Circular Façade Systems

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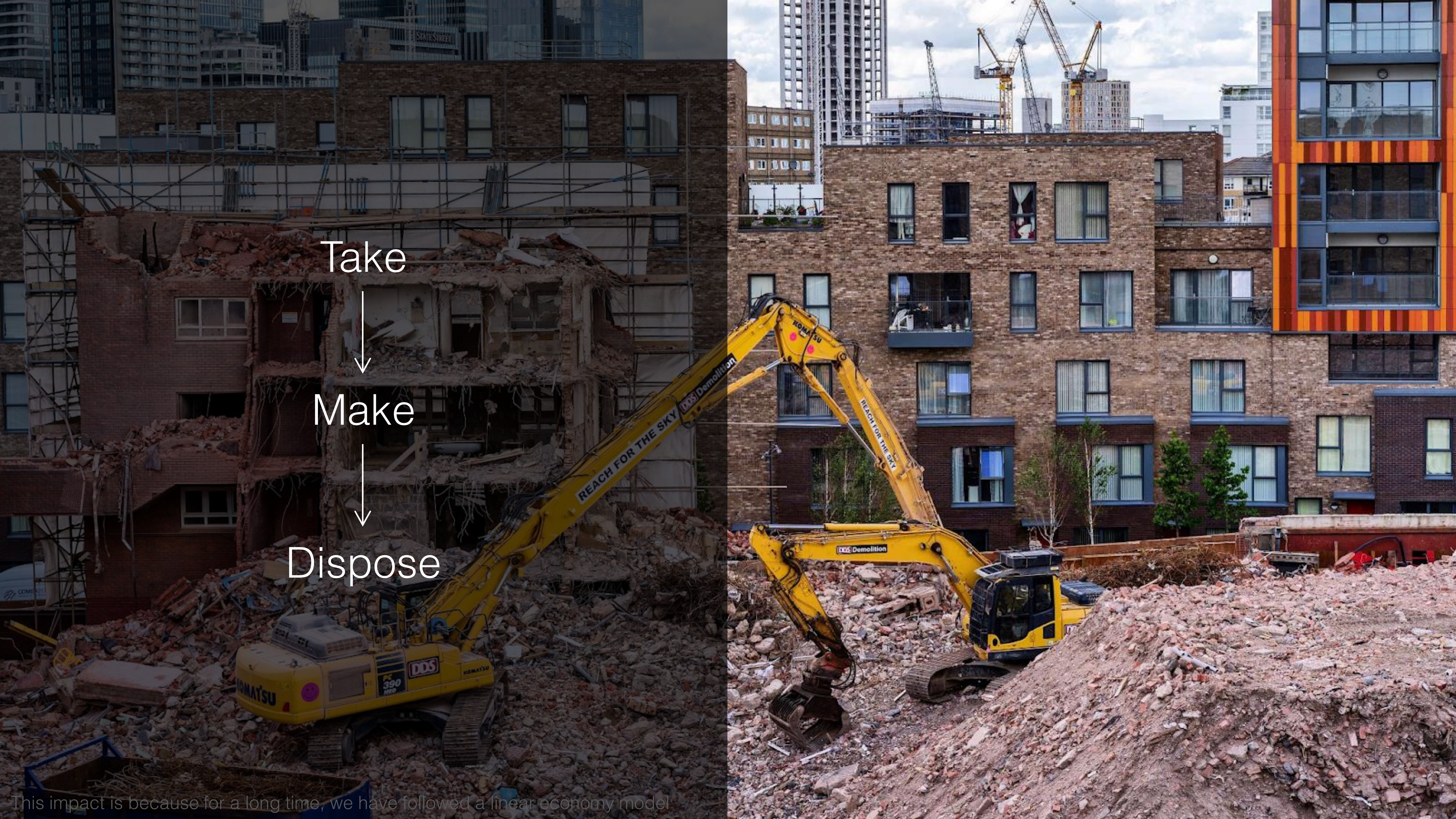
