade Cradle to Cradle® certification, Komproment is the only company in Denmark offering certified-sustainable tile facade solutions containing no harmful substances and where the entire system can be fully disassembled. Komproment supplies a material passport with its facade systems, enabling the individual components and materials to be sorted and reused in future.

The passport records important data on the products, which ensures full utilisation of the products and the materials in subsequent use cycles.

Case supplier
KOMPROMENT
TAG OG FACADE
Contact: Niels Heidtmann, R&D Director
Mail: niels@komproment.dk

Derbigum - Recycled roofing paper.
Image © Derbigum

Since 1999, Derbigum has reused 4,000 tonnes of bitumen per annum, which reduces the plant's carbon emissions by more than 40% per annum.

What if **your roofing cleaned the air around your home?**

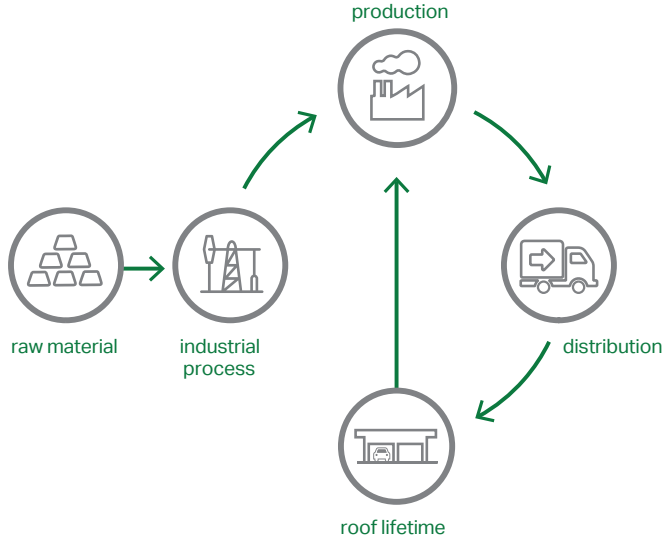
Since 1977, Belgian roofing membrane manufacturer Derbigum has supplied eco-friendly roofing to Denmark and fed end-of-life roofing products into its production. The eco-choice roofing membranes Derbicolor Olivine and Derbipure have made Derbigum one of the world's leading manufacturers of roofing membranes that improve their surroundings.

Derbipure is the only roofing membrane in the world to gain Cradle to Cradle® certification, and has also received the EU's prestigious EMAS eco-award.

Recycled roofing membrane
Derbigum manufactures roofing membranes from the raw material bitumen as the main component. However, the manufacturing plant also receives around 4,000 tonnes of roofing membrane from old roofs, corresponding to about 1 million m^2 of membrane.

The old bituminous membrane is processed, melted down and recycled in Derbigum production. In this way, the material circulates in multiple use cycles. The product has a documented lifespan of more than 40 years. The life doubles to 80 years with an extra layer of Derbigum roofing membrane in either the traditional black or the reflective white roofing membrane.

Derbigum is committed to the use of all recycled and organic materials in its production. This combination ensures that the final product is in itself fully recyclable. The company's 20-year commitment to R&D in new sustainable products is driven by a mission to exclusively use raw materials that result in reduced carbon emissions.



Material diagram.

Derbicolor Olivine for air purification
The mineral olivine is one of the most commonly occurring minerals on Earth and readily neutralises atmospheric carbon dioxide. When it rains, carbon dioxide in the air is converted into two environmentally friendly substances – silicium dioxide and magnesium carbonate – simply by coming into contact with rooftop olivine.

Case supplier
DERBIGUM®
MAKING BUILDINGS SMART
Contact: Peter Kranz, Adm. Manger, Eurotag
Mail: kranz@eurotag.dk

Residues can be recycled from the construction for the production of Rockwool.
Image © GXN

Rockwool collects by-products for upcycling in its production of new stone wool. In 2016, a total of 16,000 tonnes of stone wool was collected and upcycled globally.

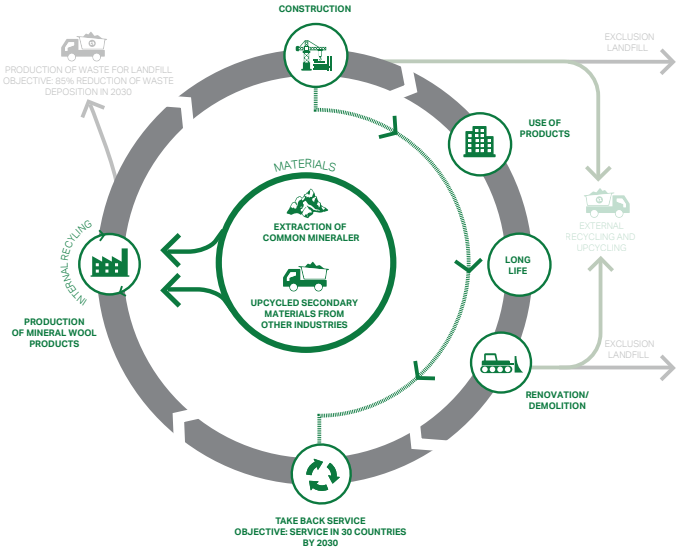
'The RockZero system is rapid and efficient to install and deinstall on construction sites, and its carbon footprint is 50% smaller than conventional heavy concrete structures'.

— Connie Enghus Theisen, Director Stakeholder Engagement

What if **your toilet was transformed into the wall in your next home?**

A non-depletable raw material
The primary raw material for the production of Rockwool is volcanic rock – a natural and non-depletable resource. Every year, volcanic activity and plate tectonics create around 38,000 times the volume of rocks used annually by the Rockwool Group.

For decades, Rockwool has recycled scrapped Rockwool insulation and surplus insulation from newbuilds. It all goes into the production of new insulation, which closes the cycle, as the material can always be melted down and hence recycled.



Material diagram.

Case supplier
ROCKWOOL
Contact : Connie Enghus Theisen, Dir. Stakeholder Engagement
Mail: c.enghus.theisen@rockwool.com

Recycling and upcycling
For decades, Rockwool has been committed to recycling materials. The by-products that are waste for other industries become secondary raw materials in Rockwool's production, replacing the extraction of new resources. Together with recovered stone wool, used materials currently make up one third of Rockwool's raw materials.

Stone wool lasts for the service life of the entire building
To date, 40-50,000 tonnes of other-industry by-products have been recycled in Denmark, such as filter dust from the cement industry and ash from wood-chip-fired power plants. In production, the volcanic process is recreated in a furnace which melts the stone, and the molten mass is then spun into fibres.

The process involves extremely high temperatures, and the surplus heat is used by the nearest district heating system. The thermal insulation and noise dampening properties of stone wool do not decline over the building's life. Rockwool is committed to improving the energy performance of both existing and new buildings.

Made for sustainability
The modular and high-efficiency RockZero wall system is designed for disassembly.

The system is zonal and the insulation is retained without the use of hardware such as screws, which is what enables partial or entire insulation layers to be disassebled and the parts to be reused, without any further treatment, in other projects, with its insulating properties retained.

