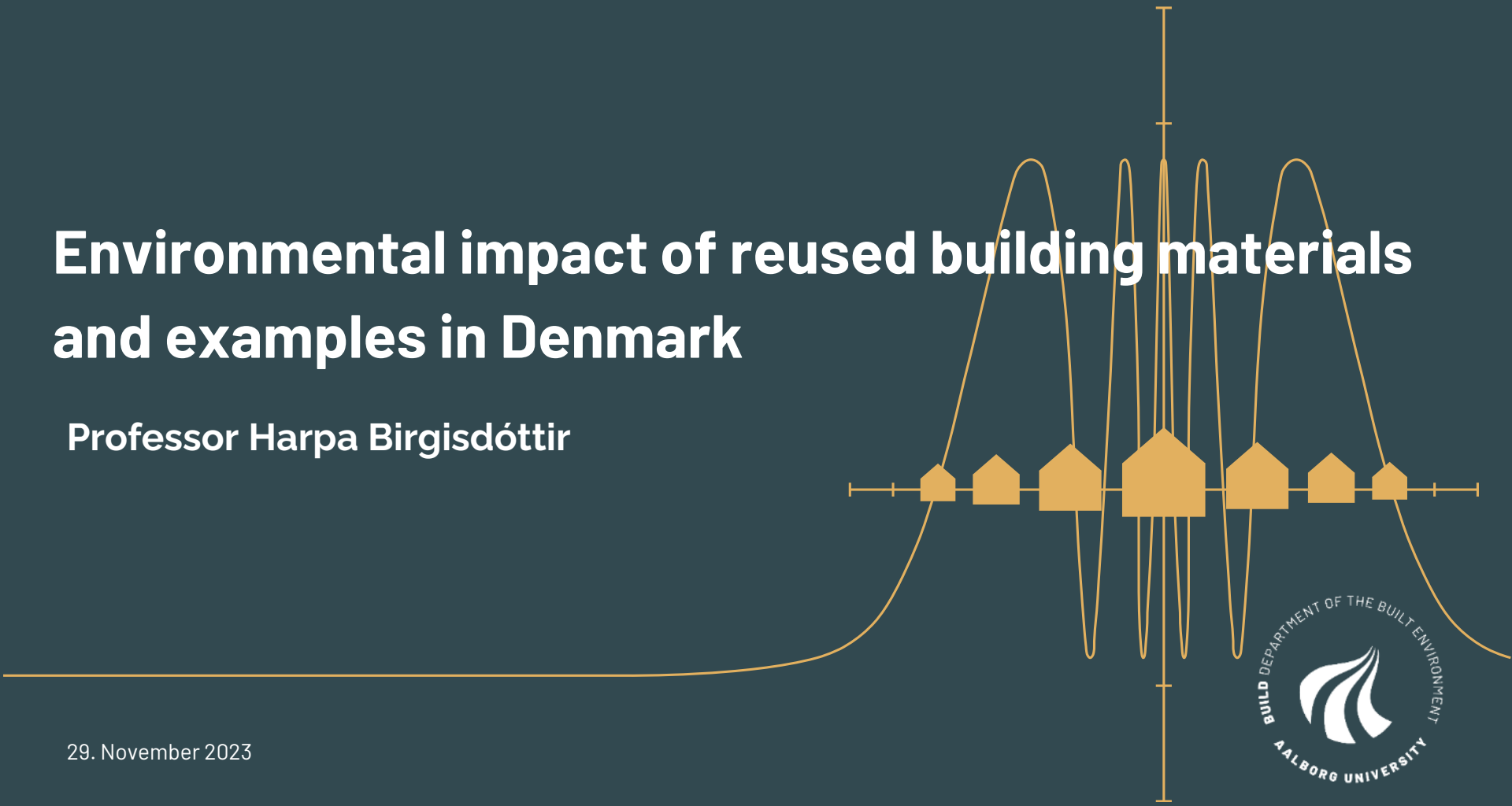
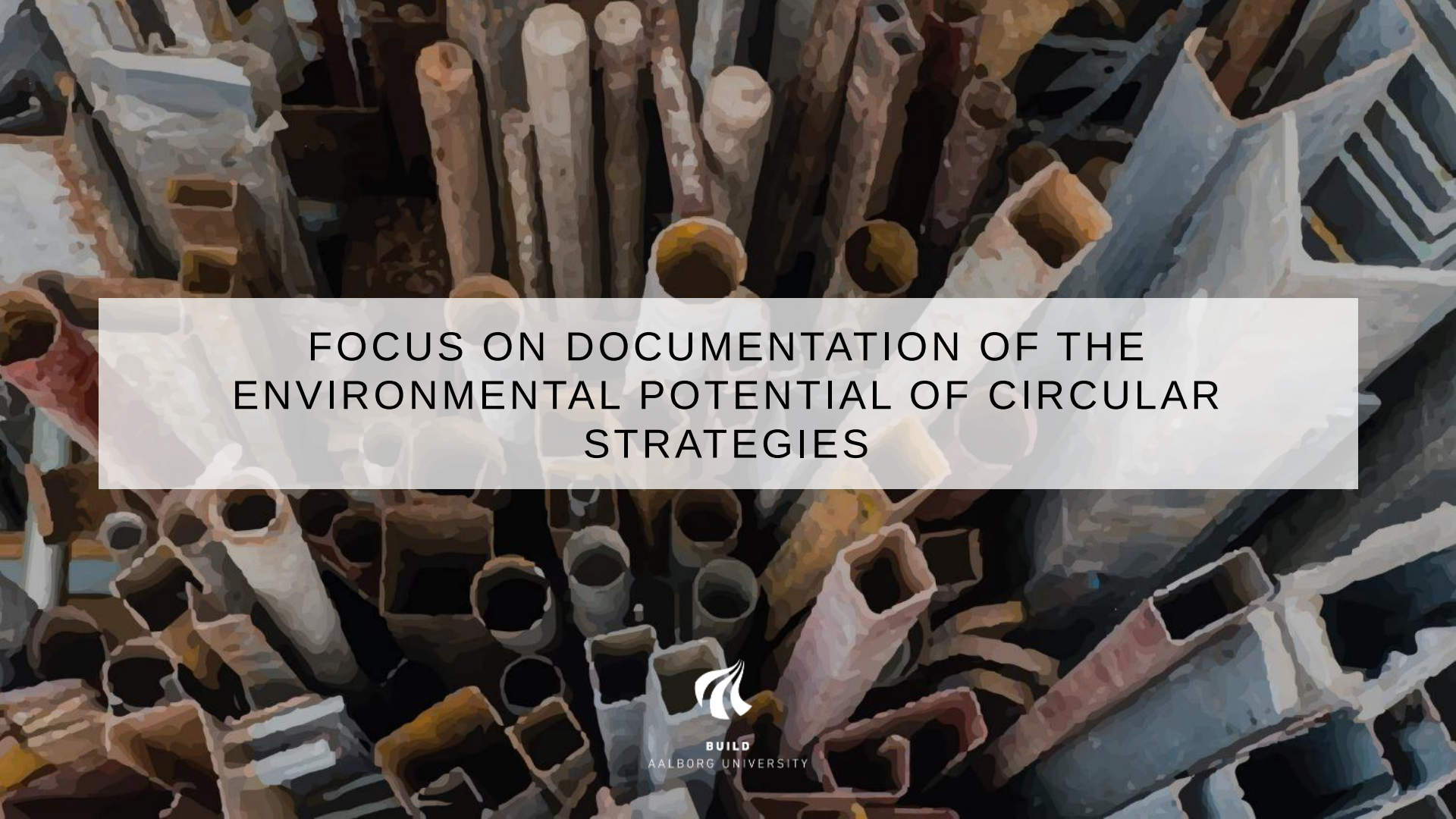
Environmental impact of reused building materials and examples in Denmark

Professor Harpa Birgisdóttir



29. November 2023



FOCUS ON DOCUMENTATION OF THE ENVIRONMENTAL POTENTIAL OF CIRCULAR STRATEGIES

BUILD
AALBORG UNIVERSITY

SBI 2019:08

Livscyklusvurdering for cirkulære løsninger med fokus på klimapåvirkning

Forundersøgelse

Buildings & Cities

Andersen, C. E., et al. (2020). Comparison of GHG emissions from circular and conventional building components. *Buildings and Cities*, 1(1), pp. 379–392. DOI: https://doi.org/10.5334/bc.55

RESEARCH

Comparison of GHG emissions from circular and conventional building components

Camilla Ernst Andersen[1], Kai Kanafani[2], Regitze Kjær Zimmermann[3], Freja Nygaard Rasmussen[4] and Harpa Birgisdóttir[5]

Abstract

The concept of circular economy has been introduced as a strategy to reduce the greenhouse gas (GHG) emissions from buildings and mitigate climate change. Although many innovative circular solutions exist, the business model is challenged by a lack of environmental data on the circular solutions, and thus the potential benefits are not verifiable. The study assesses the embodied GHG emissions of five circular building elements/components. Circular solutions are compared with conventional solutions to ascertain whether the business model has the potential to reduce GHG emissions. The GHG emissions are quantified using life-cycle assessment (LCA) for five circular-economy and three conventional building elements/components. The environmental data show that circular building components have the potential to reduce GHG emissions. However, there is a risk of increasing the GHG emissions when compared with conventional solutions, emphasising the need for standardised environmental data. Lastly, the study identifies logistic, economic, technological and regulatory barriers that prevent complete implementation of circular economy.

Practice relevance

Standardised environmental data on building elements/components are needed to support decision-making at local and national levels. Uncertainties about waste from manufacture and transport in the production stage can affect the environmental potential to such an extent that the benefits from introducing circular economy are lost. One central barrier is identified that prevents complete implementation of the circular economy in buildings; the industry is not geared to support a steady supply of some circular building elements/components. In general, it is clear that the implementation of circular economy requires the identification of environmental, logistical, economic, technological and regulatory concerns.

sustainability

MDPI

Article

Development of a Life Cycle Assessment Allocation Approach for Circular Economy in the Built Environment

Leonora Charlotte Malabi Eberhardt [1,*], Anne van Stijn [2], Freja Nygaard Rasmussen [1], Morten Birkved [3] and Harpa Birgisdottir [1]

1 Department of the Built Environment, Aalborg University, A.C. Meyers Vænge 15, 2450 Copenhagen, Denmark; fnr@build.aau.dk (F.N.R.); hbi@build.aau.dk (H.B.)
2 Department of Management in the Built Environment, Faculty of Architecture and the Built Environment, Delft University of Technology, Julianalaan 134, 2628 BL Delft, The Netherlands; a.vanstijn@tudelft.nl
3 SDU Life Cycle Engineering, Department of Chemical Engineering, Biotechnology and Environmental Technology University of Southern Denmark, Campusvej 55, 5230 Odense-M, Denmark; morb@kbm.sdu.dk
* Correspondence: lcl@build.aau.dk

Received: 19 October 2020; Accepted: 13 November 2020; Published: 17 November 2020

check for updates

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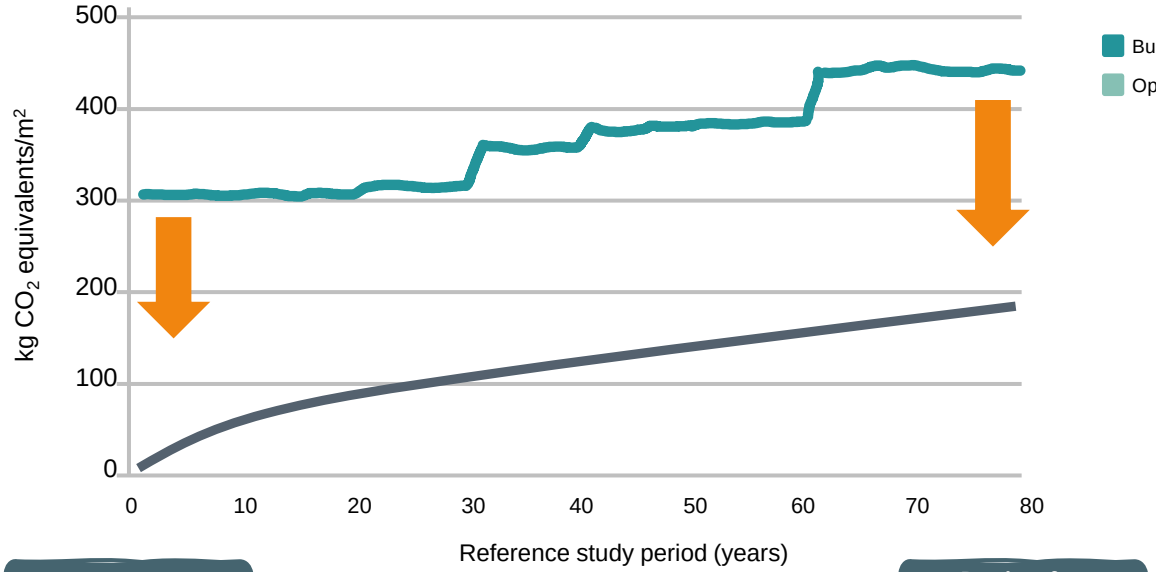
BUILD
AALBORG UNIVERSITY

MANY CIRCULAR STRATEGIES EXISTS
WHAT ARE THE BENEFITS?