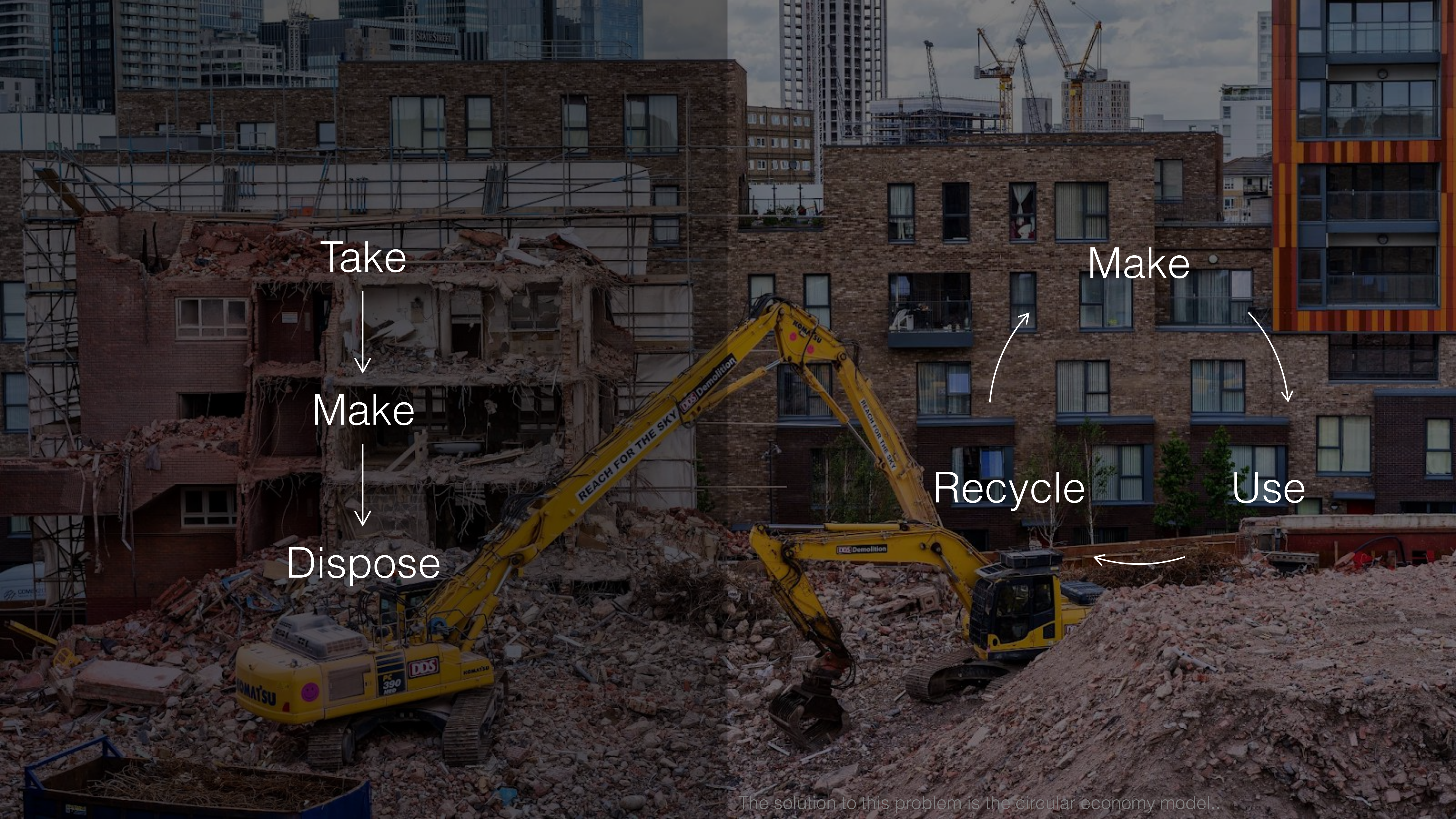
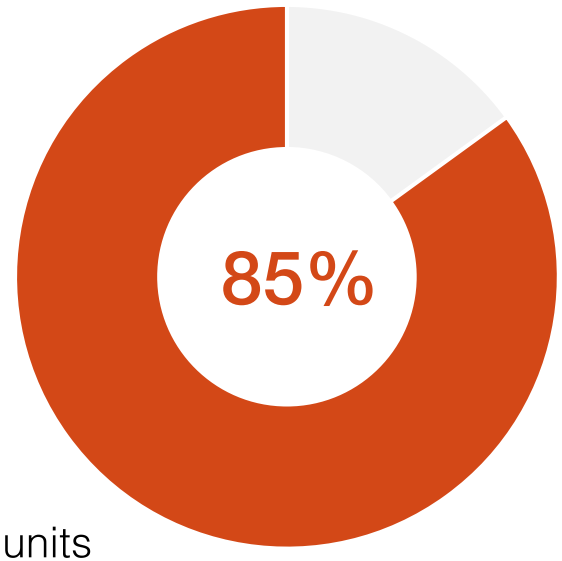
P5 Presentation