The system's carbon footprint is 50% smaller than conventional heavy concrete structures. RockZero installation requires no crane/lifting gear, is rapid and efficient to install on a construction site, and is also based on a novel thermal bridge-free technology guaranteeing low energy consumption.

Aurubis product come from the recycling of copper.

Iamge © Arubis

What if **your facade became your pension scheme?**

Hamburg-based Aurubis is Europe's largest copper manufacturer and the company in the world that recycles the most copper.

Copper is one of the most costly roofing options available, but can be melted down again without appreciable loss of value and strength. This makes copper a readily recyclable material, and hence a long-term investment.

Copper is 100% recyclable and the proportion of recycled copper is 40% globally.

Copper used for roofing or sidings has a lifespan of 100 years, after which it can be disassembled, melted down and used in new products with its strength and lustre revived. Over time, copper exposed to the elements acquires a verdigris patina, which is the metal's own protection against further corrosion.

In Europe, copper is in great demand as an efficient heat conductor. For this reason, by-products and scrap copper are very commonly recycled to form new products, it being one of the first materials in history where reuse was a given. Copper can be melted down and recycled infinitely, as the quality of the metal is retained.

Auribis recycles 700,000 tonnes of raw material annually.

Copper value trend.

The scrap metal is analysed, sorted and cleaned before being melted, and then subjected to high-tech fine-sorting before it is transformed into a new product. Aurubis has been committed to increasing the volume of recycled metals by 20% between 2013 and 2018.

Almost 100% of copper scraps are recycled.

Case supplier
Aurubis
Contact: *Henrik* Kjær, Marketing, Muncholm
Mail: hk@muncholm.dk

Spiral tubes as facade material.

Image © Vandkunsten

What if your old **ventilation ducts could be used for a new facade?**

In 2004, the architectural practice Tegnestuen Vandkunsten and the architectural salvage business GenByg launched the Nordic Built Component Reuse open source project.

The project addressed the resources that are lost when building components are scrapped by refurbishment projects. Numerous concepts were proposed as alternatives to new construction products, including the SpiroWall facade concept.

Waste with new value

Due to global demand for steel, almost 100% of available scrap steel is melted down and recycled. If steel pipe is reused directly instead, the energy consumption of the melting process can be deferred.

Steel does not lose its strengthen by being pressed flat, and in no time it provides a very stable and extended durability facade element that is every bit as effective as newly-produced steel.

Ducting.

A robust facade

End-of-life ventilation ducts are often scrapped when buildings are refurbished or demolished, but can easily be taken down as they are mounted in a simple suspension system. The principle for the two partners was to process the ducts as little as possible.

The spent ducts are rolled or pressed flat, which can be done on-site after removal so as to make their transportation more efficient also. Subsequently they can be cleaned, but require no further treatment to be fit for use as facade cladding.

The panels can subsequently be reversed, demounted and cleaned or used elsewhere.

Case supplier

Vandkunsten

Contact: Katrine West Kristensen, Architect MAA
Mail: kwk@vandkunsten.dk

The wing strokes are exposed in the facade composition.

Image © Torben Eskerod

'We should not only be talking about circular building principles in terms of necessity, but also in terms of aesthetics and functionality'.

— Katrine West Kristensen, Architect

What if you **could replace your facade during the weekend ?**

The architectural practice Vandkunsten developed a winged mounting for refurbishment of the Gårdhusene estate in the Albertslund South suburb of Copenhagen.

The Gårdhusene estate belongs to a generation of low-rise, high-density large-scale housing projects that grew in Copenhagen's outer suburbs in the 1960s.

An industrial and uniform project of a technical standard that has necessitated upgrades over numerous renovation schedules. As part of an architectural competition, Vandkunsten blazed a trail for a new renovation practice by introducing both sustainability and autonomy to the Gårdhusene estate.

The architects have tested the solutions in several demo homes and consideret the Gårdhusene renovation project as a potential game changer for large-scale social housing renovation projects in Danish building and construction practices generally. The focus has been on achieving significantly lower waste production than in a conventional building project.

The wing fasteners are attached with one screw.

Image © Torben Eskerod

Easily replaceable siding
The use of industrialised materials and standard dimensions make materials more readily recyclable in other future use-cycles without the need for pre-treatment, thus enabling direct use in a new context.

One of the innovations in the project is a winged fixing for one of the siding solutions. This fixing retains the facade elements without any need to drill through the panels and is also very easy to deal with in both installation and replacement processes.

So much that the occupants can do it themselves. When the siding panels are worn out, the fixing can still be used or re-sited. As the winged fixing is visible on the exterior, it serves as a decorative element and displays an honesty about raw materials, joints and constructions.

Case supplier
Vandkunsten
Contact : Katrine West Kristensen, Architect MAA
Mail: kwk@vandkunsten.dk

Environmental benefit

45% CO_2

Precast concrete structures

EXAMPLE Precast concrete structures installed using Peikko connections deliver a saving of 45% CO_2 as compared with conventional precast structures. This is achievable because the precast structures can be disassembled and reused directly. The fixings allow the shell structure to be assembled using bolts and screws instead of cast-in-place connections. The assumption is that 90% of the precast concrete structures can be reused.

HOW The reusability value is based on a single reuse of the product. In the event of further reuse, the environmental benefit rate increases. The result is based on Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD) data. The calculation was carried out by SBi, the Danish national building research institute.

Cycle of use

50-100

years

— Structure

The structure in our layers context is the building superstructure, so its joins are not expected to be immediately accessible. Superstructure members have a long service life as compared with a building's other components, so it is important that they can be disassembled and reused in other buildings.

Interview

Circular connections for precast concrete structures

'Peikko is a supplier of cast-in-place parts with mechanical connections for pre-cast structures. The conventional way of assembling precast concrete structures is to cast them together to make one continuous unit.

We want to abandon this method in favour of using bolted connections. Circle House is a useful project for us to be involved in because it gives us a unique opportunity to partner with the industry to develop new solutions and products that make it possible to design and build circularly and ultimately enable precast concrete elements to be disassembled and reused.

Many of the projects the Danish architectural practices are involved in designing and build already embody some of the circular mindset. For that reason, the precast industry is forced to get involved and engaged in the industry's transition. Today, everything is at the pioneering stage, but ultimately we hope and expect it to be a profitable business'

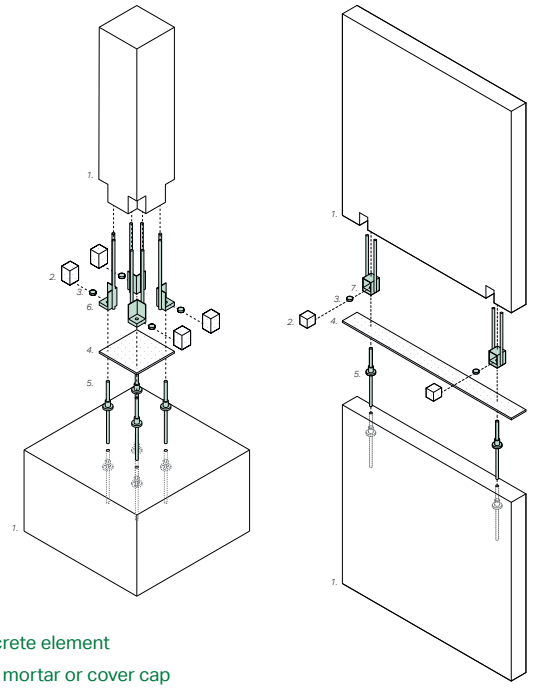
— Jonas Høg,
Building Engineer, Director Peikko Denmark

'The precast industry is forced to get involved and engaged in the industry's transition'.