Leonora Charlotte Malabi Eberhardt, Morten Birkved & Harpa Birgisdottir (2022) Building design and construction strategies for a circular economy, Architectural Engineering and Design Management, 18:2, 93-113, DOI: 10.1080/17452007.2020.1781588

MANY CIRCULAR STRATEGIES TARGETING DIFFERENT SOLUTIONS AND TIMESCALES

Upcycle house

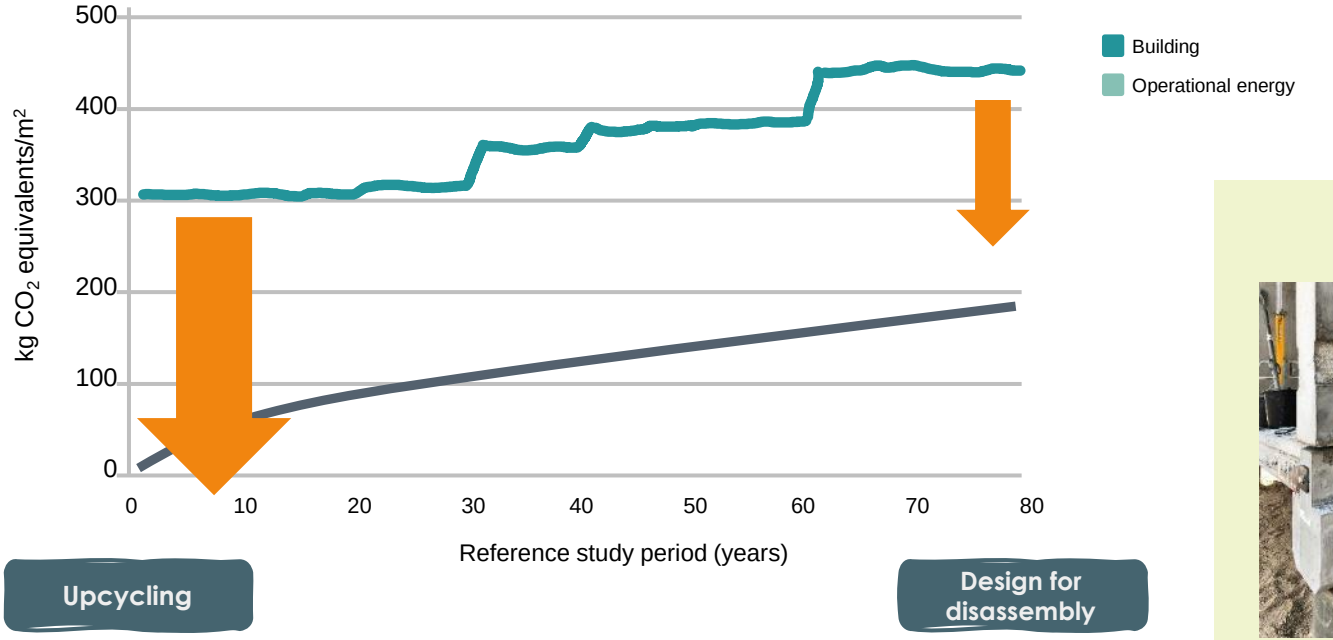


Circle house

FN Rasmussen, M Birkved and H Birgisdóttir. Upcycling and Design for Disassembly – LCA of buildings employing circular design strategies. IOP Conf. Ser.: Earth Environ. Sci. 225 2019

MANY CIRCULAR STRATEGIES TARGETING DIFFERENT SOLUTIONS AND TIMESCALES

Upcycle house

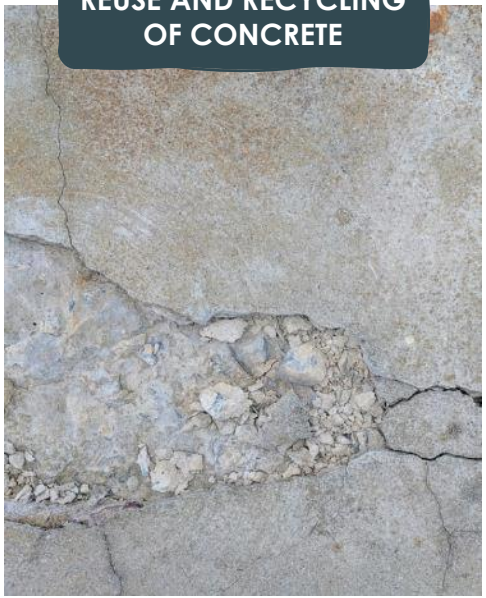


Circle house

CICULAR STRATEGIES

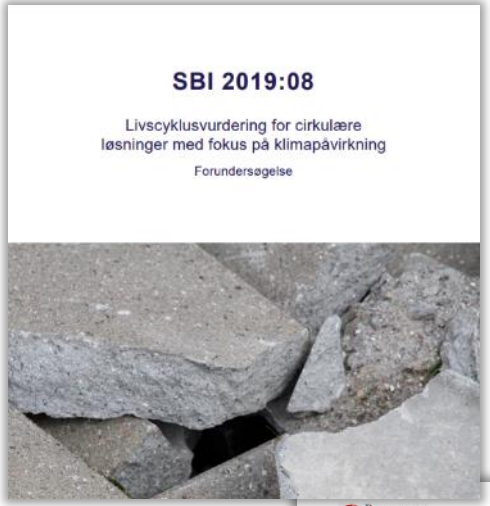
REUSE OF BRICKS

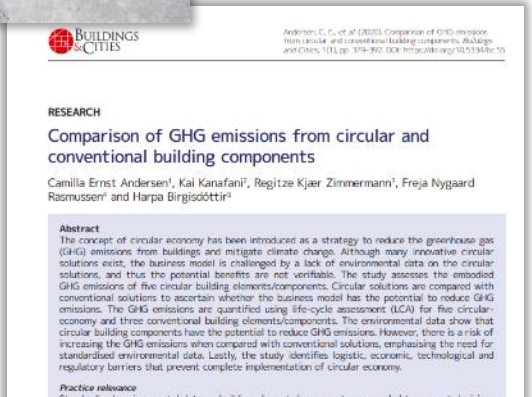
REUSE AND RECYCLING OF CONCRETE



REUSE OF WINDOW GLASS

ENVIRONMENTAL BENEFITS




BUILDINGS & CITIES

RESEARCH

Comparison of GHG emissions from circular and conventional building components

Camilla Ernst Andersen[1], Kai Kanafani[2], Regitze Kjær Zimmermann[3], Freja Nygaard Rasmussen[4] and Harpa Birgisdóttir[5]

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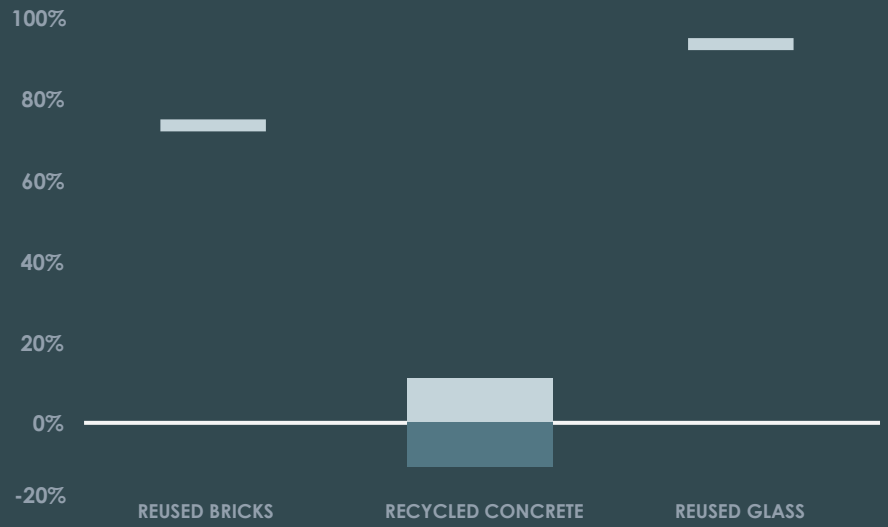
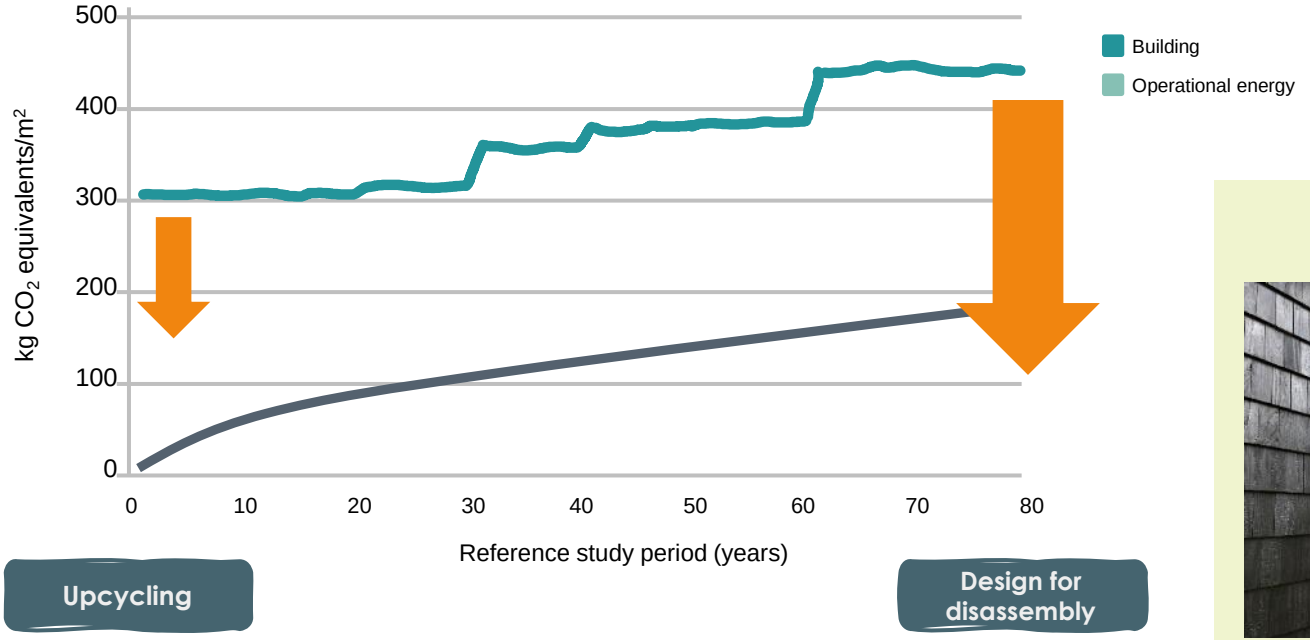
Practice relevance

OF REUSE AND RECYCLING



MANY CIRCULAR STRATEGIES TARGETING DIFFERENT SOLUTIONS AND TIMESCALES

Upcycle house



Circle house

ENVIRONMENTAL BENEFITS OF DESIGN FOR DISASSEMBLY

sustainability

MDPI

Article

Development of a Life Cycle Assessment Allocation Approach for Circular Economy in the Built Environment

Leonora Charlotte Malabi Eberhardt [1,*], Anne van Stijn [2], Freja Nygaard Rasmussen [1], Morten Birkved [3] and Harpa Birgisdottir [1]

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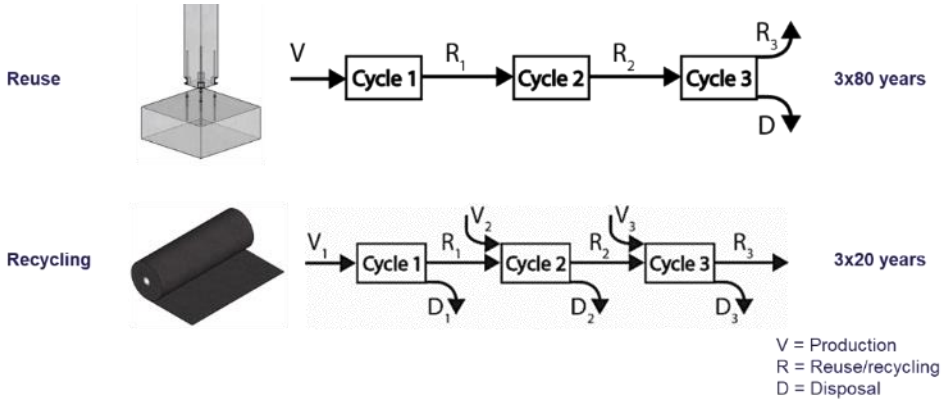
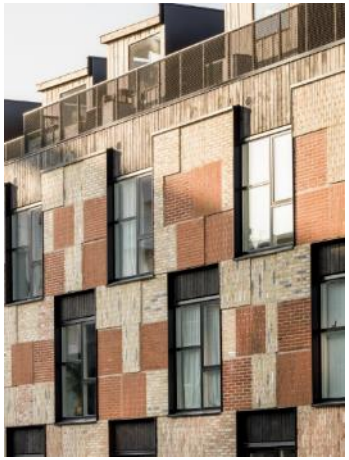