16th June 2022


REACH FOR THE SKY
DDS Demolition
DDS Demolition
KOMATSU
DDS


Take
Make
Dispose
REACH FOR THE SKY
DDS Demolition
KOMATSU
This impact is because for a long time, we have followed a linear economy model


Take
Make
Dispose
Make
Recycle
Use
REACH FOR THE SKY
DDS Demolition
KOMATSU
The solution to this problem is the circular economy model...



Built before 2001

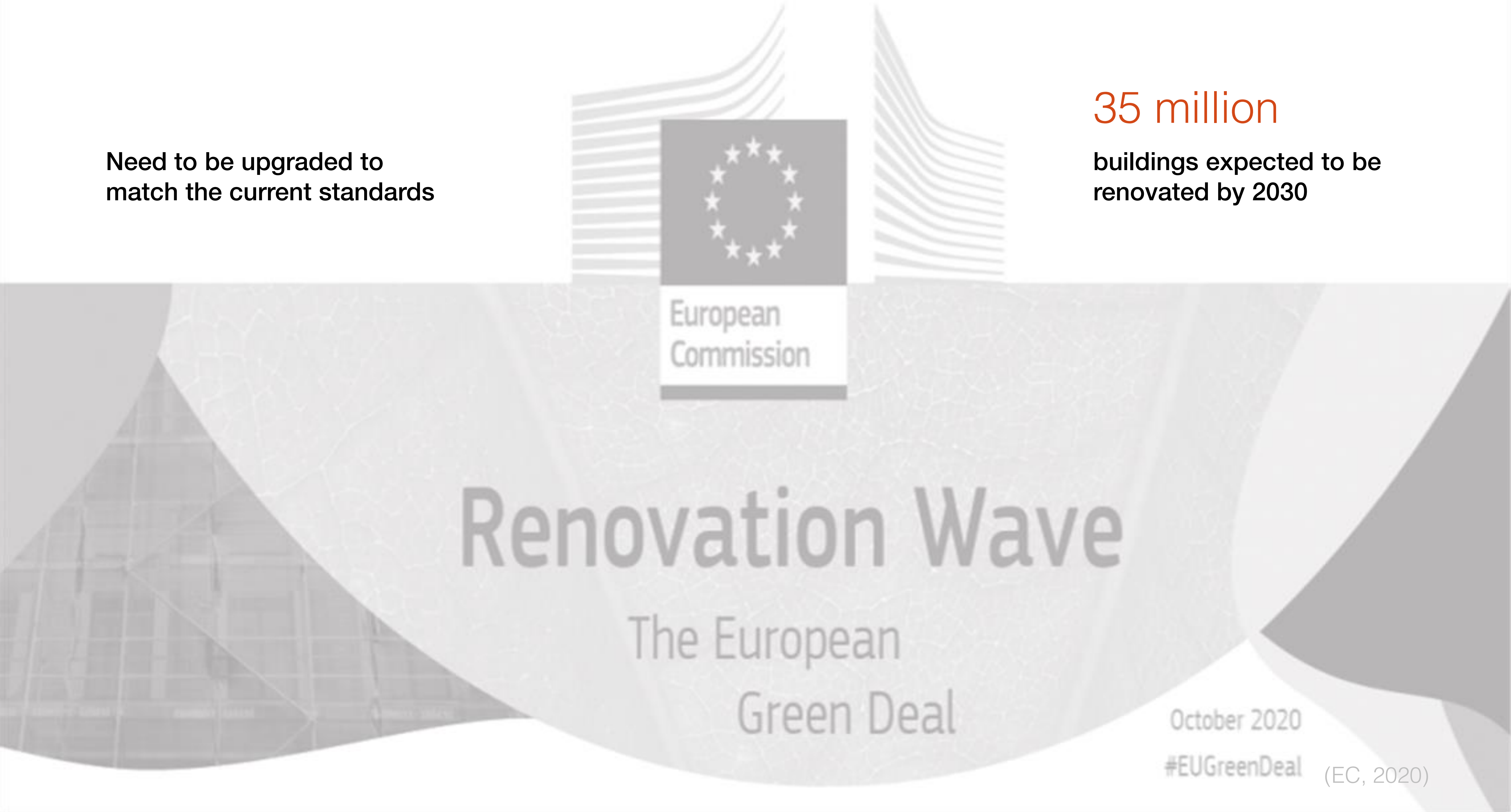
220 million building units

85 – 95% of these will still be standing in 2050!

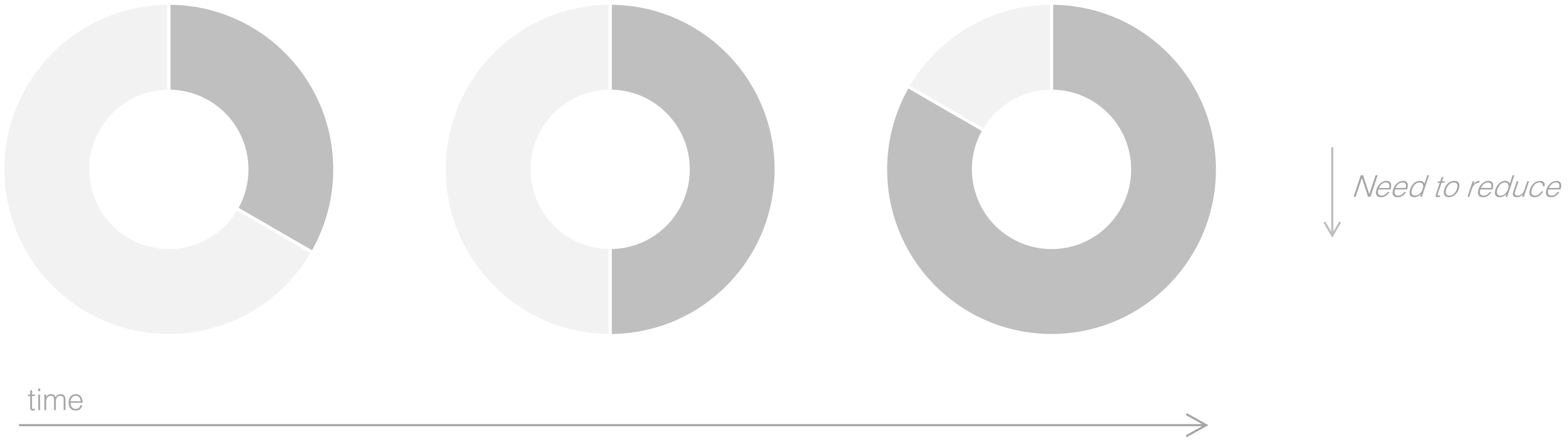
Need to be upgraded to
match the current standards