What if you **could deconstruct your entire house using a wrench?**

Mechanical connections for concrete buildings
The Finnish business Peikko manufactures mechanical connections for pre-cast structures. The connections permit disassembly in the future. Their wall and column system consists of shoes cast into prefabricated concrete structures, and anchor bolts cast into foundations or other concrete structures.

The structures are assembled on-site and fixed to anchor bolts by means of nuts and special AL washers as the bolt connection. After installation, the hardware and connections are grouted so that they can no longer be disassembled.



1. Concrete element
2. Lime mortar or cover cap
3. Nut
4. Undercutting mortar
5. Anchor bolt with thread
6. Peikko pillar shoes
7. Peikko wall shoes

Everyone stands to benefit from Peikko solutions – precast concrete plants, clients, consulting engineers, developers and architects.

Peikko is keenly focused on product development. The company has introduced many new and innovative solutions on the markets over the years, all of which have improved construction techniques. A good example of such a solution is their column shoe, which ensures a robust concrete column connection.

Peikko is actively involved in the standardisation project at the European level and in major international research projects. Peikko products make client construction processes faster and easier. Peikko product development takes the client's or market's needs as its point of departure.

The aim is to influence the construction process throughout the building's life-cycle, right from the choice of technical solution, through the construction phase and for the life of the entire building.

Prefabricated concrete pillars are mounted using Peikko pillar shoes.

Attachment and adjustment of the elements can easily be done by means of a wrench.

Case supplier
peikko®
Contact: Jonas Høg, CEO, Construction Engineer
Mail: jonas.hog@peikko.com

Tiles with 10% (left) and 50% (right) recycled concrete in.
The 50% has a rough surface and will probably not meet the applicable quality requirements.

What if **your home was made of recycled concrete?**

Current use of concrete
Even now, 90% of all scrap concrete is recycled as base course under roads in place of coarse gravel. In fact, it is superior to gravel base course, making it possible to economise on the asphalt volume.

In addition, there is the option of using crushed concrete in place of quality stone and other aggregates in new concrete, for example for constructions and tiles, provided that it meets the prevailing performance requirements and standards.

Crushed concrete should be avoided in the future.

Image © GXN

A trade organisation for concrete manufacturers
Dansk Beton, the federation of Danish concrete manufacturers, is working to drive progress in the industry. They do so through two initiatives with recycling in focus:

— Recycling of scrap concrete for roads and tiles, where tests are performed using 10-20-30 and 50% aggregates of crushed concrete. The products are checked for product quality conformity.

— Reuse of residual concrete directly at the plants, where the ambition is to use most of the residual concrete to make new products.

The Danish Construction Association welcomes the circular economy because we believe in solutions that are based on quality and that benefit both the economy and the environment.

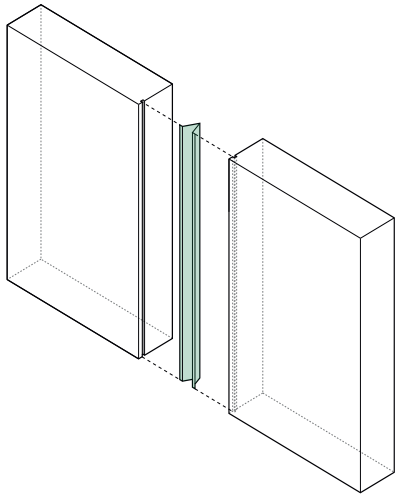
Case supplier
dansk beton
Contact: Thomas Uhd, Branch Director, Danish Construction
Mail: thu@danskbyggeri.dk

Close-up of spring steel fuge.

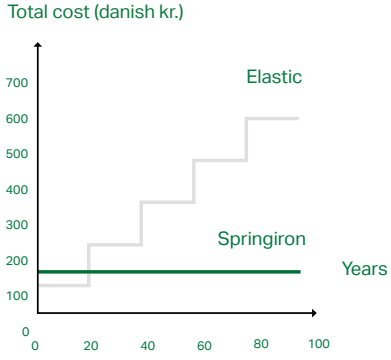
What if **your sealings were made of metal?**

Reusable steel sealing
Connovate is a knowledge-based business that sells licensing rights, high-strength concrete and consulting services etc. The company has invented a mechanical steel sealing for pre-cast concrete structures with an extremely long life of +100 years. The sealing is applied by forcing it into a recess between concrete structures.

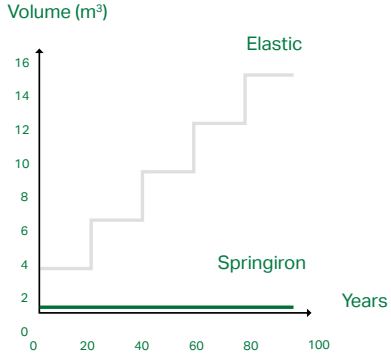
The sealing functions like a coiled spring to sustain the pressure between two abutting building components and is self-retaining so as to fill the gap. The use of sprung stainless steel profiles preserves the flexibility of the sealing for its service life. The steel sealing accommodates the dynamic movements that arise between two abutting structural components over time. The steel sealing can be removed without leaving any traces.



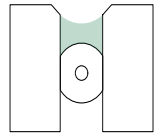
Spring steel sealings are placed between the two concrete elements



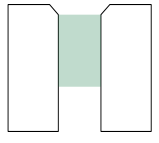
Total economy / lifetime.



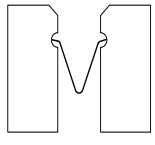
Material consumption / lifetime.



Elastic



Sealant Tape



Springiron

Types of joints

The sealings are 100% reusable, have low environmental impact and are maintenance free.

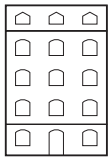
Case supplier
connovate
Contact: Karsten Bro, CEO, Architect MAA
Mail: Kb@connovate.com

Removal of the limestone test.

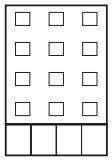
Image © GXN

What if **your binding material could be hosed away?**

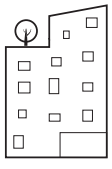
Lime as a primary binder
70% of Denmark's building stock was constructed using lime, and for millennia, this was the preferred material for binding building blocks together. Unlike the cement mortar that has generally replaced it, lime mortar can, advantageously, be removed from the structure it binds. Since cement mortar began to displace lime mortar in the 1960s, this hard and strongly binding material has dominated in newbuilds.



1900
Lime morta



1950
Cement mortar



2000
Lime mortar

Cradle to Cradle® certification
KALK is the world's first Cradle to Cradle®-certified supplier of lime products. KALK is committed to creating a sustainable and preservation-worthy building culture.