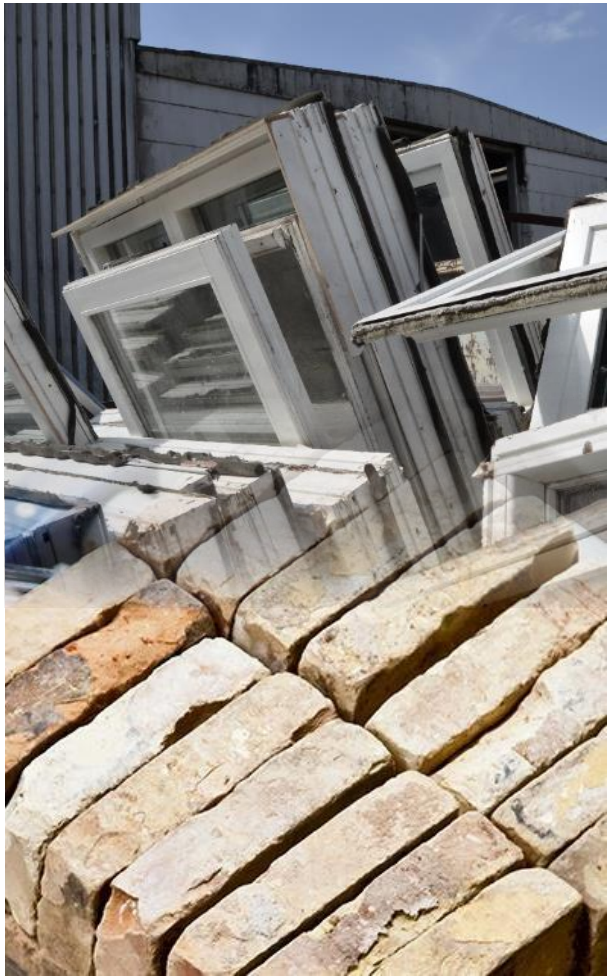


SAMPLES FROM DENMARK

LENDAGER GROUP

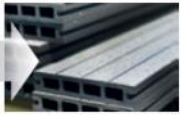
LENDAGER GROUP

Upcycle House | Location: Nyborg, Denmark | 140 m2 house | Built: 2011-2013



Facedebeklædning


Plast


UPM Profi-facade

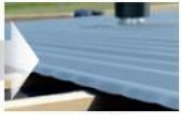
Gulve


Korkpropper


Korkgulv

Tagbeklædning


Genbrugsaluminium


Aluminiumsplader

Lofter og vægge


Brugt gips


Gipsplader

Isolering

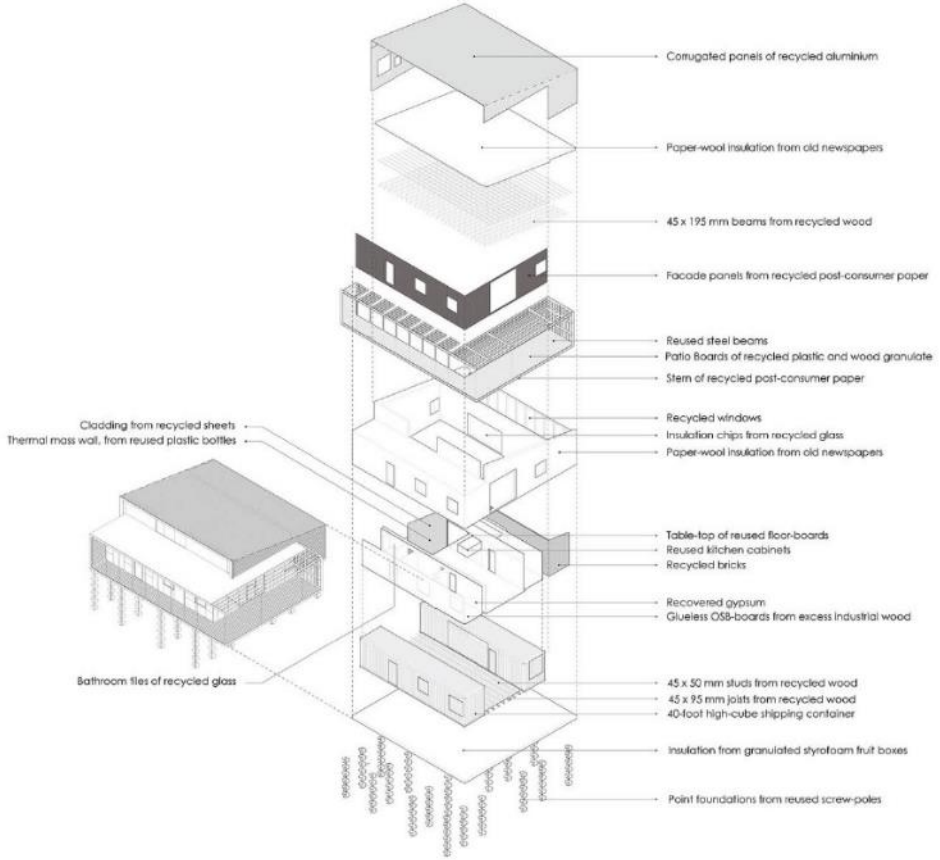

Avis/papir


Papirisolering

Indervægge, gulve


Genbrugstræ

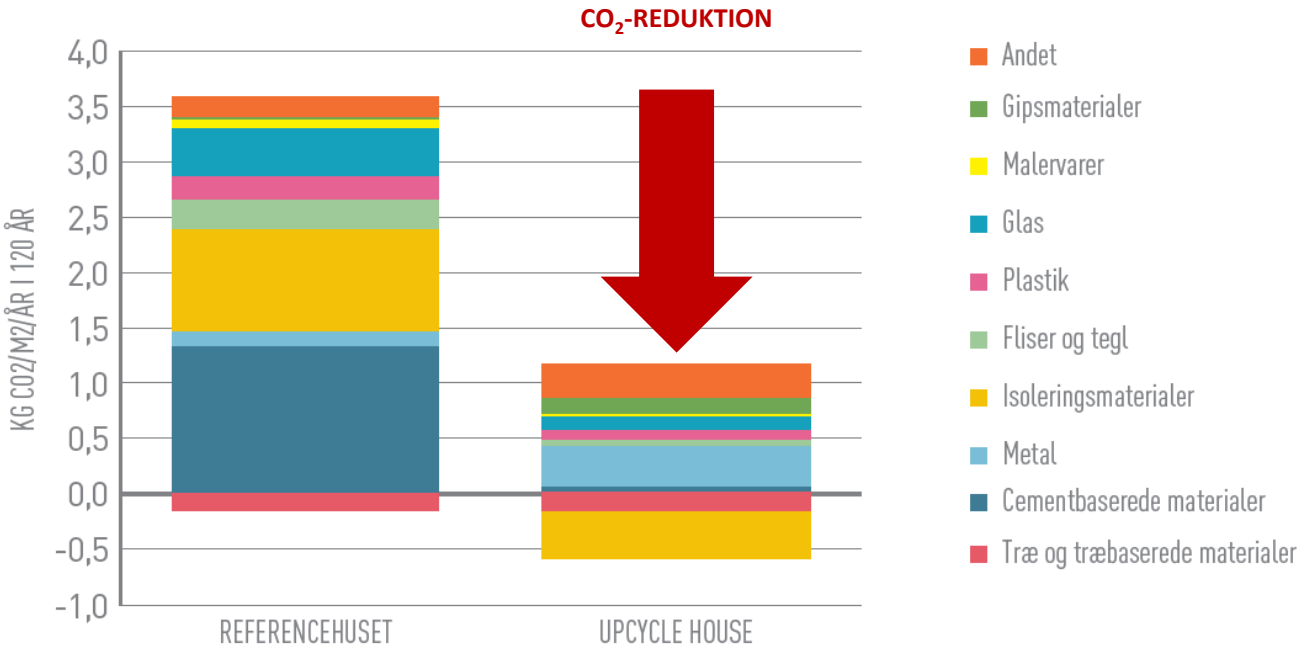

OSB-plader



CO2-udledningen fra Upcycle House's materialeforbrug til konstruktionen er **86 pct. mindre** end Referencehusets.

HUSETS CO2-PROFIL

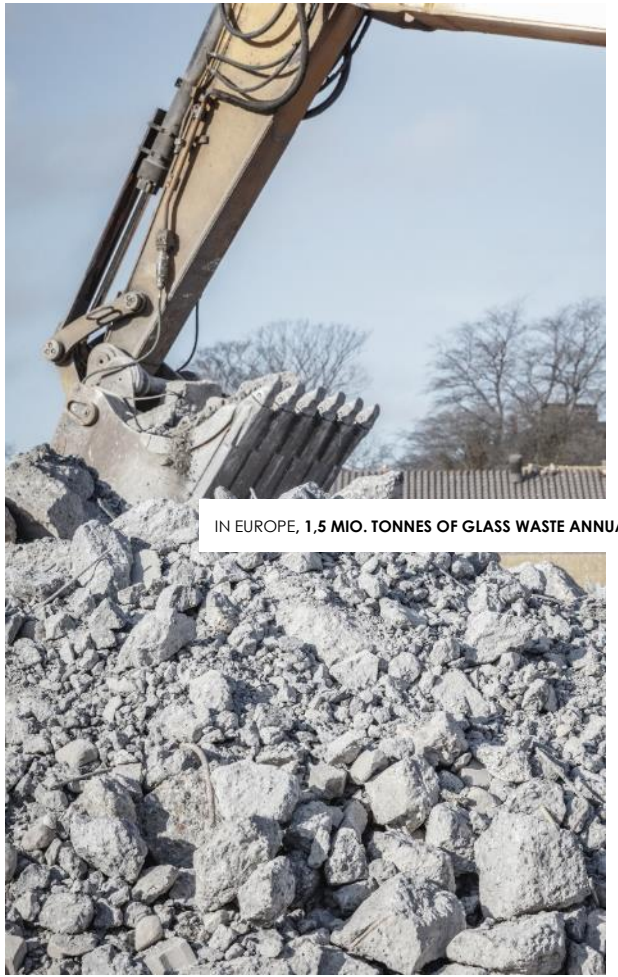
CO2-udledning for hhv. referencehuset og
Upcycle House fordelt på materialer



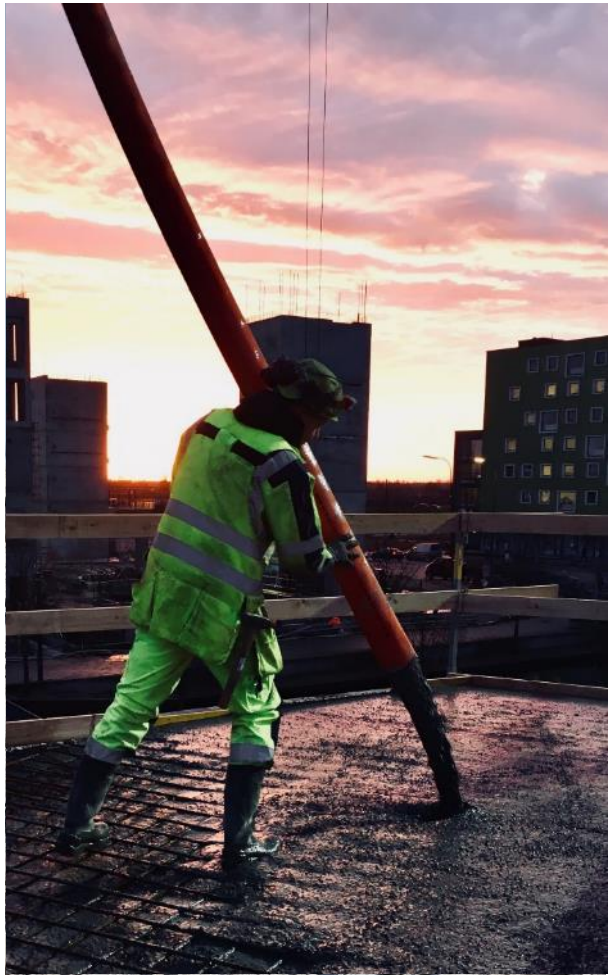
LENDAGER GROUP

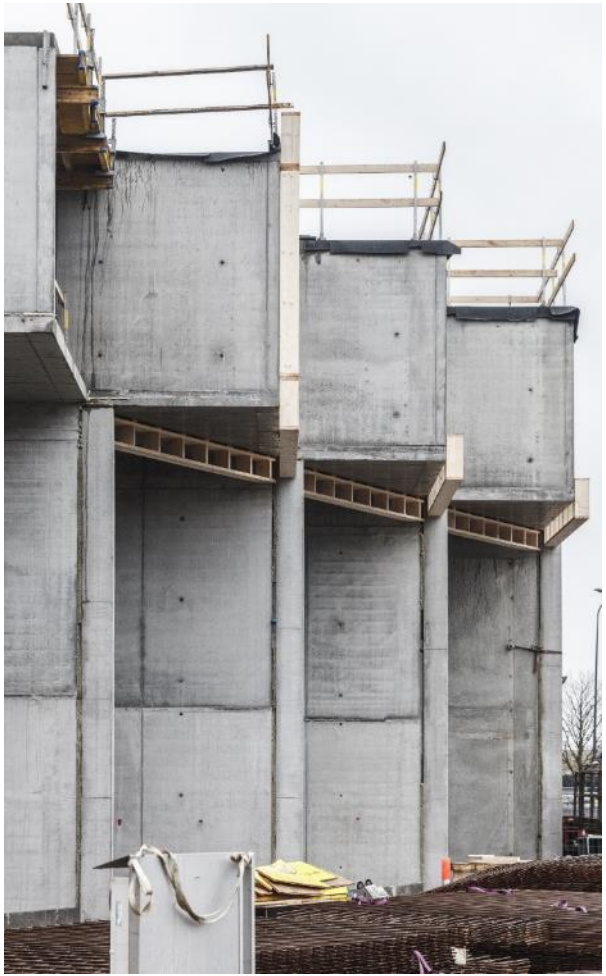
LENDAGER GROUP

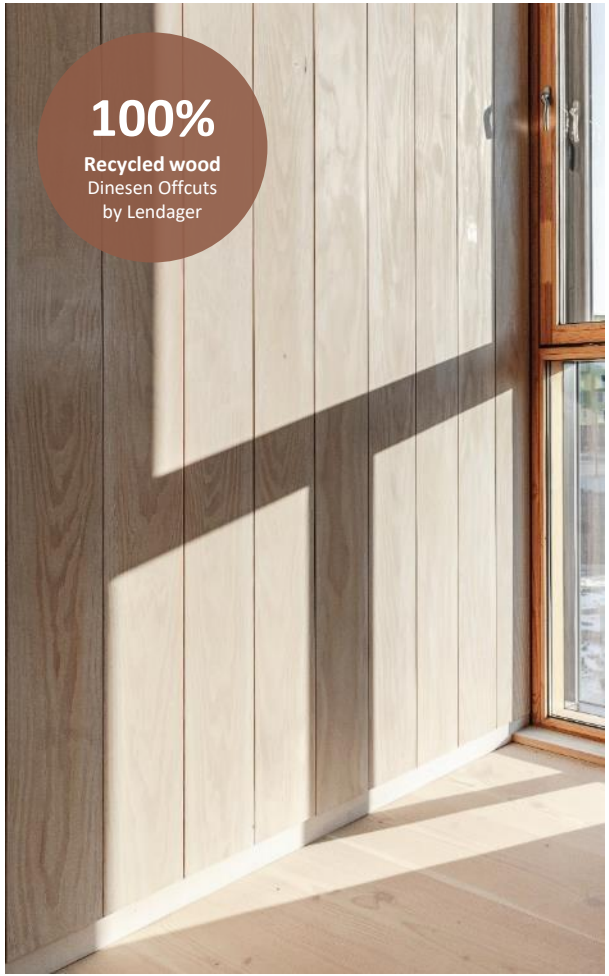
Upcycle Studios | Location: Ørestad, København | 3,909 m2 housing | Built: 2015-2018