35 million

buildings expected to be
renovated by 2030

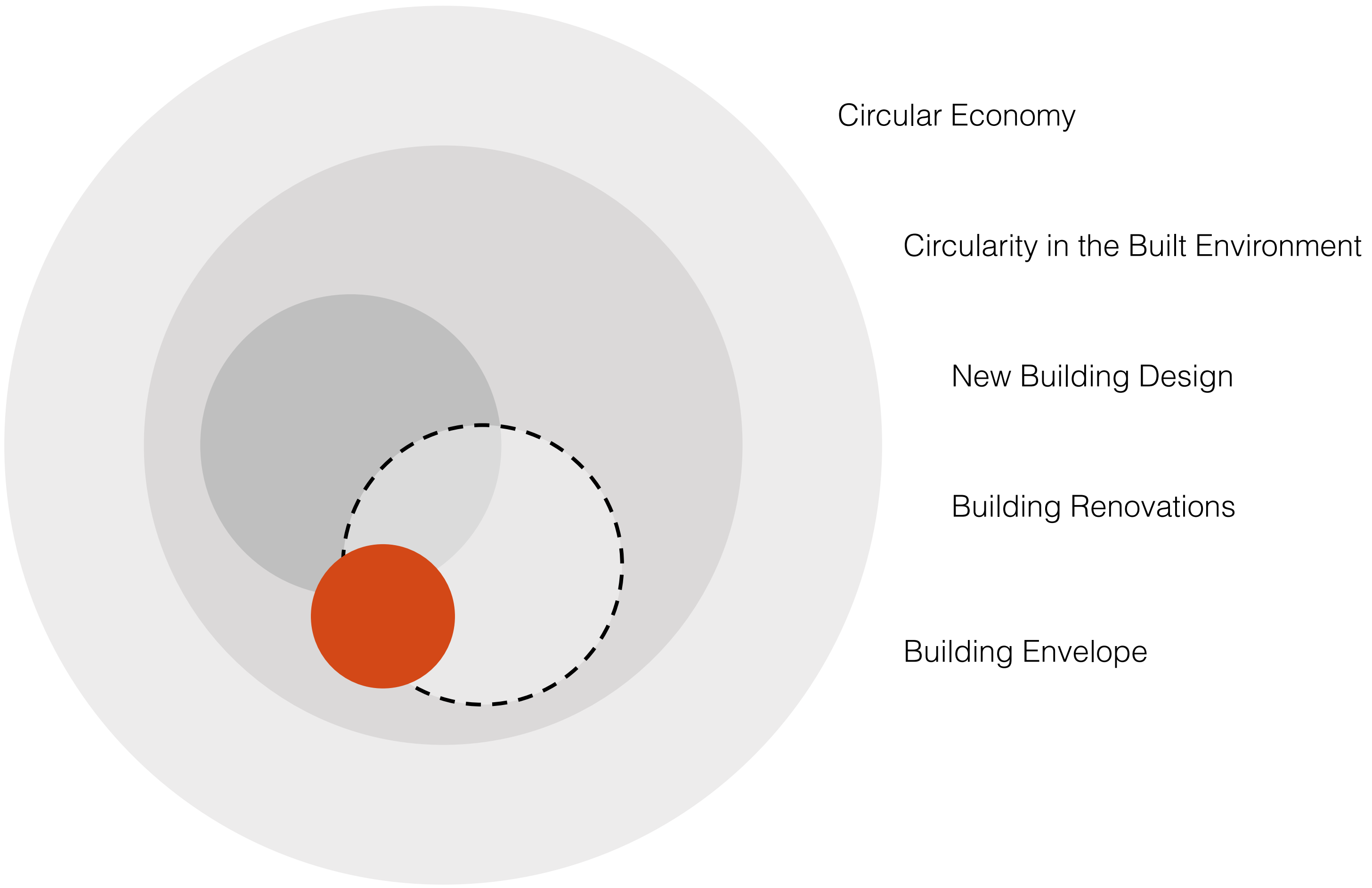


(EC, 2020)



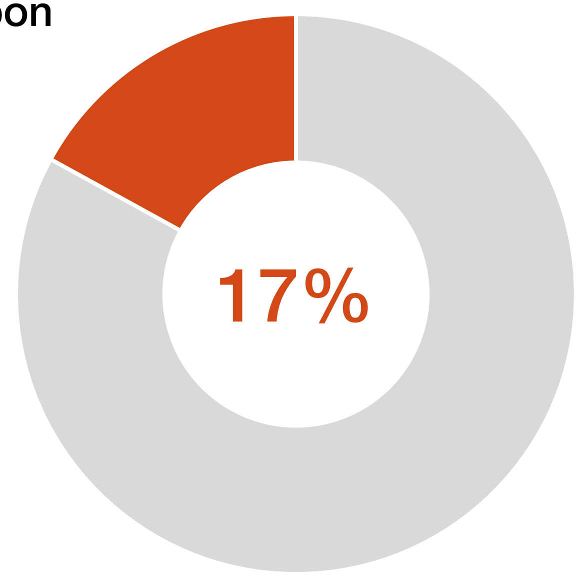
Embodied carbon

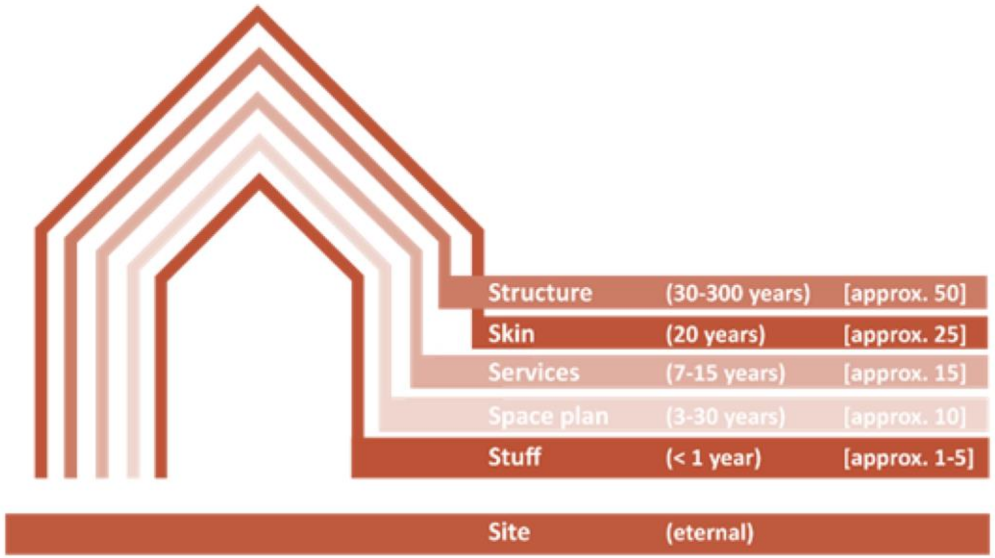
Operational carbon


Circular Economy
Circularity in the Built Environment
New Building Design
Building Renovations
Building Envelope

Contribution to Embodied Carbon

- Architectural demands
- Thermal performance
- Indoor comfort
- Actors
- Complex geomtery

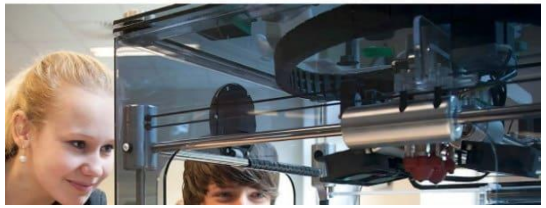




(Brand, 1994)

UNITED NATIONS
PARIS CLIMATE AGREEMENT
SIGNING CEREMONY
22 APRIL 2016

A Circular Economy in the Netherlands by 2050



v/s

There is a lack of a clear and strategic approach to designing a circular façade. The process is complex due to many interconnected factors involved.

“How can we implement circularity in façades during the planning and design processes of building renovation projects in the Netherlands?