Field study
During the Circle House project, trials were done of casting Peikko fixings with lime mortar, which can then be removed by hosing. The mortar only needs to protect the fixing against fire and corrosion and as such need not have any strength.

Through field studies at KALK, this technique was tested. Three fixings with different strengths of mortar were left for two months, after which the mortar was hosed off.

The production of lime mortar emits up to 30% less CO_2 per m^2 wall as compared with cement mortar.

The lime mortar is flushed with a high pressure cleaner.

It was possible to remove the weakest of the three mortars in 10 seconds.

Case supplier
KALK®
Contact: Rasmus Jørgensen, CEO, KALK
Mail: rasmus@kalk.dk

The piles are shaped like large screws up to two meters in size.

Image © Uretek

What if your **house could be moved without a trace?**

New pile-driving solutions
Today, the majority of foundations for newbuilds are made of cast-in-place concrete. This prevents demolition or the removal of a building without leaving both a large physical footprint and a large environmental footprint. With new products on the market, it is now possible to move and reuse buildings without leaving any footprint.

ScrewFast Screwdrivers
ScrewFast Skruepæle® is a non-disruptive method for pile driving of new and existing buildings.

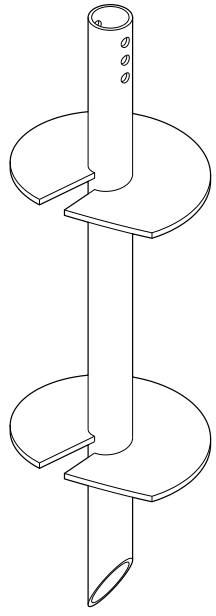
The technique is simple, fast and vibration-free. It also avoids consequential damage to adjacent buildings and extensive reestablishment work. Another advantage is that the piles can easily be extracted and reused, which makes them ideal for pile-driving for temporary installations.

Once a ScrewFast Skruepæl® pile has been driven into the ground, it is primarily the helix sheets that take up the stresses from the soil and structure. The screw piles can be driven more than 20 metres down into the ground, depending on the site soil conditions.

Each pile must be anchored at least 1.5 metres down in supportive soil layers.

The screw piles allow you to reuse your foundations and leave your site intact.

Screw piles are installed with construction machinery.



ScrewFast Screw pile

Case supplier
URETEK®
Contact: *Morten G. Havndrup, Project leader*
Mail: *morten@uretek.dk*


VÆRDIEN AF
STÅLELEMENTET
NU :
MULIG FREMTID :

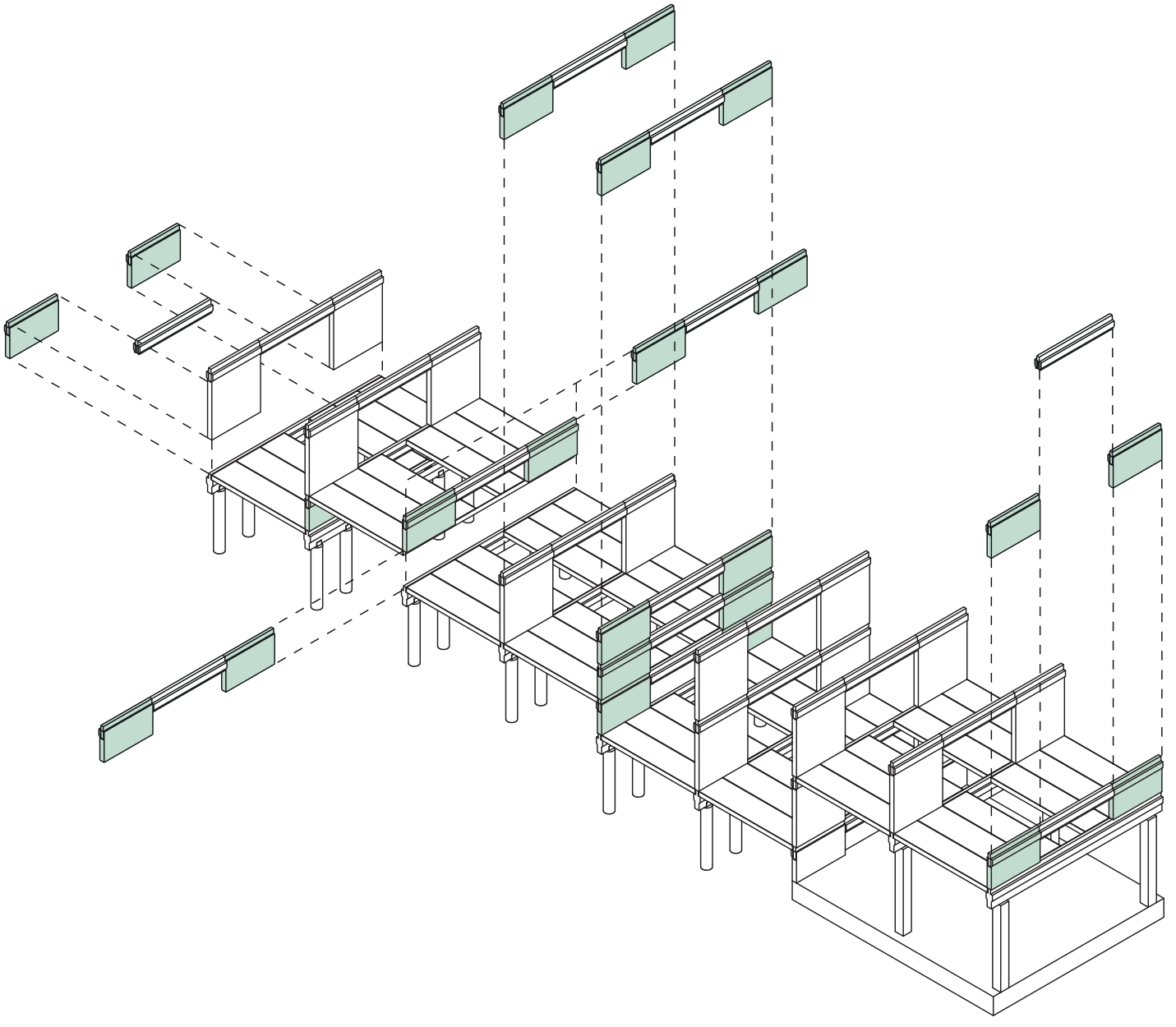
The future and Circle House

The present chapter is the outcome of a partnership between practising architects 3XN Arkitekter, GXN Innovation and five students from CINARK – Centre for Industrialised Architecture at The Royal Danish Academy of Fine Arts, School of Architecture.

The studies referred to here represent a number of academic projects in two categories: Firstly, the students hypothesised that the Circle House construction system and its associated components would be used in a different context in their second life. Secondly, they studied the options afforded by supplementing and extending the construction system with further components, thereby elaborating on the system.

Image © GXN

80% Circle House Building System.



What if **Circle House was to accommodate landscape topography?**

Circle House's second life cycle

One of the three scenario contexts was the landscape, where the students implemented a half wall element so that the construction system could incorporate site landscape and offer varying ceiling heights.

Equally, it was vital for the students to challenge the Circle House project on its original design parameters such as construction budget, environmental impacts, flexibility and component reusability.