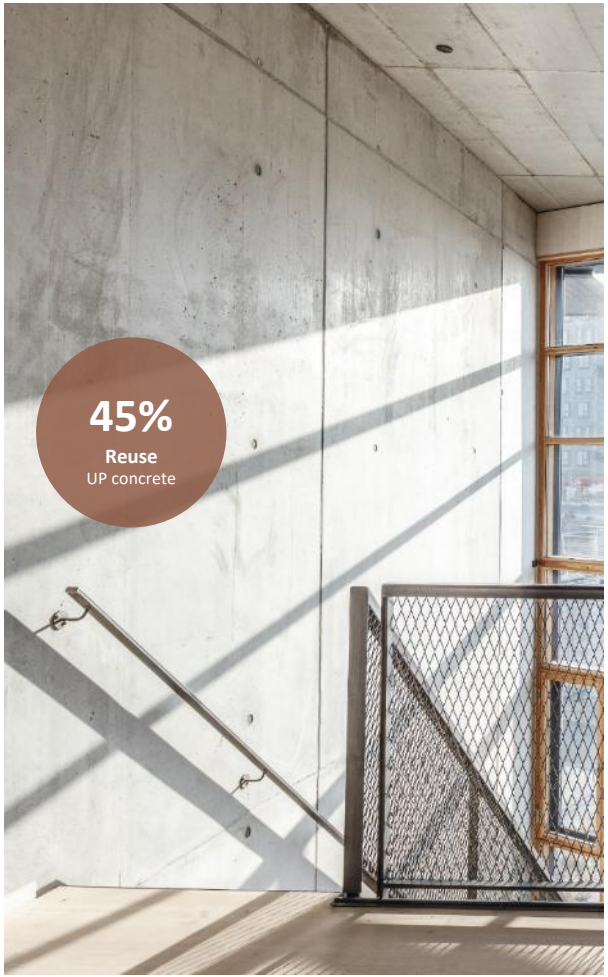


IN EUROPE, **1,5 MIO. TONNES OF GLASS WASTE ANNUALLY** IS PROVIDED FROM DEMOLITION OR RENOVATION OF BUILDINGS



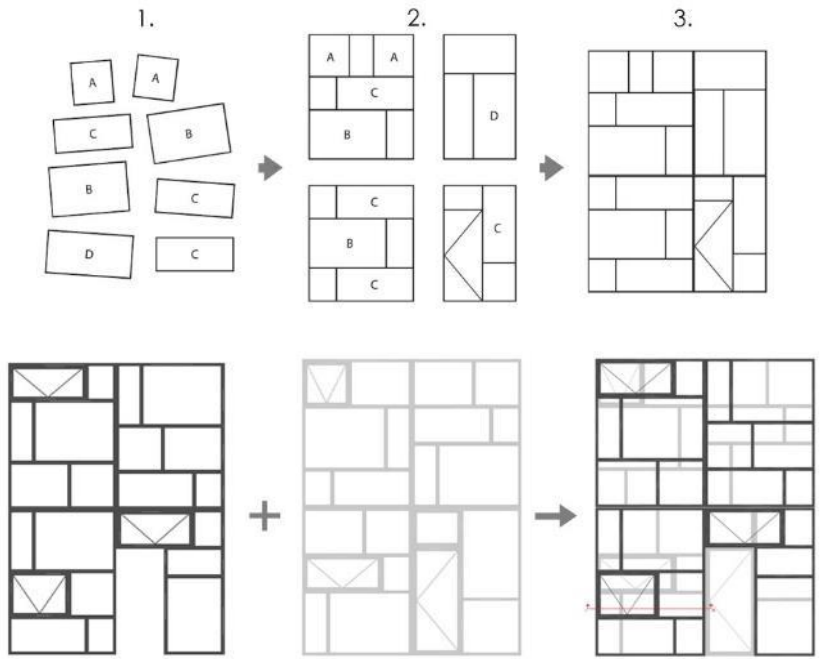



100%
Recycled wood
Dinesen Offcuts
by Lendager

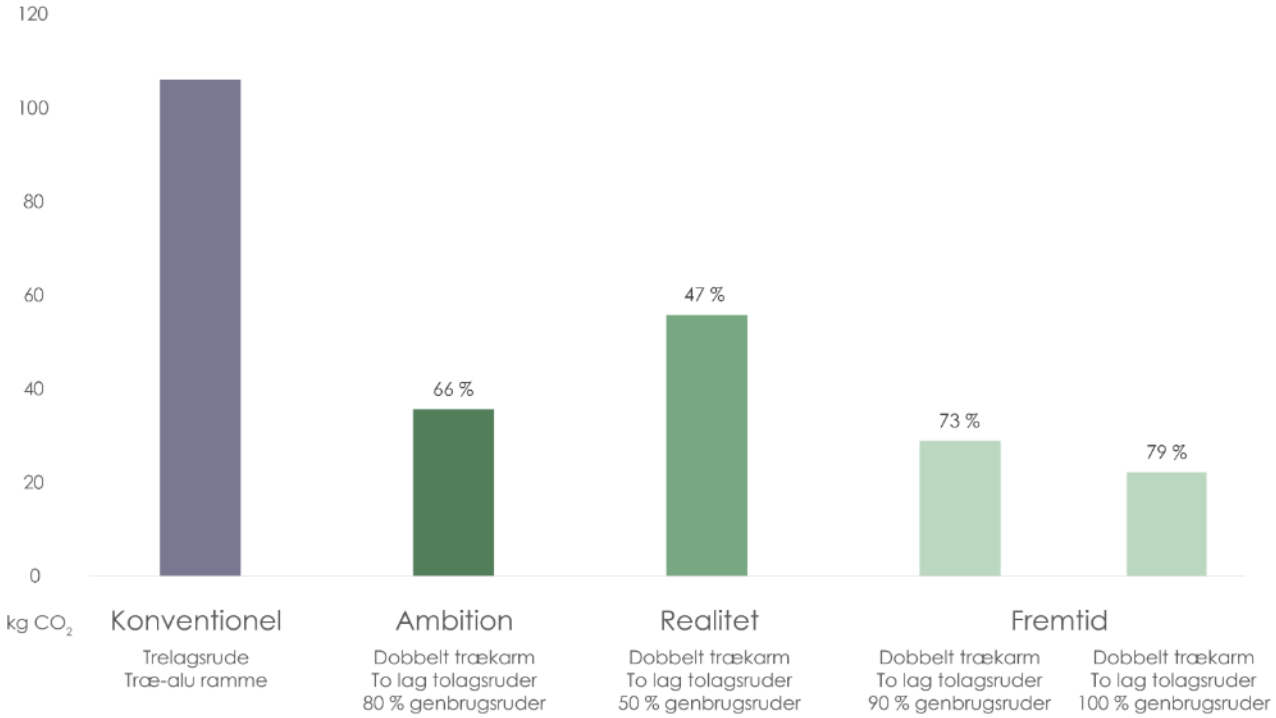

45%
Reuse
UP concrete


50-85%
Reuse
Krone UP Windows
by Lendager

UP Product development | Krone UP Windows by Lendager



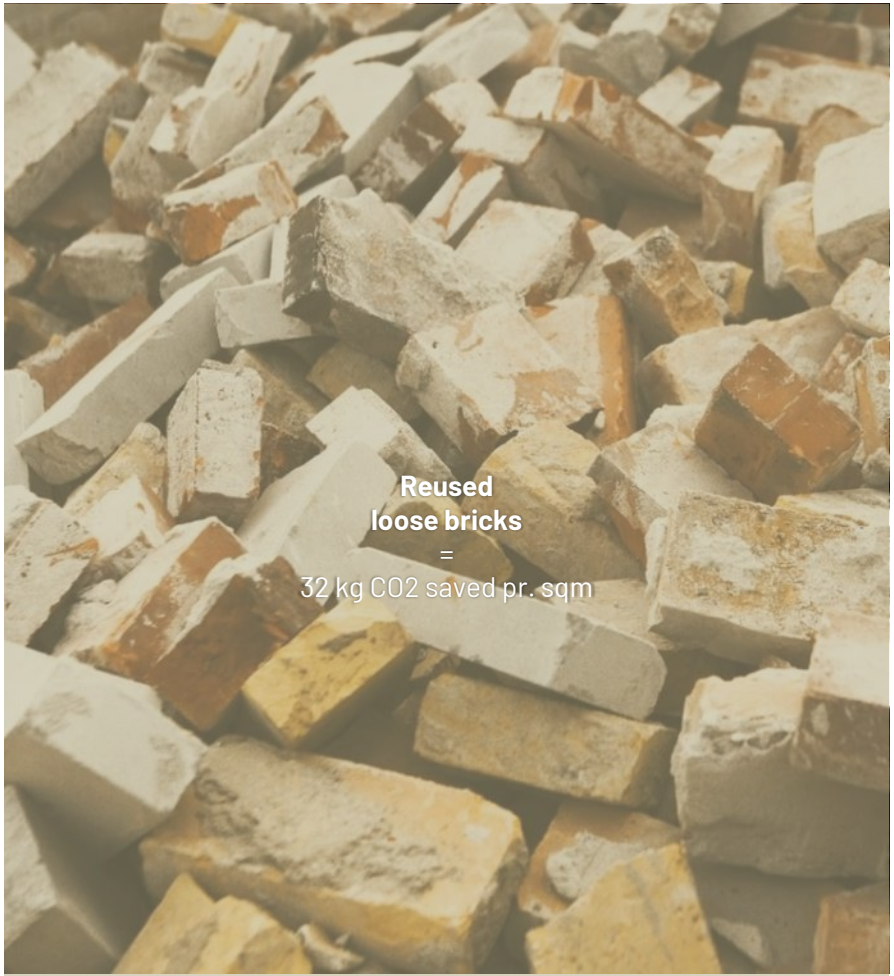
POTENTIALET ER EN CO2-BESPARELSE PÅ 79%

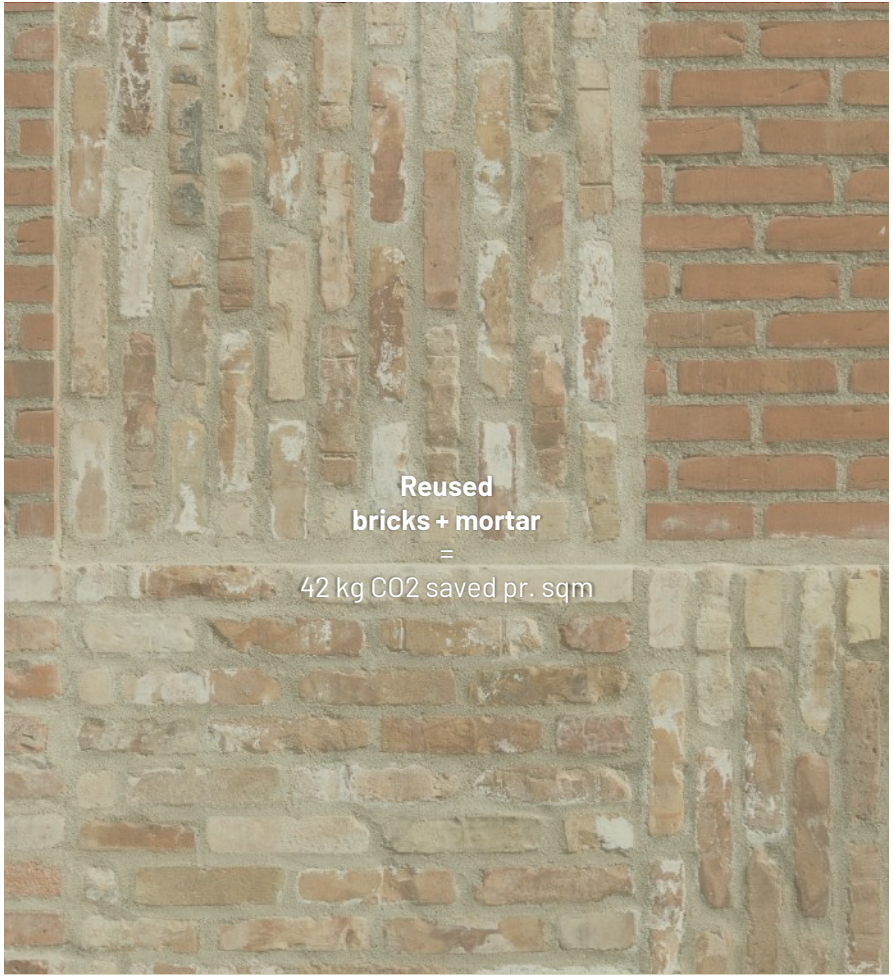


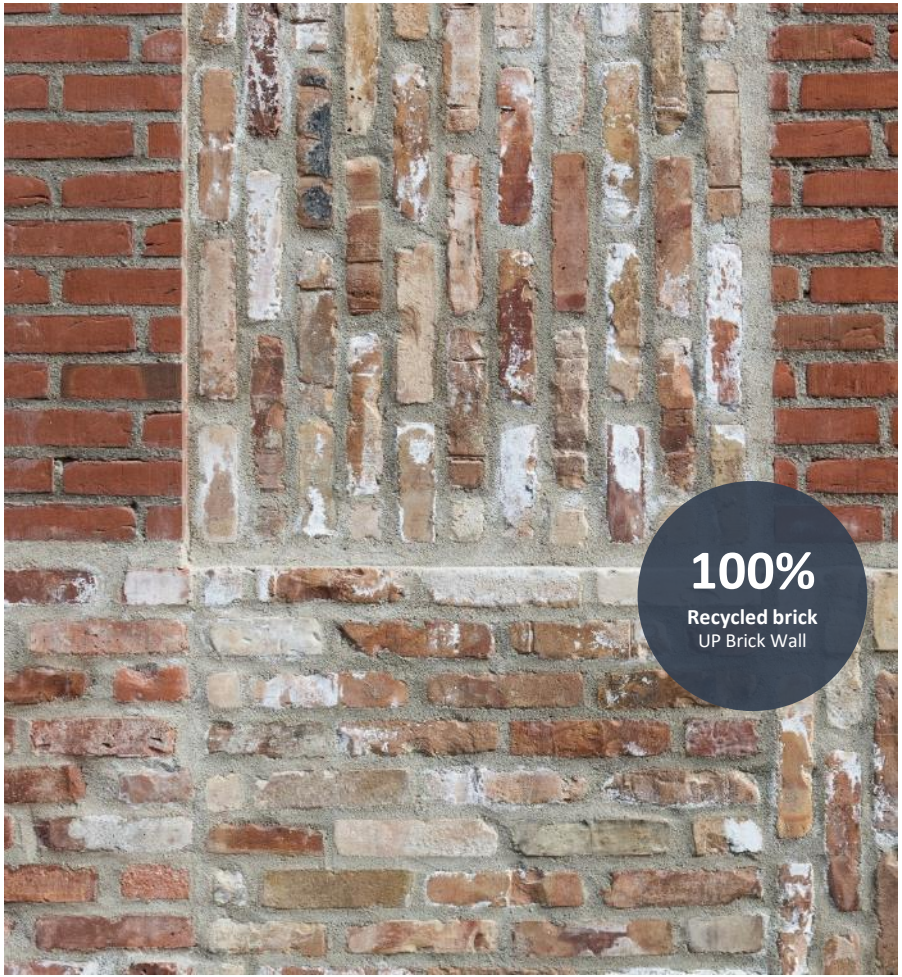
LENDAGER GROUP

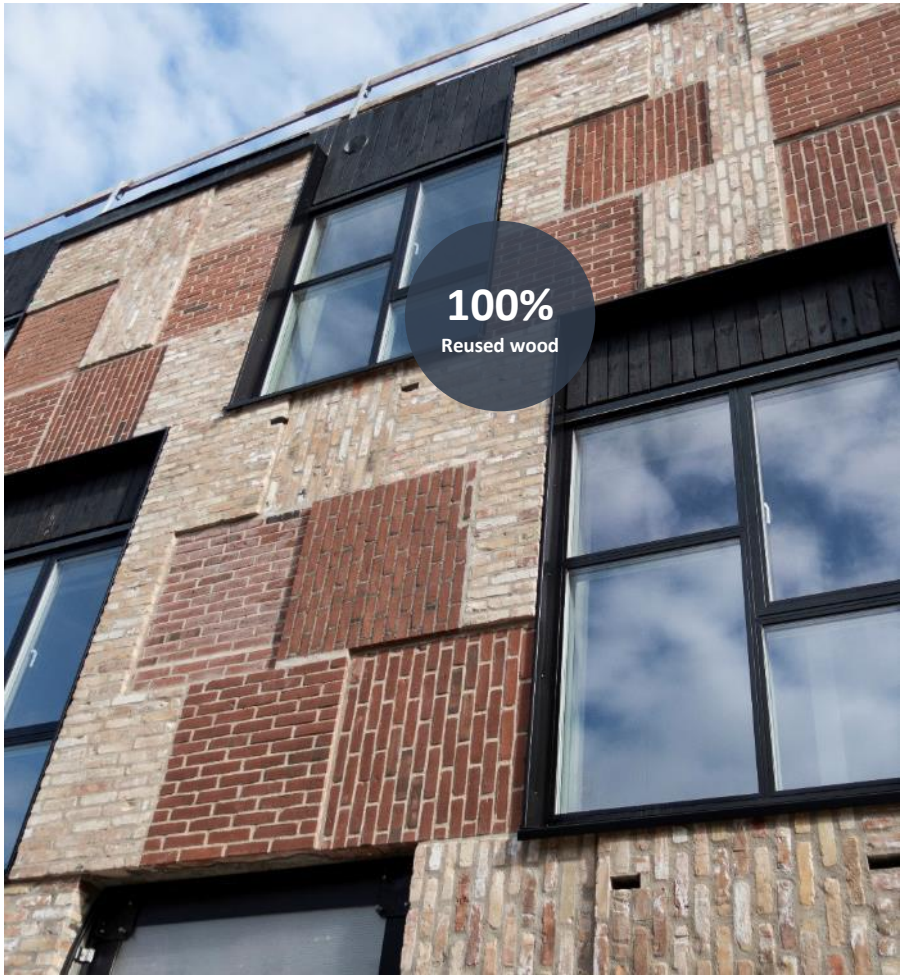
LENDAGER GROUP

Resource Rows| Location: Ørestad, Copenhagen | 9,148 m2 housing | built: 2015-2019