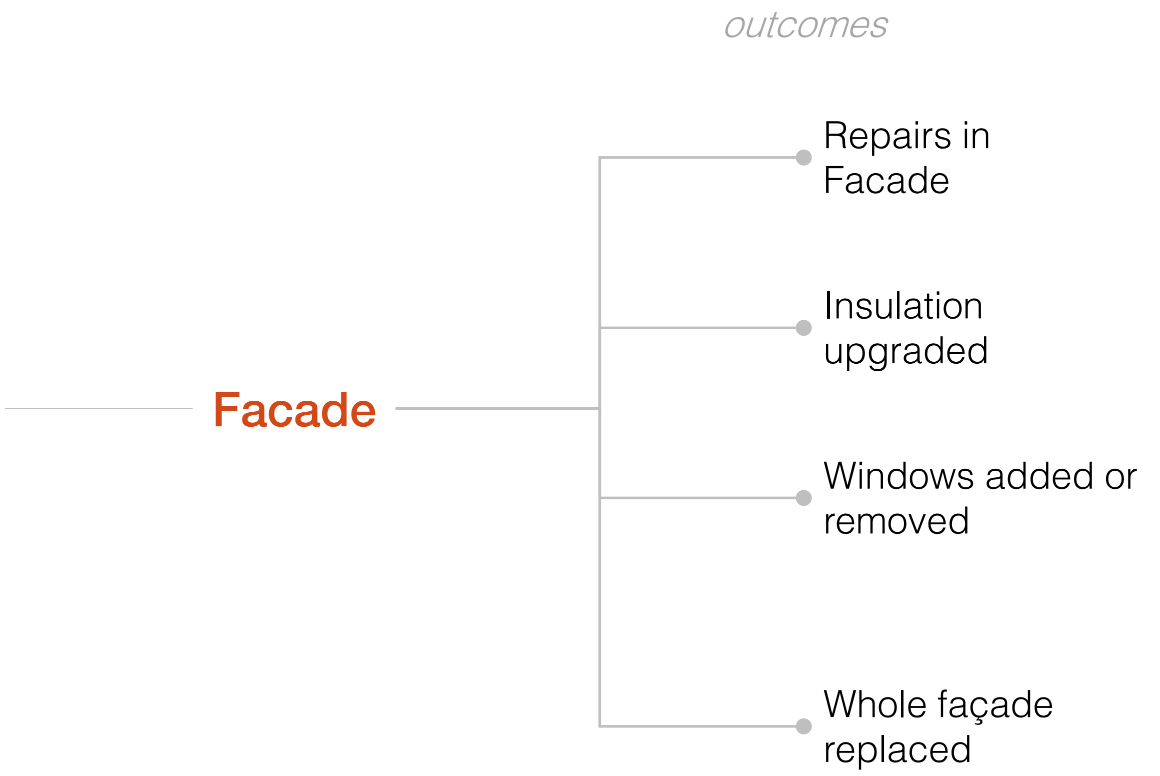
“How can we implement circularity in façades during the planning and design processes of building renovation projects in the Netherlands?

Literature

- Building Renovation Goals
- Circular Economy in Built Environment

Building Renovation Goals

Urban Design	Improvement of the urban and architectural quality, preventing vacancy in a neighborhood to avoid social problems are important factors related to the urban context in which the building is placed.
Architectural Design	Avoid the decay of valuable architectural heritage and construction, update the appearance of the overall building, and change the character to suit the current times.
Function	Transform the building spatially, optimize the spaces as per requirement
User Comfort	Eliminate unpleasant indoor conditions, hygiene, and ventilation problems, avoid sick building syndrome or building related illnesses.
Technical Installations	Reduce the high operational energy demand and maintenance needs
Hazardous Materials	Get rid of hazardous materials if any have been used in the original construction
Building Physics	Eliminate building physics concerns like lack of insulation, wind or water leaks, fire protection deficiencies while planning for climate change and the current climatic conditions.
Fire Regulation	Introduce compulsory fire safety improvements as per current building standards and regulations
Safety	Avoid danger or damage to third party
Energy Consumption	Meet the current energy consumption standards as per building norms.
Operational Costs	Avoid the high maintenance costs and high energy demands of building
Lett ability	Bring and vacant building back into the market
Marketing	Users' representation needs
Financial Market	Investment from institutional investors

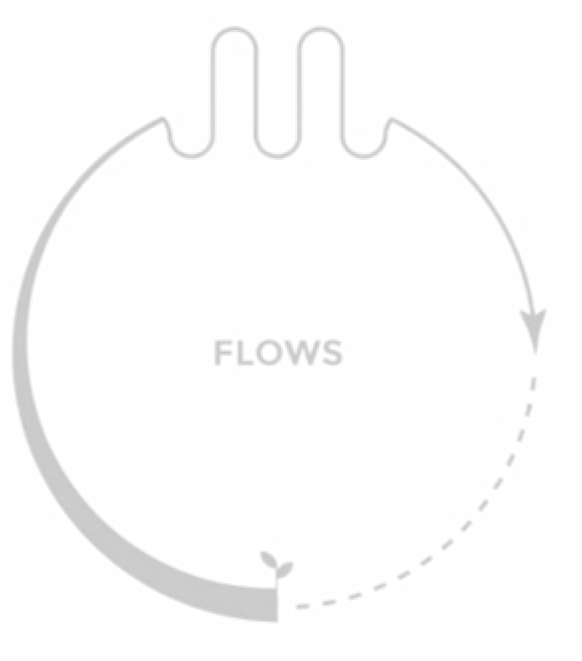


(Ebbert, 2010)

Circular Economy in the Built Environment

Slow

use longer



Narrow

use less

Close

use again

Circular Economy aims to: close and extend the loops of material cycles, in order to preserve value of materials, resulting in decreased virgin material consumption and waste generation in our current society

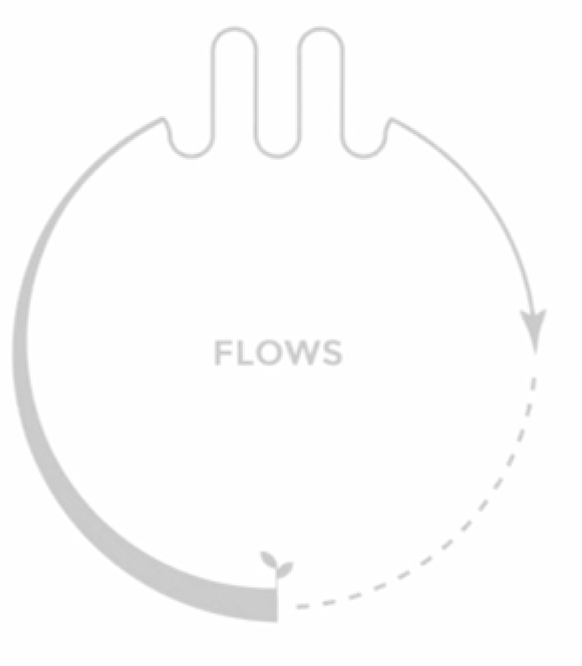
Circular Economy in the Built Environment