For that purpose, the students created a basis for comparison, where data on any components and spatial dimensions added or altered are rated against existing ones. Further, they developed a rating system and basis for comparison for each of the above-mentioned design parameters as an estimate of the given solution's performance compared to the original one.

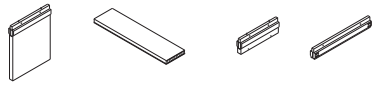
'We wanted to test the Circle House construction system by placing it in three locations that each challenged it in different ways'.

— Casper Ravn, student at KADK

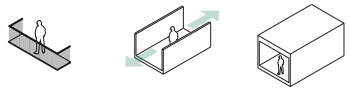
Comparison

Existing elements and spaces

Elements

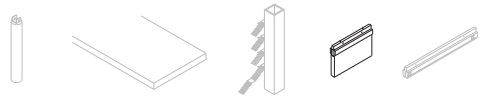


Spatialities

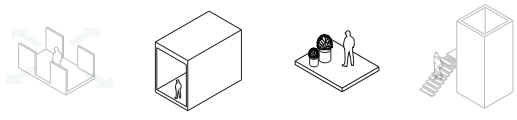


Addiotional elements and spaces

Elements

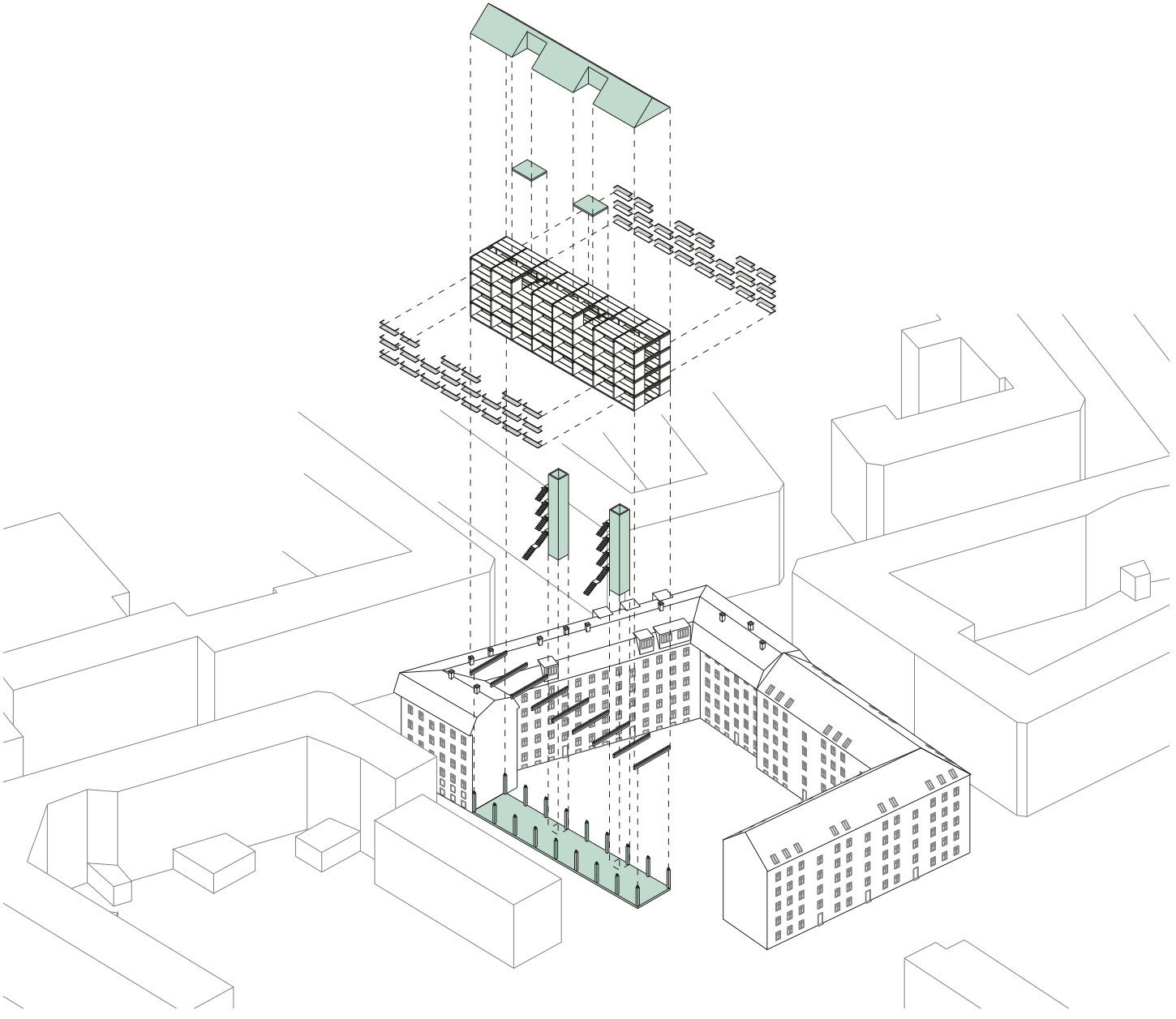


Spatialities



Student
KADK - Settlement, Ecology & Tectonics
Contact: Casper Skrøder Rasmussen Ravn, studarc, *KADK*
Mail: stud5064@edu.kadk.dk

Exploded axonometry.



What if **Circle House was to be built in an urban setting?**

Circle House's second life cycle
This study question addresses the adaptability of the Circle House system's flexibility and construction system to a new context. The Circle House project was sited in one of the proposals for a development in the Nørrebro district of Copenhagen.

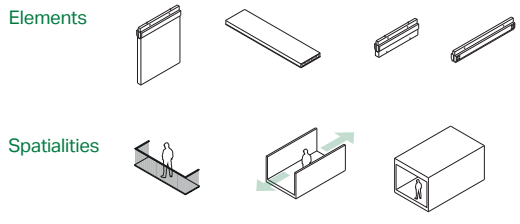
Here, the aim was to arrive at an elevated ground floor to accommodate retailers or a car park. Next, the construction system was given a new columnar member, a radiating structure, a lift axis and stairs. In addition, roof terraces and a new brick roof. A simple ranking system was developed in order to understand how the changes applied impacted the system. This should serve as a rough pointer.

'We wanted our studies to be as relevant as possible and therefor places our proposal on an actual site i Copenhagen'.