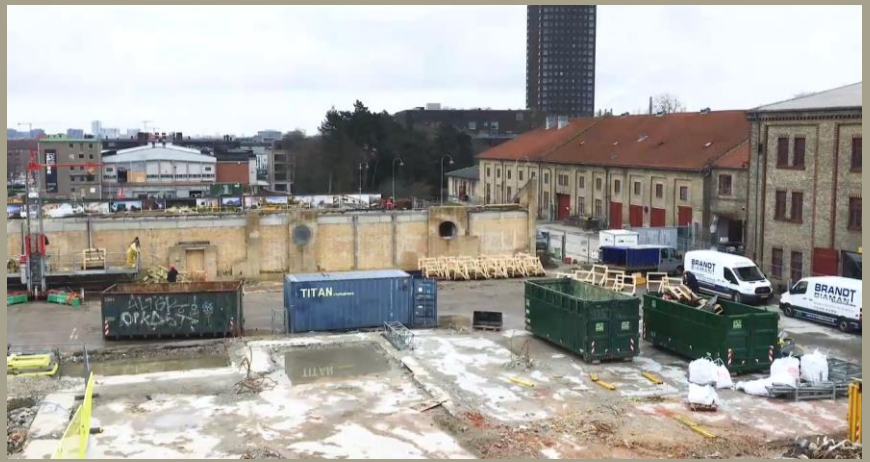

Reused
loose bricks
=
32 kg CO2 saved pr. sqm


Reused
bricks + mortar
=
42 kg CO2 saved pr. sqm


100%
Recycled brick
UP Brick Wall

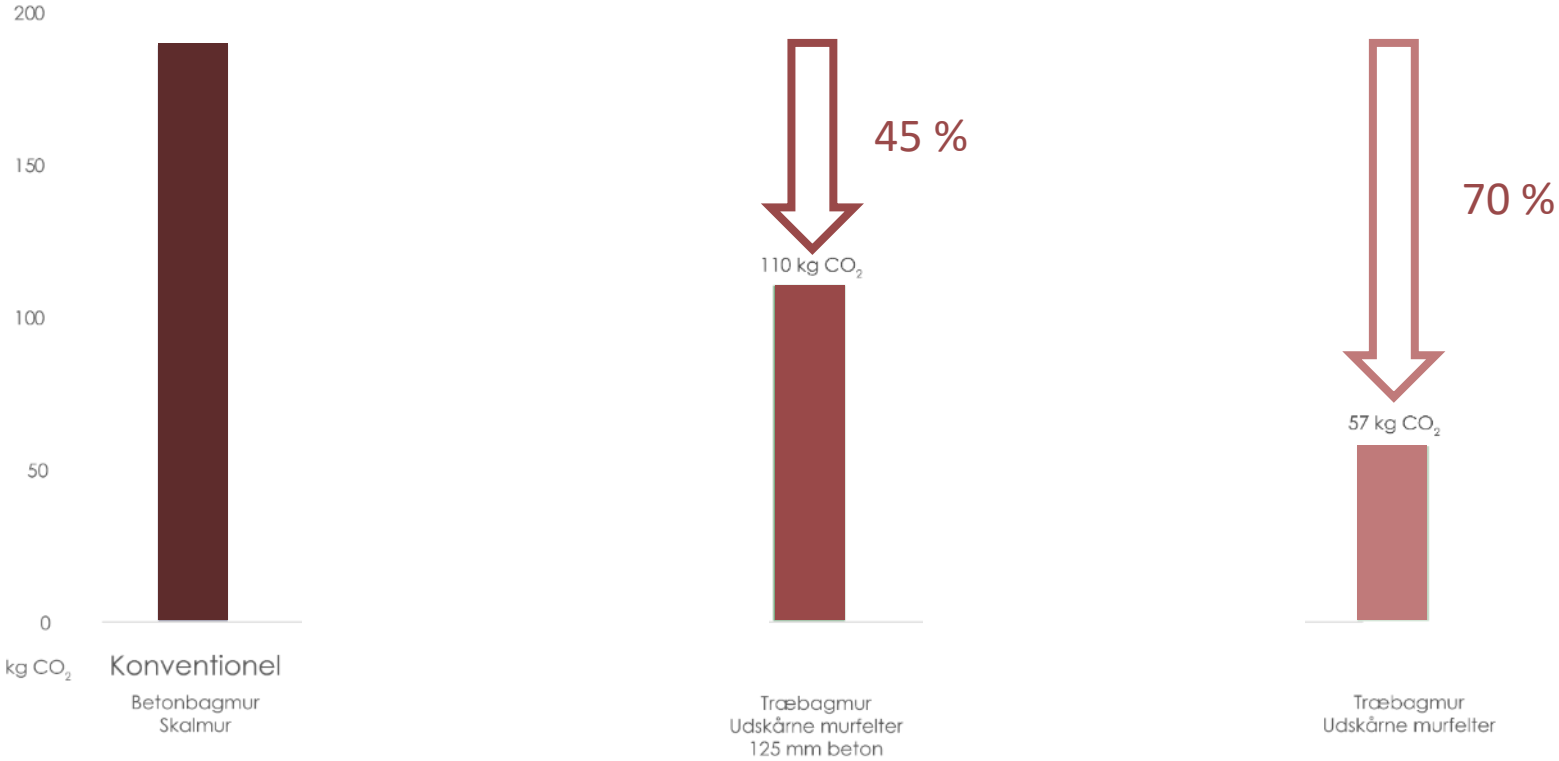

100%
Reused wood

The process

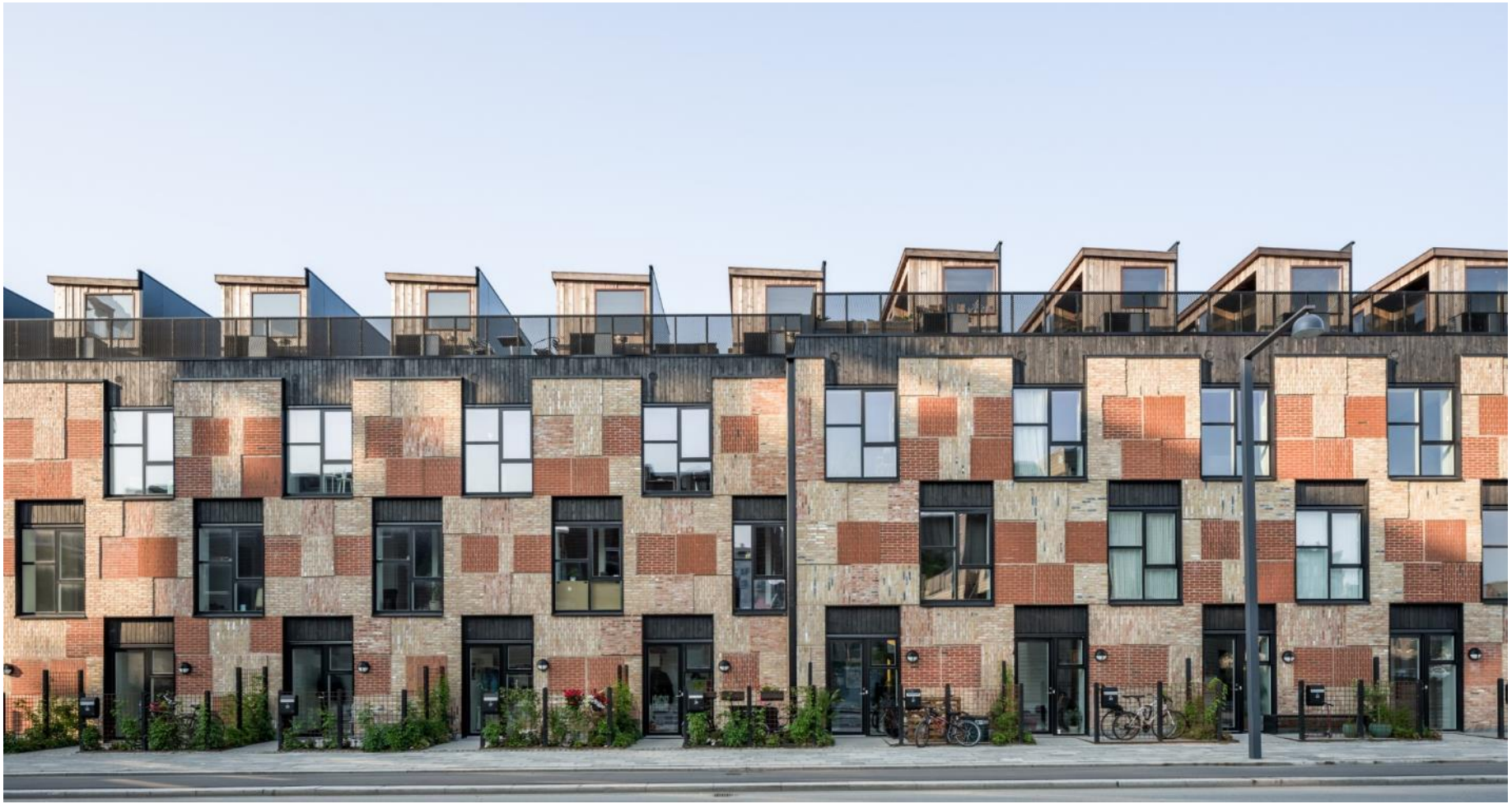


AROUND **1.5 TRILLION** NEW BRICKS ARE PRODUCED WORLDWIDE EACH YEAR

EN TRADITIONAL SKALMUR UDLEDER CA. 200 KG CO2 PER KVADRATMETER

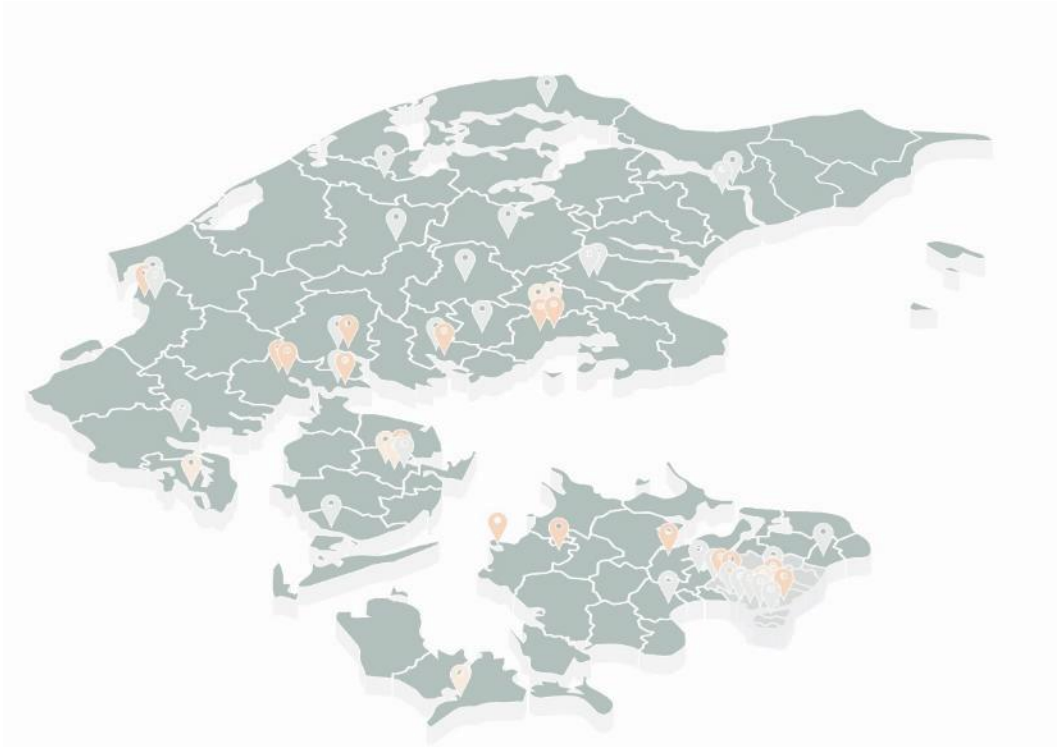



100%
Genbrugstræ



Project Ressourceblokken

Upcycling af 60'erne og 70'ernes
almene byggeri



Project Ressourceblokken

Upcycling af 60'erne og 70'ernes
almene byggeri

95% of the homes in the area are social housing

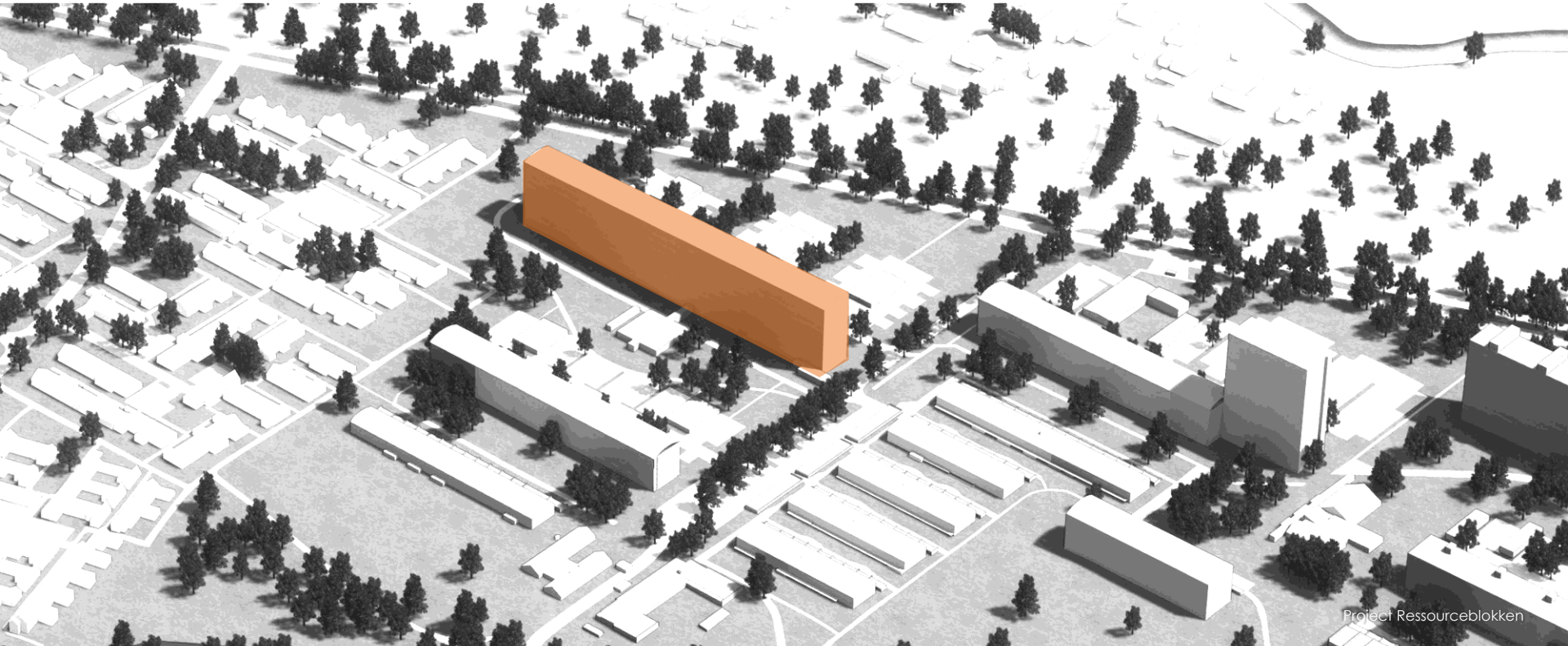
1.300.000 m²
To be Demolished

40% rule.
Housing mass maximum 40% general construction in the areas.

700.000 m²
To be build

Vollsmose –Birkeparken