Slow

use longer

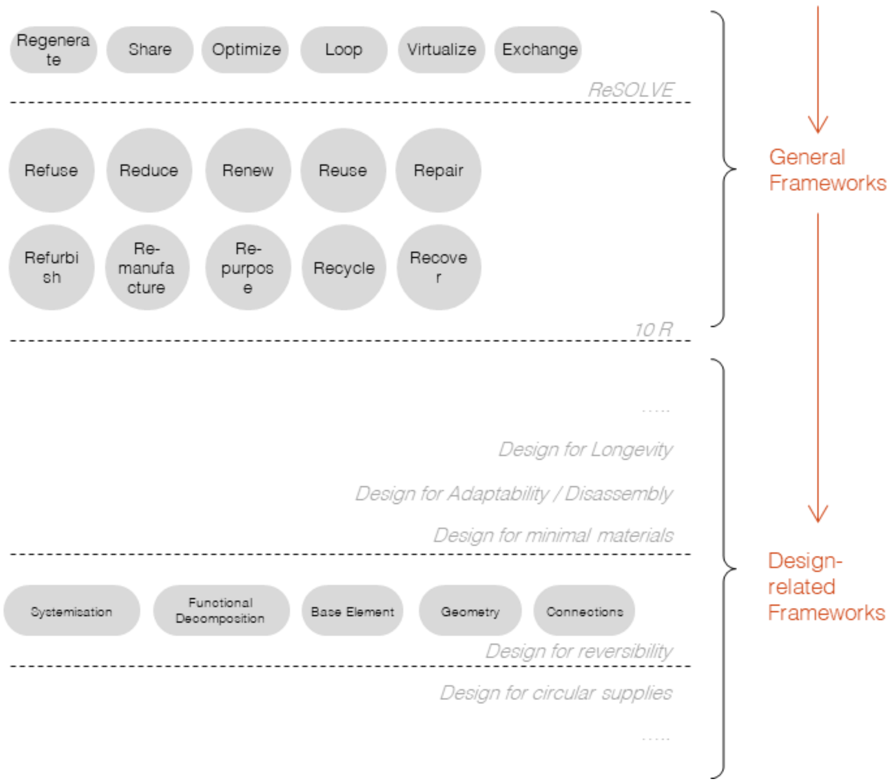
Narrow

use less



Close

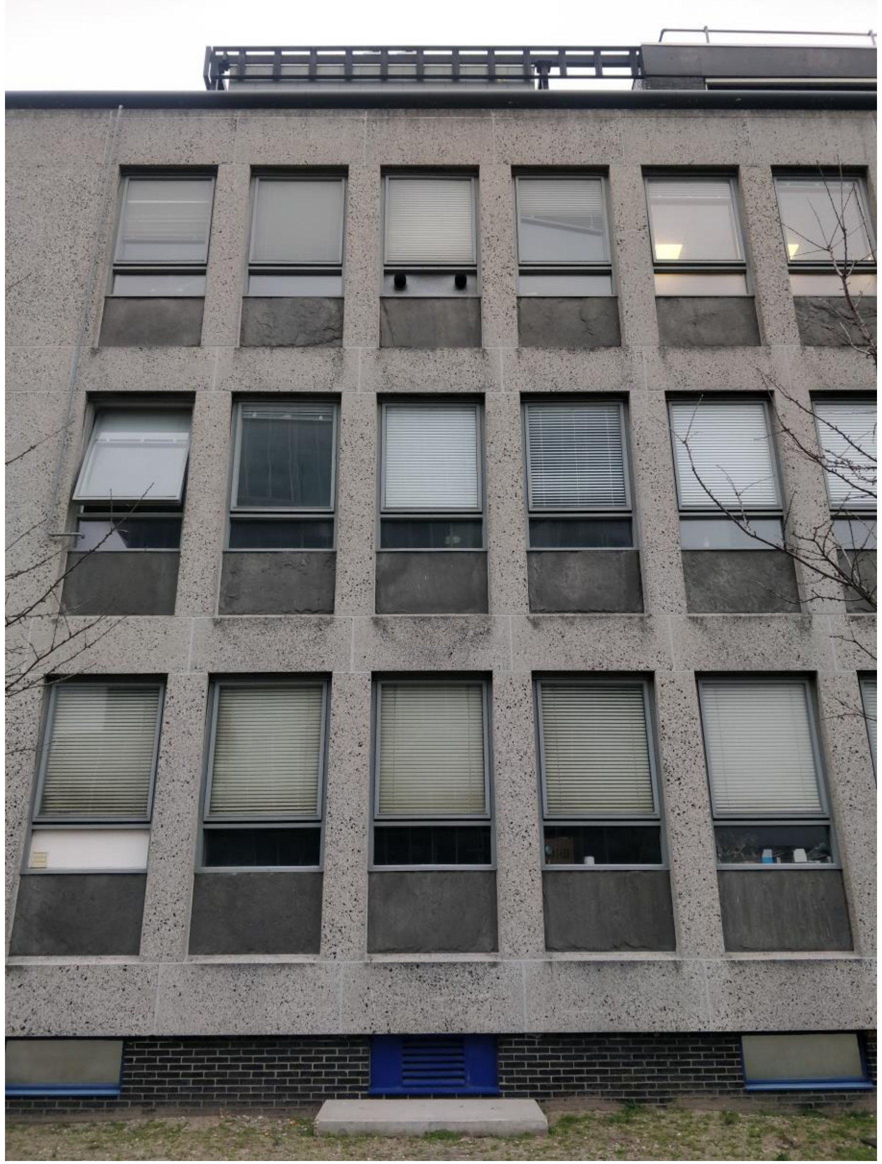
use again



Case Study Analysis

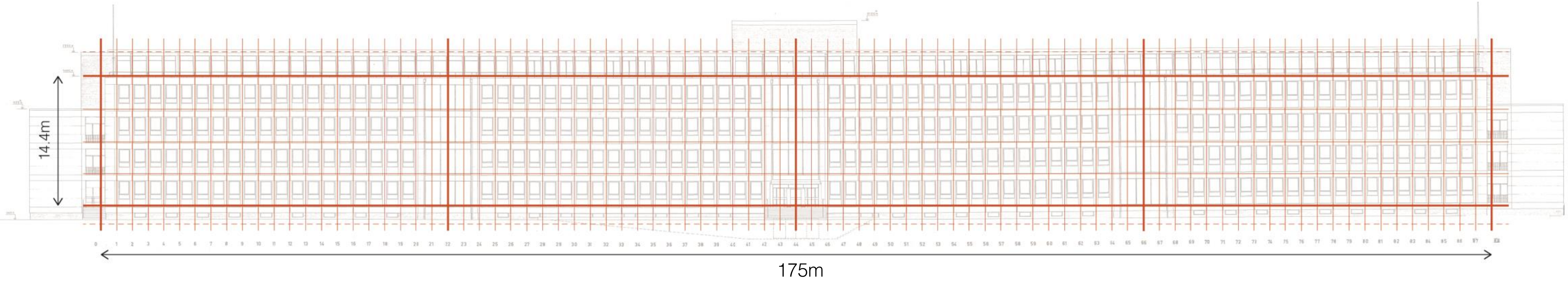
Planning Process