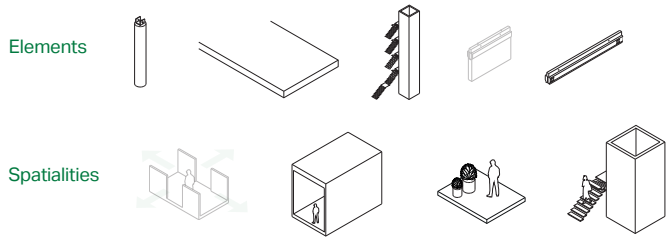
— Sarah Sonne Glatz, student at KADK

Comparison

Existing elements and spaces

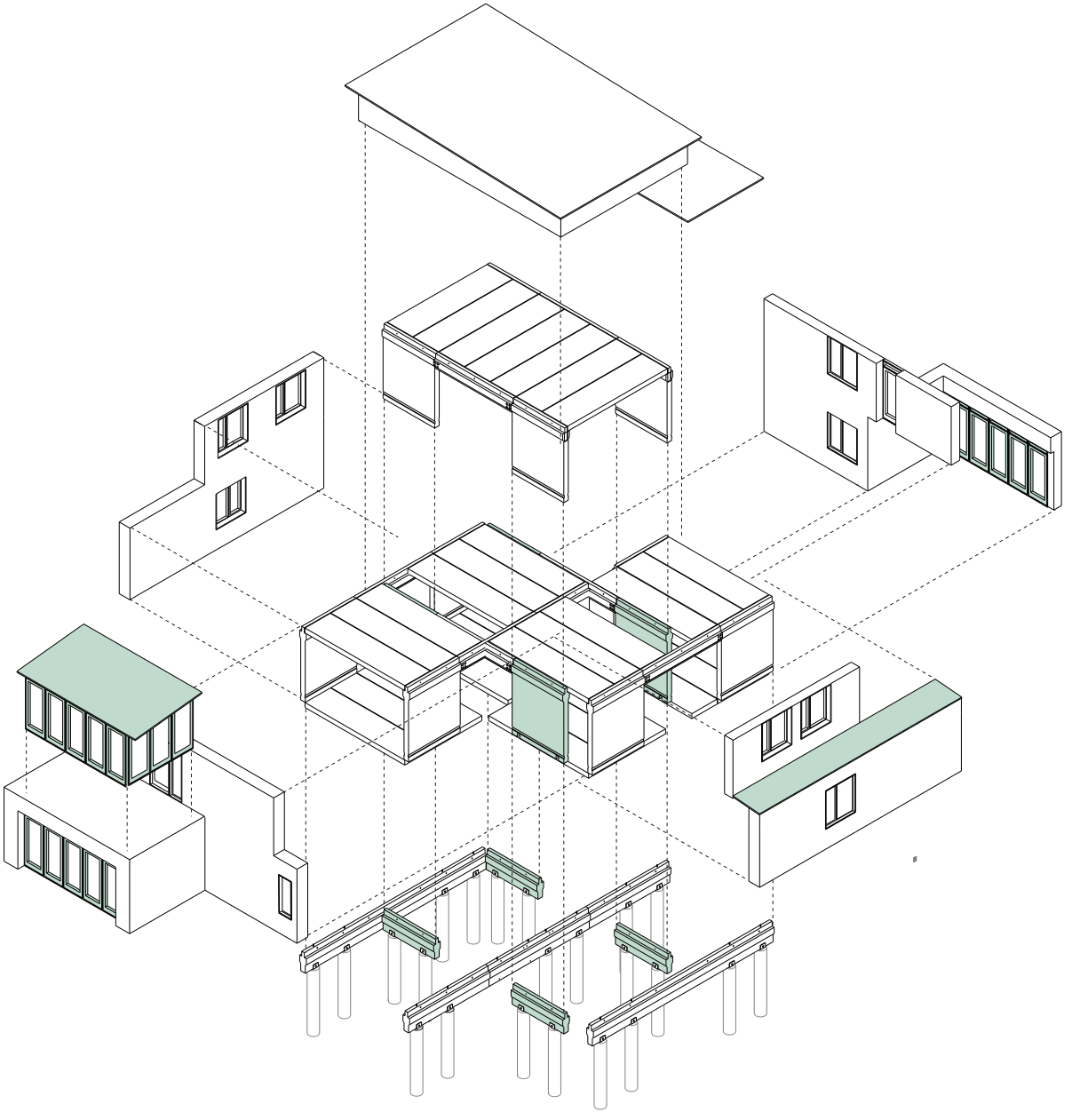


Addiotional elements and spaces



Student
KADK - Settlement, Ecology & Tectonics
Contact: Andreas Holmøy Ilstad, stud.ark, *KADK*
Mail: Stud5120@edu.kdk.dk

Exploded axonometry of single family house.



What if **Circle House could be used as building blocks for a new single-family home?**

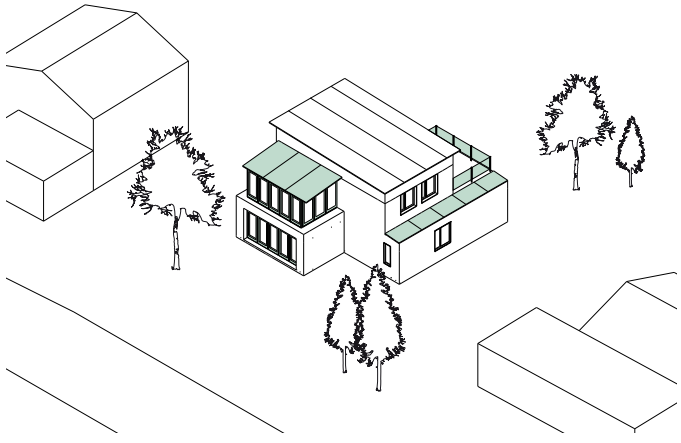
Circle House's second life cycle
For the vision of a building that can be disassembled and rebuild to be viable, its main components must be able to be reused and assembled in a great variety of ways.

This example is a single-family home constructed using Circle House components. In the example, the Circle House system is displaced and rotated in order to test the versatility of the components and the options for adding new spatialities for new occupants.

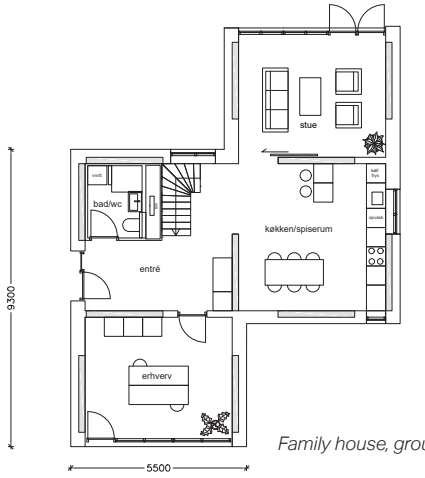
This allowed for the option of building open facades, add-ons in the shape of a conservatory and patio, and the option of business or workshop premises on the ground floor of the building.

Comparison

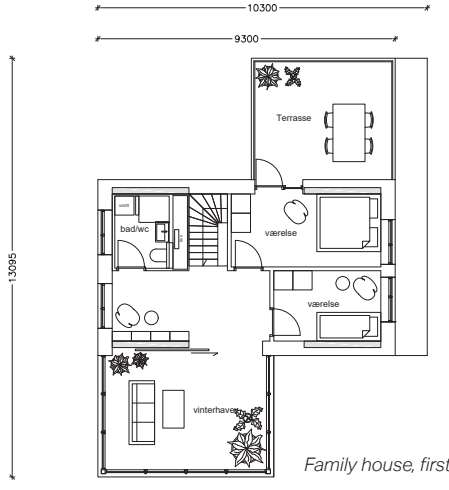
Flexibility	●	●	●	●	●
Construction costs	●	●	●	●	○
Recycling	●	●	●	○	○
Environment	●	●	●	●	○



Single-family house as an assembled building



Family house, ground floor



Family house, first floor

Student
KADK - Settlement, Ecology & Tectonics
Contact: Sarah Sonne Glatz stud.arc, *KADK*
Mail: sglatz@gmail.com

Circle House groundfloor: pillar and stair system.