Birkeparken 68-80, Blok 45

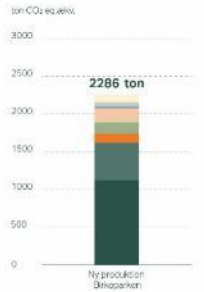


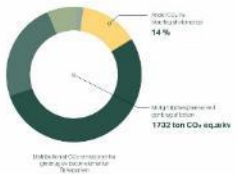
Vollsmose – Birkeparken

Birkeparken 68-80, Blok 45

Birkeparken

Der er udført en LCA på boligblokken Birkeparken 65. Beregningen er repræsentativ, dvs. at det er beregenet hvad et tilsvarende byggeri ville have af CO_2-påvirking hvis det skulle opføres i dag.

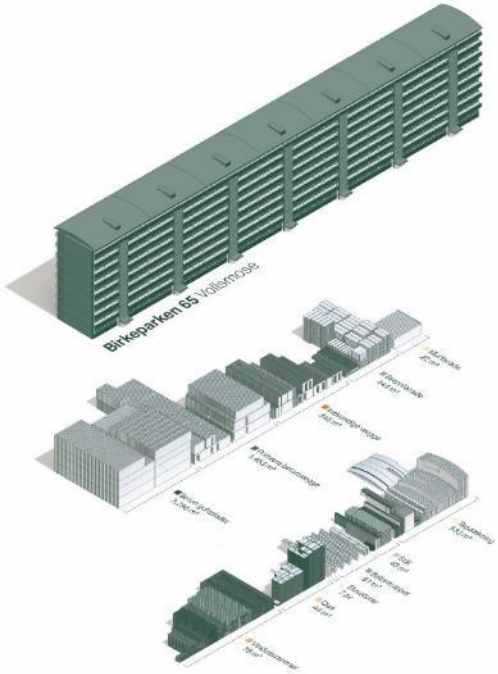




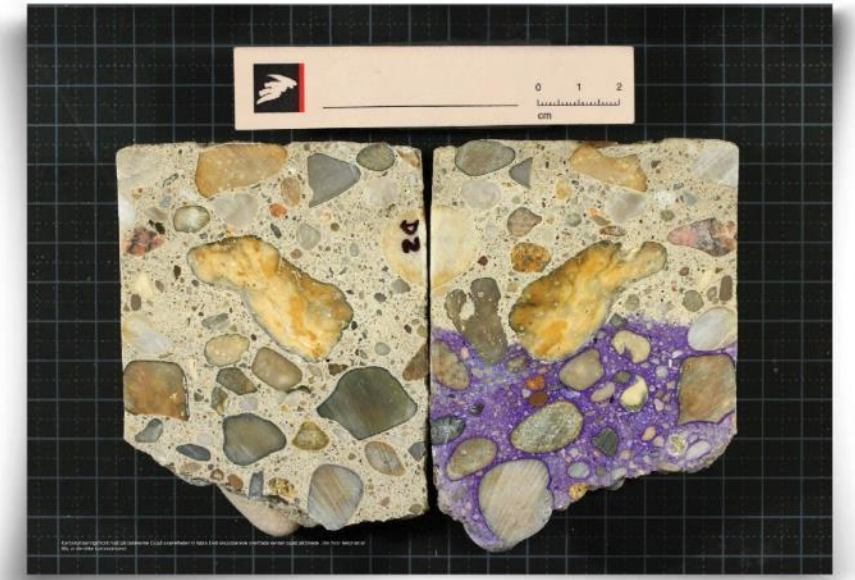
Livscyklusanalyse (LCA)

LCA'en på Birkeparken viser et betragteligt fodaftryk i form af indlejret CO_2. I alt næsten 2.000 tons CO_2 er indlejret i byggeriets betonelementer, mestendels i gulvdæk og primære vægge.

Cirkeldiagrammet viser indlejret CO_2 for at beton i bygningen, samt ansiket CO_2-påvirkning ved adskillelse med henblik på genbrug. Dette udgør 14% af den samlede CO_2 og muliggør således en besparelse på i alt 1.700 tons CO_2.