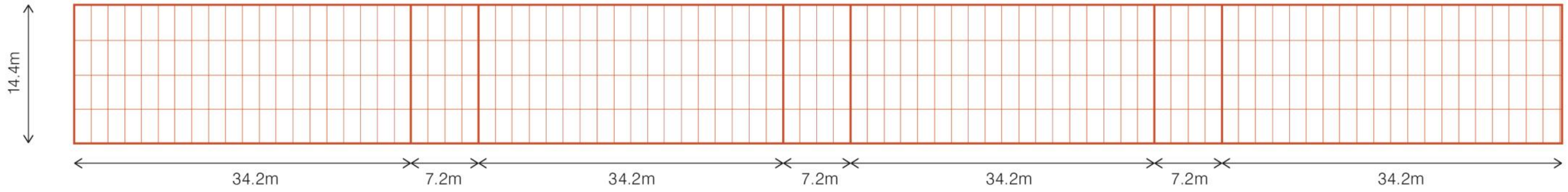
Case Study



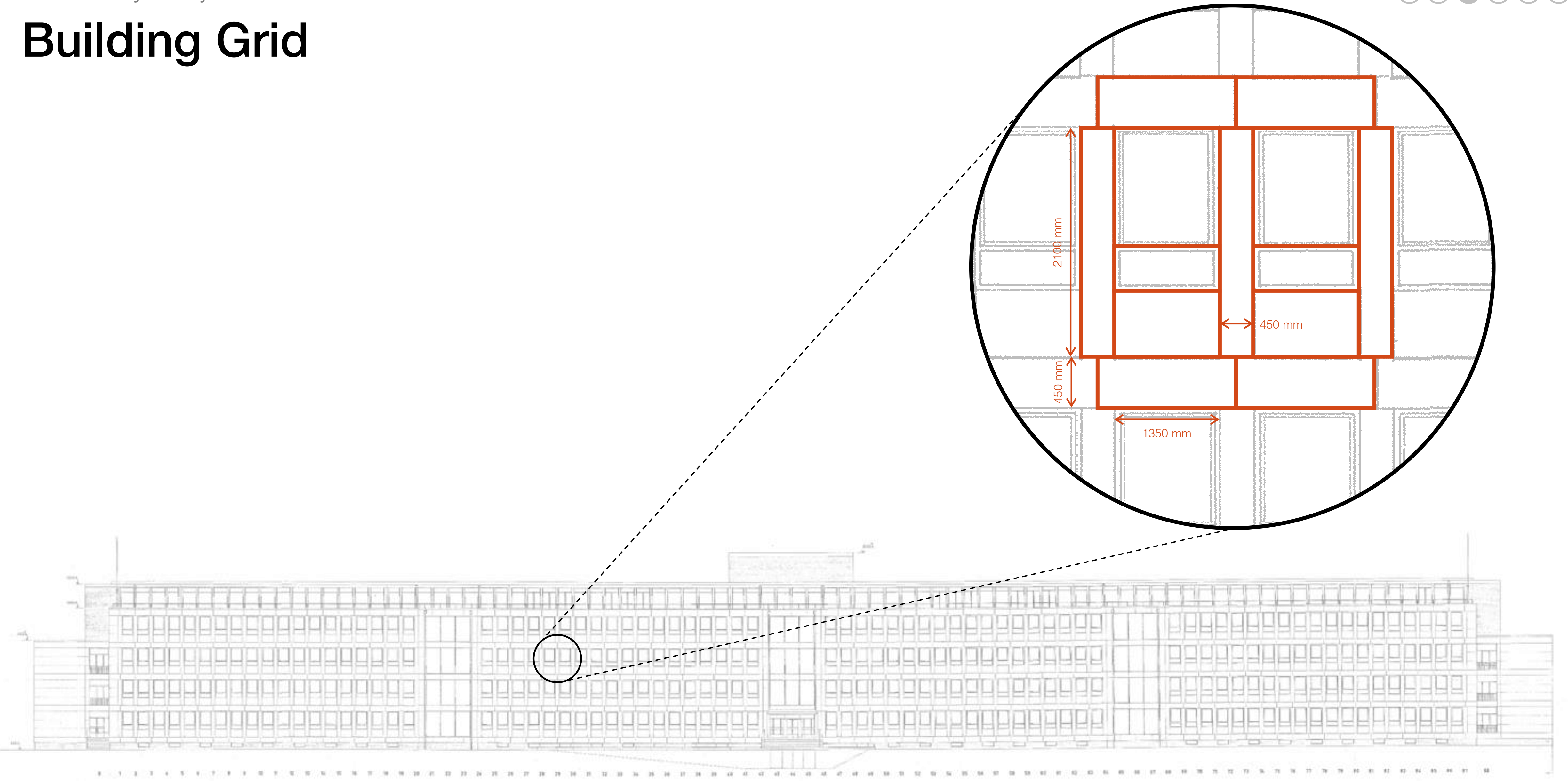

Inter-dependent
Intermediate
Dependent
Building Layer Analysis
Rigid
Flexible
Grid Analysis
Reuse
Recycle
Incinerate
Landfill
Building Material Analysis