'The system of columns and beams allows for a large number of options for customisation and spatial variation'.

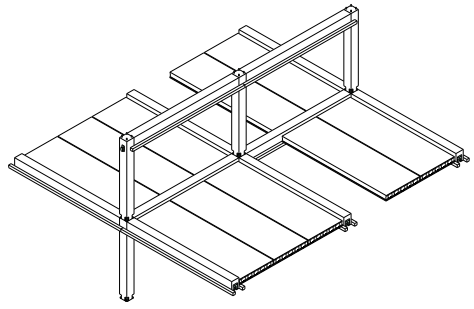
— Rasmus Feddersen, Student at KADK

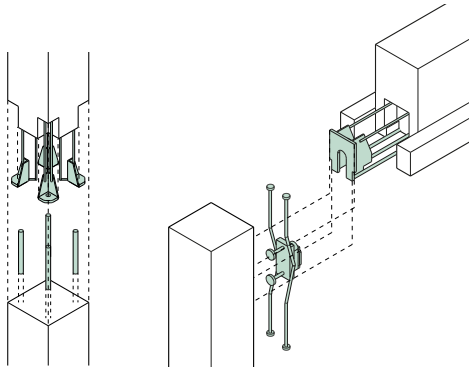
What if **Circle House was constructed with columns and beams?**

Challenging the construction system
The superstructure is the Circle House layer with the longest anticipated lifespan.

Accordingly it should also embody a high degree of versatility in both its design planning and use. With that in mind, we addressed the viability of a column-and-beam construction system.

This is undoubtedly a more costly solution because there are more structural members and more joints. On the other hand, this would allow less concrete to be used, and would hold more options for customising the system to a specific context. Because the superstructure has the longest lifespan, its spatialities need to be correspondingly long-lived.

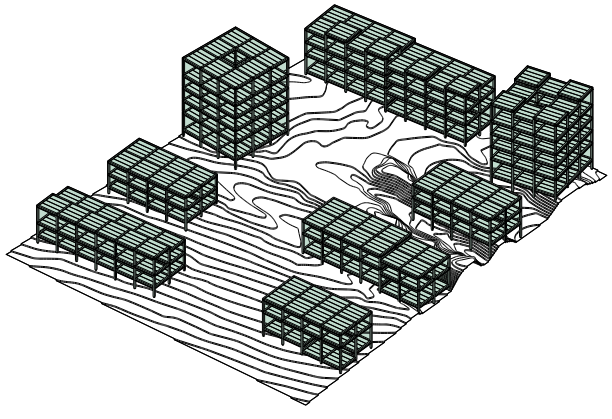


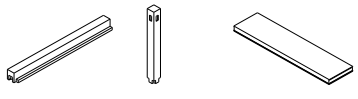


Columns and beams joined mechanically.

5.791,08 m² gross

0,42 components/m²	Flexibility	●●●●
30,12% additional elements	Economy	●●○○
17,49% smaller volumen	Recycling	●●●●
7,07% additional joints	Environment	●●●○





	Beam	Column	Deck	Total
Type				
Number	861	372	1.184	**2.417**
Volume	232,5 m³	113,1 m³	769,6 m³	**1.115,2 m³**
Number of joints	1.722 pcs	32 pcs	0 pcs	**1.754 pcs**

Students

KADK - Settlement, Ecology & Tectonics

Contact: Tim Bruun & Rasmus Feddersen ,stud.arc, *KADK*
Mail: tim_bruun@hotmail.com & rbfedders@gmail.com

Circle House groundfloor: pillar, stair system and extension.

'Adding new components to the system greatly extends the customisability options.'

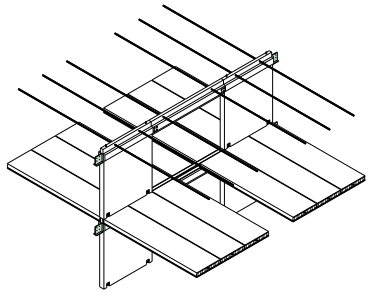
— Tim Bruun, Student at KADK

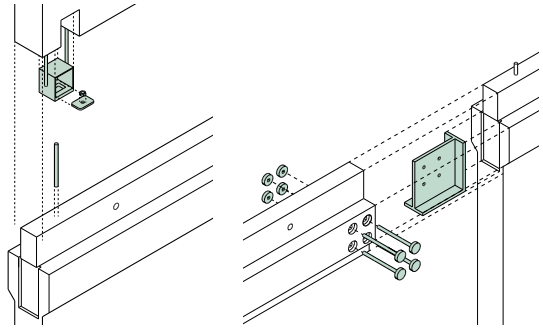
What if the **Circle House construction system was enlarged?**

Challenging the construction system
We examined the options embodied by the Circle House construction system. The project will be built on a hilly site, which poses challenges in terms of its customisability.

Adding a few extra components but retaining the same mechanical assembly principle provides a number of new options. For example, the architecture can then be displaced both vertically and horizontally. We also introduced higher wall components, which will allow for a higher ceiling on the ground floor or in a penthouse flat.

As indicated by the figures below, the addition of a very small number of extra components and joints allow us to achieve much greater customisability. In any event, local adaptations would need to be made for the given context. The system of load-bearing partition walls and beams with mechanical joints.

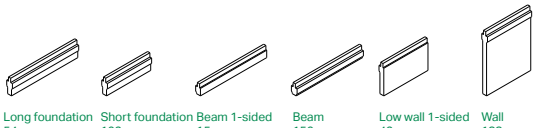




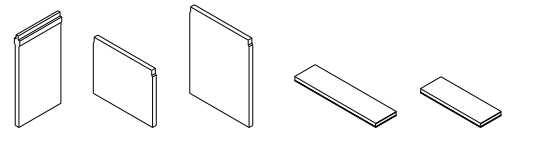
System of bearing partitions and beams with mechanical joints.

4.870,21 m² gross

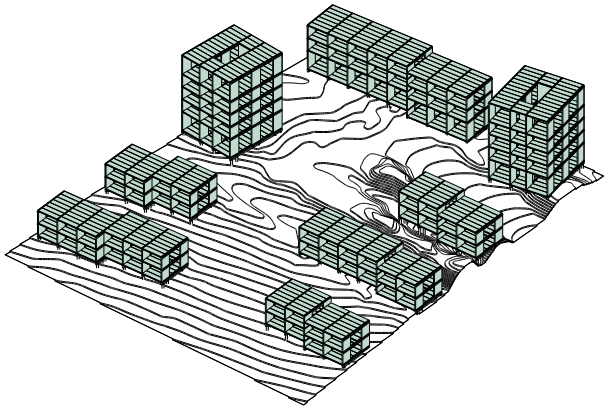
0,35 elements/m²	Flexibility	●●○○
0,88% additional elements	Economy	●●●●
2,61% additional volume	Recycling	●●●○
1,98% additional joints	Environment	●●○○