Testing of concrete structures

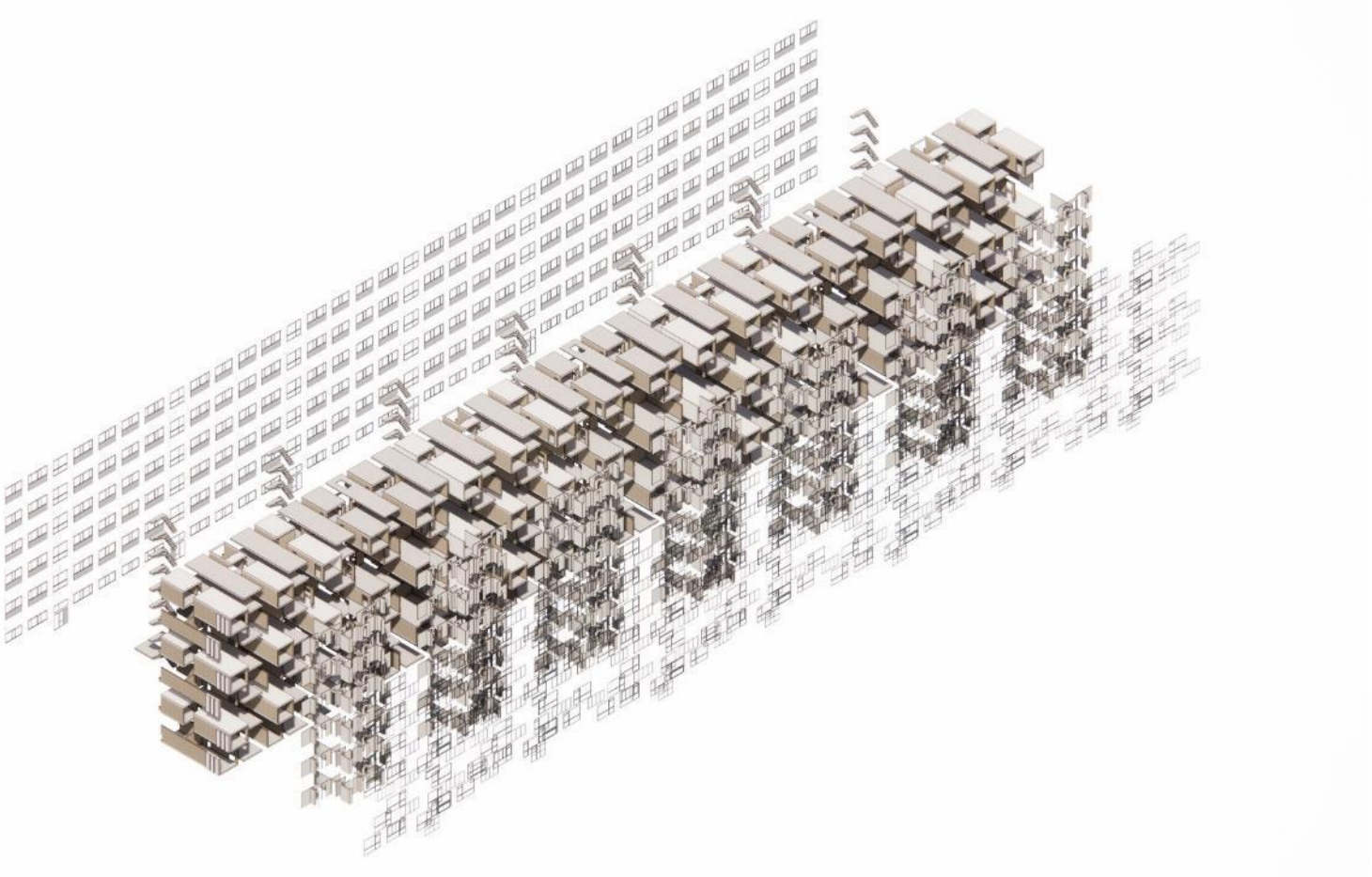


Project Ressourceblokken

Existing stage

Material bank mapping

Material bank mapping

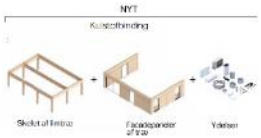


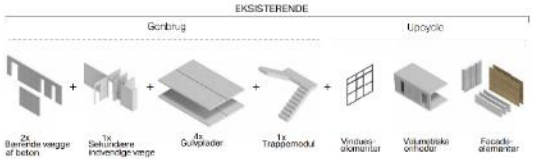
Material bank mapping

EFFEKT | re værk | jaja
Panum & Kappel | SPEKTRUM ARKITEKTER | 3xn GXN

Designsprint

6 tegnestue





1. Råhus i beton
Direkte genbrug


Betonelementer

2. Præfabrikeret klimaskærm
Tilføjede elementer


Træelementer

3. Bebyggelsens kantzone
Upcycling

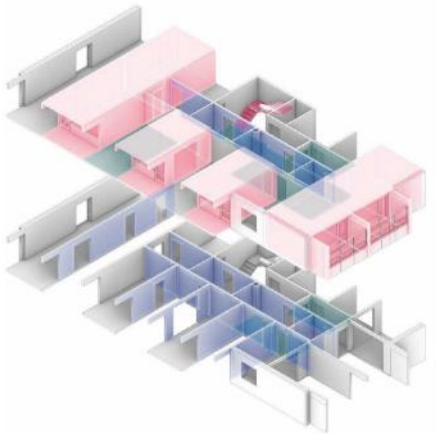

Vinduer

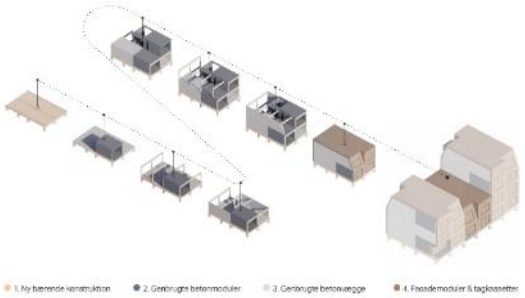

A | Stengårdsvej 10-14 fra 1976 i tegl og beton.

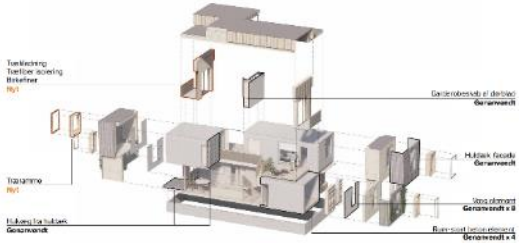

B | Læsning af linjer i eksisterende struktur.


C | Ny struktur skaber rum imellem volumer.


D | Tyngde og skiver fremhæves i ny struktur.


Genanvendte byggekomponenter


1. Ny bærende konstruktion | 2. Genbrugte betonmoduler | 3. Genbrugte betonvægge | 4. Facademoduler & tagkassetter



Designsprint

6 tegnestue

Grundlaget for designsprints

Der er udført byggetekniske analyser af bygningerne på Stengårdsvej i Esbjerg og Birkeparken i Vollsmose for at finde frem til den bedste strategi for nedtagningen af bygningerne med henblik på genbrug af bygningernes betonelementer. På baggrund heraf er bygningerne blevet digitalt dissekeret, hvilket har dannet udgangspunktet for designforslagene på de følgende sider.

Erfaring med nedtagning af betonelementer som forberedelse til genbrug er meget begrænset verden over. Det er der en række årsager til som er belyst her i rapporten. En af udfordringerne er, at bygningerne er praktisk talt umulige at skille ad som de er bygget, eftersom alle samlinger er støbt sammen. Dette betyder, at bygningerne i praksis skal skæres fra hinanden. Illustrationen nedenfor viser en mulig demontage af blok 65 (A) i Vollsmose som er elementbyggeri. Bygningen skal strippes ned til råhuset som ved en traditionel nedrivning (B). Herefter opskæres bygningen i henholdsvis rumstore moduler og væg-f dækelementer (C). Fordelen ved at nedtage hele moduler er at opskæringen af bygningen som er en omkostningsfuld proces, kan reduceres. Der kræves dog et udviklingsarbejde før end denne proces kan blive normal praksis.

Det er disse elementer (til højre) som har været udgangspunktet for de seks designsprints

1. Hele boksmoduler / 2. Væg- og dækelementer friskåret - isolerliggende "overskud" fra nedtagning af boksmoduler / 3. Væg- og dækelementer friskåret - over- og underliggende "overskud" fra nedtagning af boksmoduler / 4. Lette invendige vægge / 5. Hjørnekærne

Designsprint

6 tegnestue – Panum & Kappel

Montagerækkerne

Montagerækkerne er et bud på en ny boligbebyggelse, skabt med udgangspunkt i direkte genbrugte elementer og materialer, fremkommet ved nedrivning af Blok 45 i Birkeparken, Vollsmose. Montagebyggeriets grundprincipper, der kendetegner området, anvendes som en gennemgående metodik til opførelse af den nye bebyggelse.

Partners: Danish Technological Institute (DTI), GXN, Aarhus University, COWI, Tscherning, Søndergaard, Aarsleff, Peikko,Hi-Con, Dansk Beton, Brabrand Boligforening, AP Ejendomme, Danish Standard

(P)RECAST

Reuse of Precast Concrete Elements

Fond: MUDP under the Danish Environmental Agency

Photo: DTI

Project period: 2022-2024

(P)RECAST

Reuse of Precast Concrete Elements

Partners: Danish Technological Institute (DTI), GXN, Aarhus University, COWI, Tscherning, Søndergaard, Aarsleff, Peikko,Hi-Con, Dansk Beton, Brabrand Boligforening, AP Ejendomme, Danish Standard

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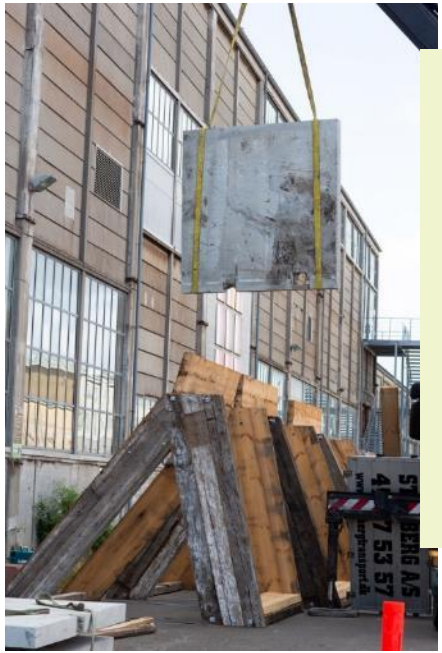
(P)RECAST

Reuse of Precast Concrete Elements



- Reuse of precast concrete elements as load bearing structures in new buildings
- Aims to develop methods that are generic and can be repeated
- Works throughout the entire value chain and focuses on challenges related specific to reuse of precast concrete elements
- Focuses on hollow core slabs, walls and TT-elements

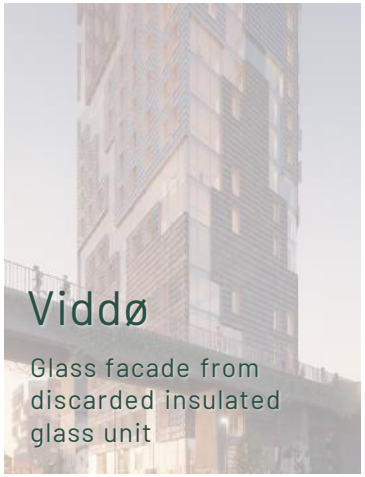
a:gain

Fusø

Tabletop

Tystø

Glass partition wall from used thermo glass units



Viddø

Glass facade from discarded insulated glass unit

Hjælmø

Flooring from window frame production waste wood

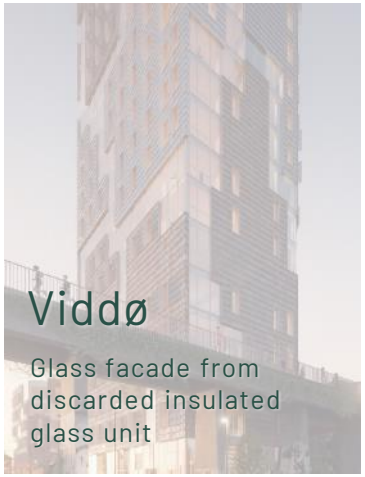
a:gain

Fusø

Tabletop

Tystø

Glass partition wall from used thermo glass units



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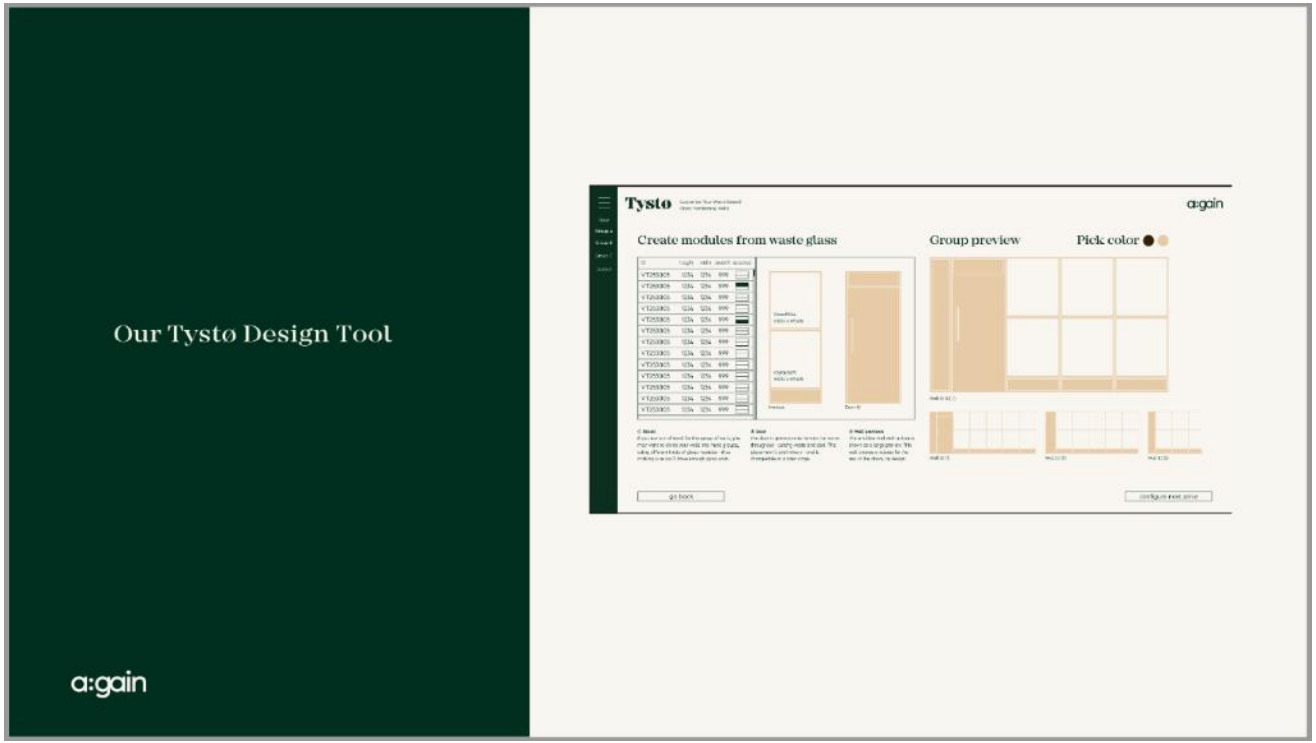

a:gain

Fusø

Tabletop

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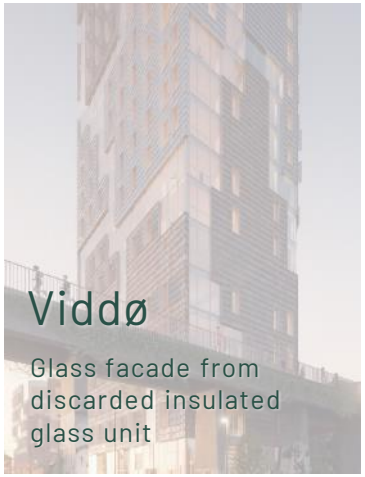

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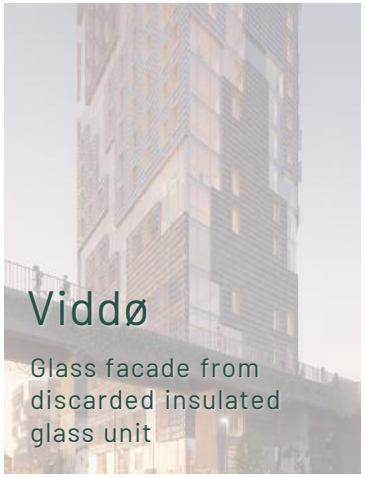