Type	Long foundation	Short foundation	Beam 1-sided	Beam	Low wall 1-sided	Wall
Number	54	102	15	159	42	188
Volume	34,56 m³	43,86 m³	6 m³	71,55 m³	31,5 m³	287,64 m³
Number of joints	108 pcs	204 pcs	30 pcs	318 pcs	168 pcs	752 pcs



	Tall wall	Transverse	Transverse tall	Long deck	Short deck	Total
	65	12	8	976	84	**1704**
	147,2 m³	23,88 m³	24,48 m³	634,4 m³	40,32 m³	**1345,39 m³**
	256 pcs	48 pcs	32 pcs	0 pcs	0 pcs	**1916 pcs**



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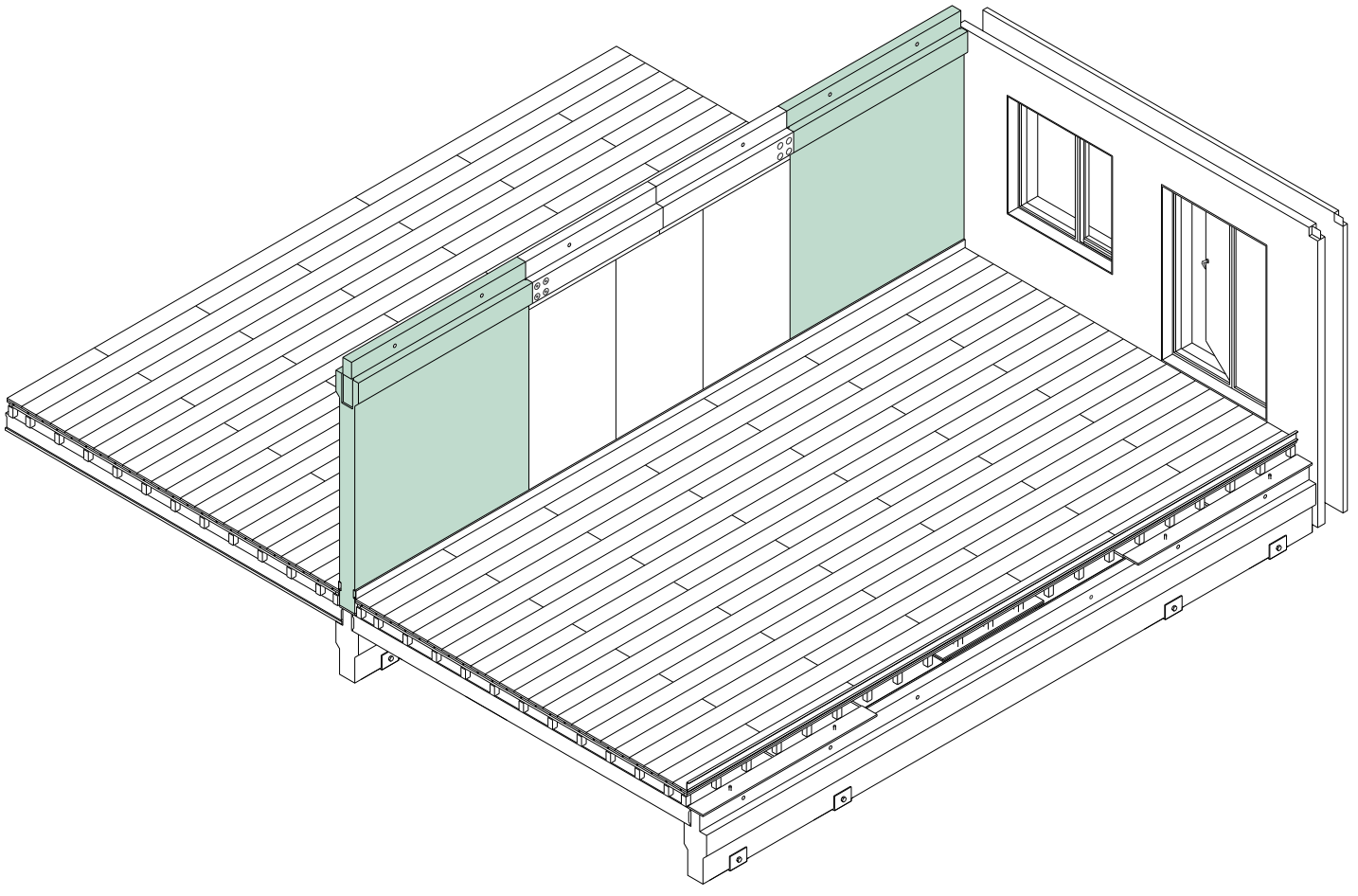
KADK - Settlement, Ecology & Tectonics
Contact: Tim Bruun & Rasmus Feddersen ,stud.arc, *KADK*
Mail: tim_bruun@hotmail.com & rbfedders@gmail.com

Circle House concrte walls.



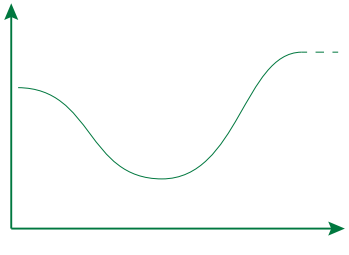
What if **you could use your wall without drilling holes?**

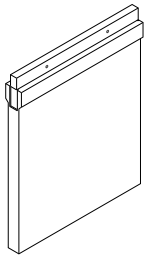
Challenging the construction system

In the Circle House project, one of the main components is the raw concrete partition walling. For their value of circularity, the concrete walls must not be contaminated by screws, plaster, adhesive etc.

To fulfil the circularity principle, yet still create a user-friendly building for the occupants, these examples explore the concept of a concrete wall that can be personalised with pictures, shelving etc. without the use of screws and nails in order to preserve the value of the concrete and circular potential of the component.

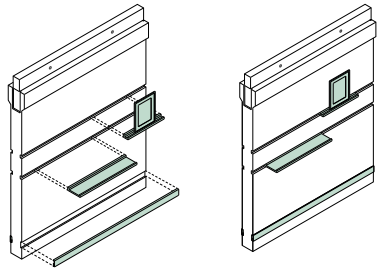
Aesthetic value



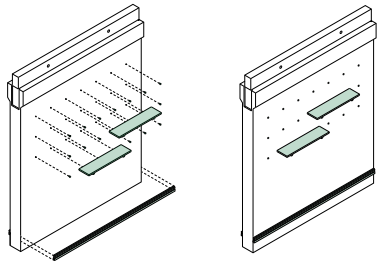


Raw concrete walls and their aging through time.

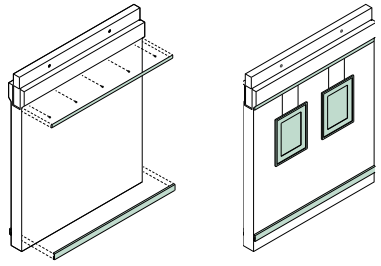
Molded track



Molded thread



Rail



Student

KADK - Settlement, Ecology & Tectonics

Contact: Sarah Sonne Glatz stud.arc, *KADK*

Mail: sglatz@gmail.com

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Circle House —
Denmark's first circular housing project
Content of GXN and Responsible Assets.

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