Viddø

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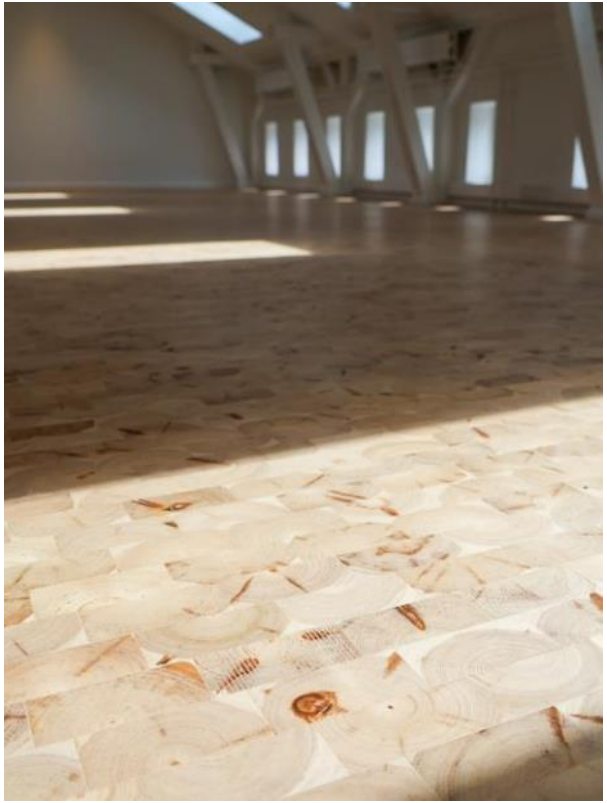
Hjælmø

Flooring from window frame production waste wood

a:gain

Hjælmø

Flooring from
window frame
production waste wood



a:gain

Fusø

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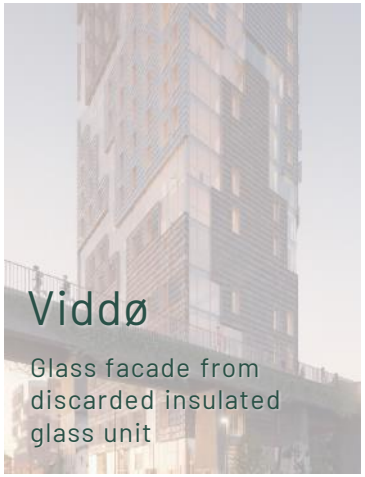

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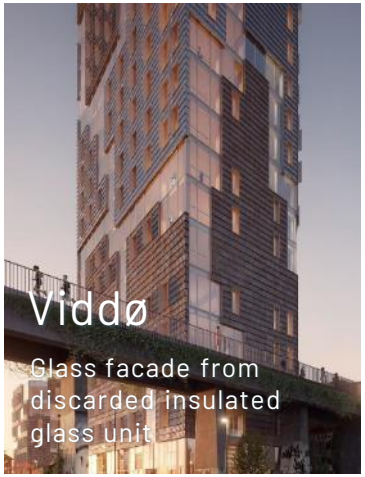

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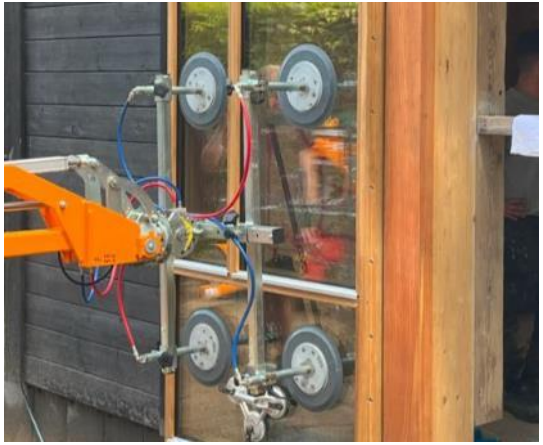
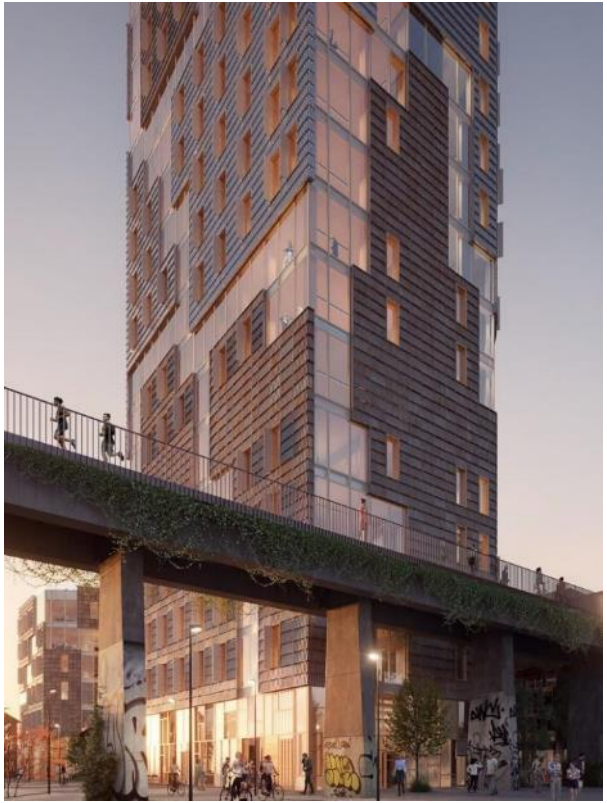




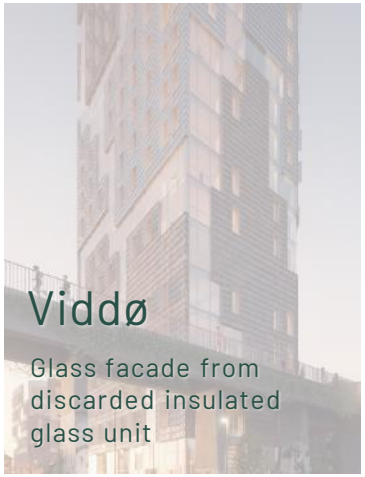
a:gain

Fusø

Tabletop
from worn out
DM kegs

Tystø

Glass partition wall
from used thermo
glass units



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Hjælmø

Flooring from
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a:gain

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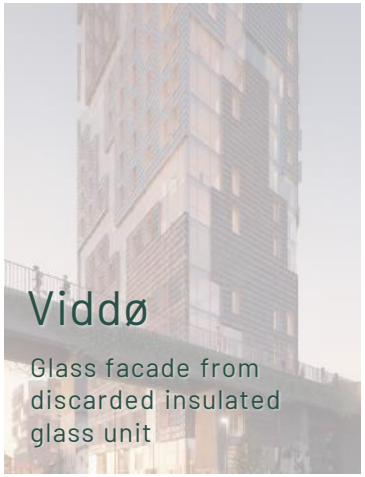

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production waste wood

a:gain

Fusø

Tabletop
from worn out DM kegs

Fusø

Tabletop
from worn
out DM kegs

Fusø + RUM + Flarø + Funderø

Bella Group, The Brewery meeting room

Building Owner: Bella Group
Architect: Bella Group
Contractor: Flemming Schröder A/S and
Tømrerfirmaet Thomas Harboe

a:gain

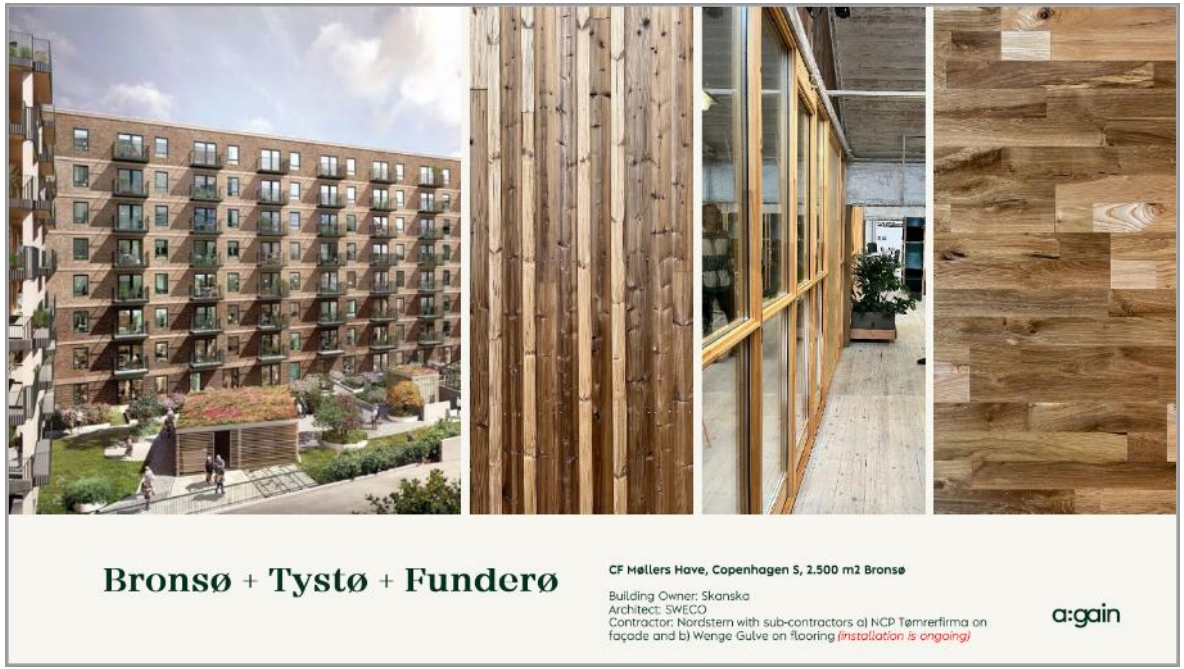
a:gain


DANISH DESIGN AWARD
FINALIST 2022
Funderø + Hjælmø +
Dybø + Viddø
TRÆ
Building Owner: Kilden & Hindby / PFA
Architect: Lendager
Contractor: Kaj Ove Madsen
a:gain


Viddø
Glass facade from
discarded insulated
glass unit


Hjælmø
Flooring from
window frame
production waste wood

a:gain



Bronsø + Tystø + Funderø

CF Møllers Have, Copenhagen S, 2.500 m2 Bronsø

Building Owner: Skanska
Architect: SWECO
Contractor: Nordstern with sub-contractors a) NCP Tømrerfirma on façade and b) Wenge Gulve on flooring *(installation is ongoing)*

a:gain

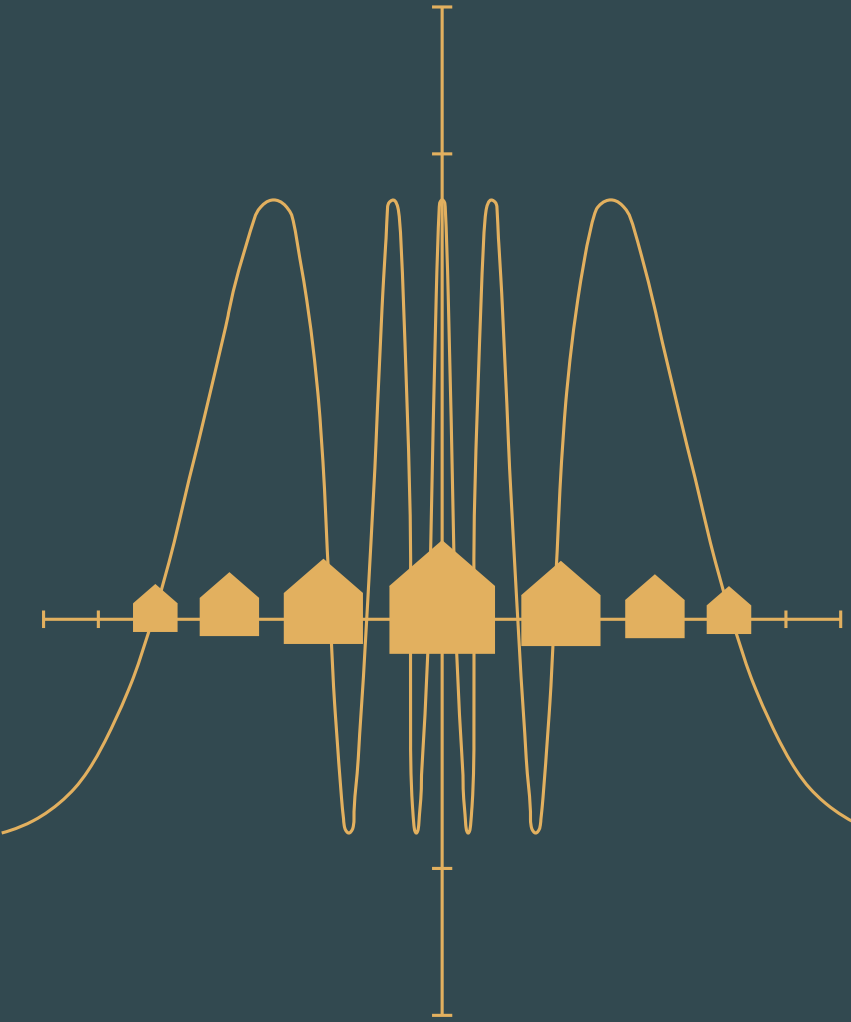
Tystø

Glass partition wall from used thermoed glass units

Hjælmø

Flooring from window frame production waste wood

a:gain



Harpa Birgisdóttir

Professor, Forskningsgruppen for Bygningers Bæredygtighed

Sektionen for Energi og Bæredygtighed i Byggeriet

BUILD – Institut for Byggeri, By og Miljø

hbi@build.aau.dk