Building Grid





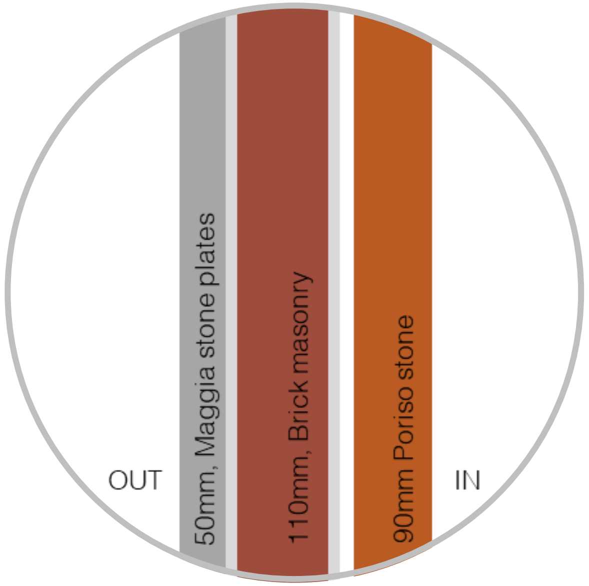
Building Grid



Building Materials

Maggia stone panels
Brick Masonry
Air gap
Poriso stone

Precast concrete panels
Air gap
Poriso stone



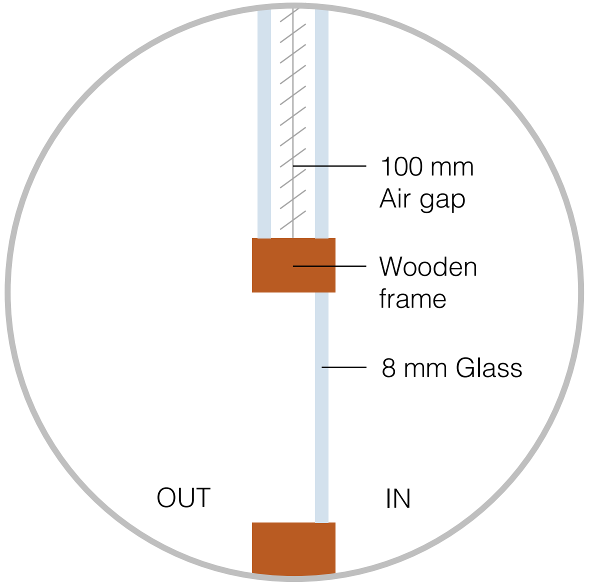
(Peutz, DGMR, 2015)

Building Materials

Good watertightness
Poor airtightness

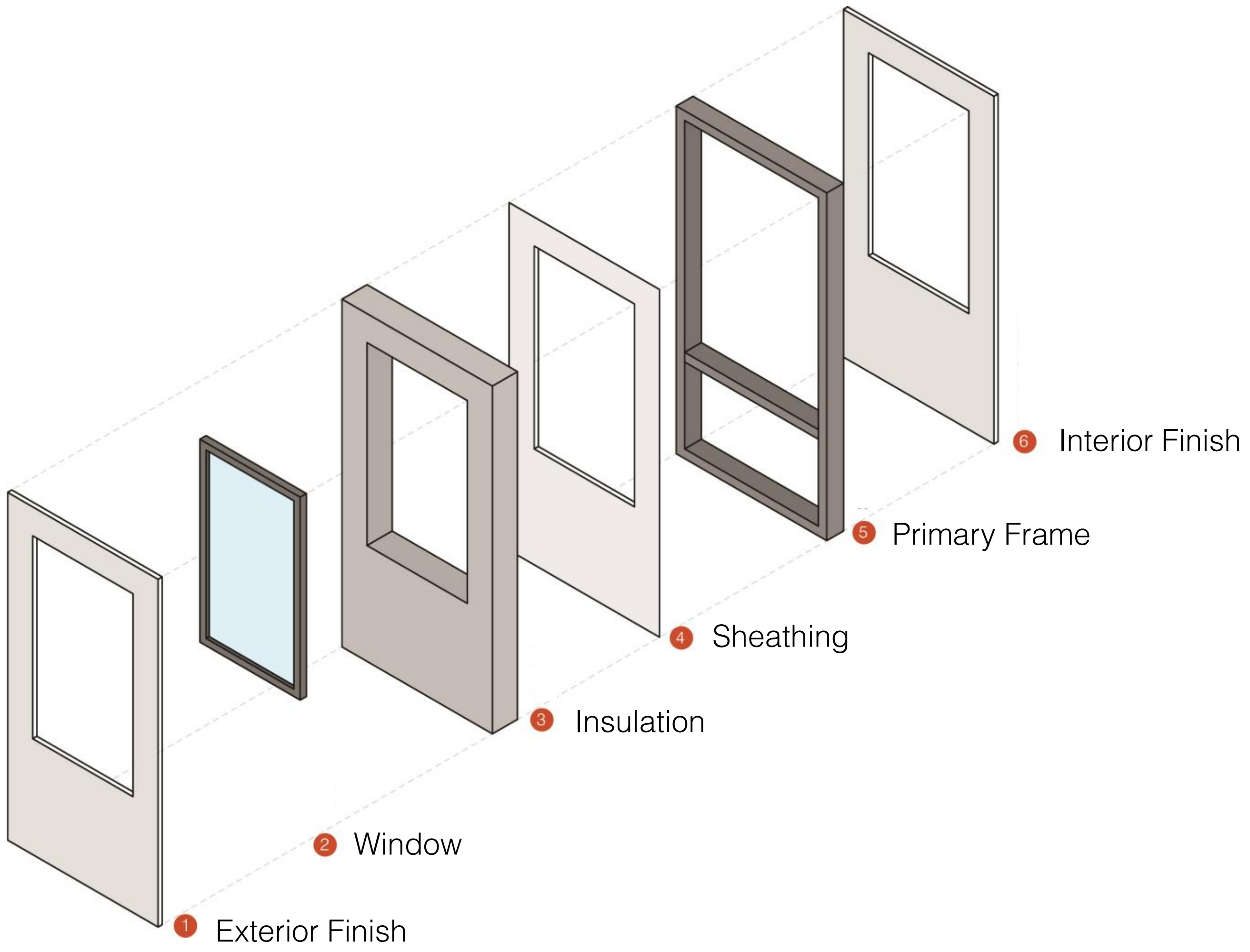
Single glazed window
with timber frame
(partially openable)

Services not
connected to the Skin



(Peutz, DGMR, 2015)

Building Facade Layers



Design Process

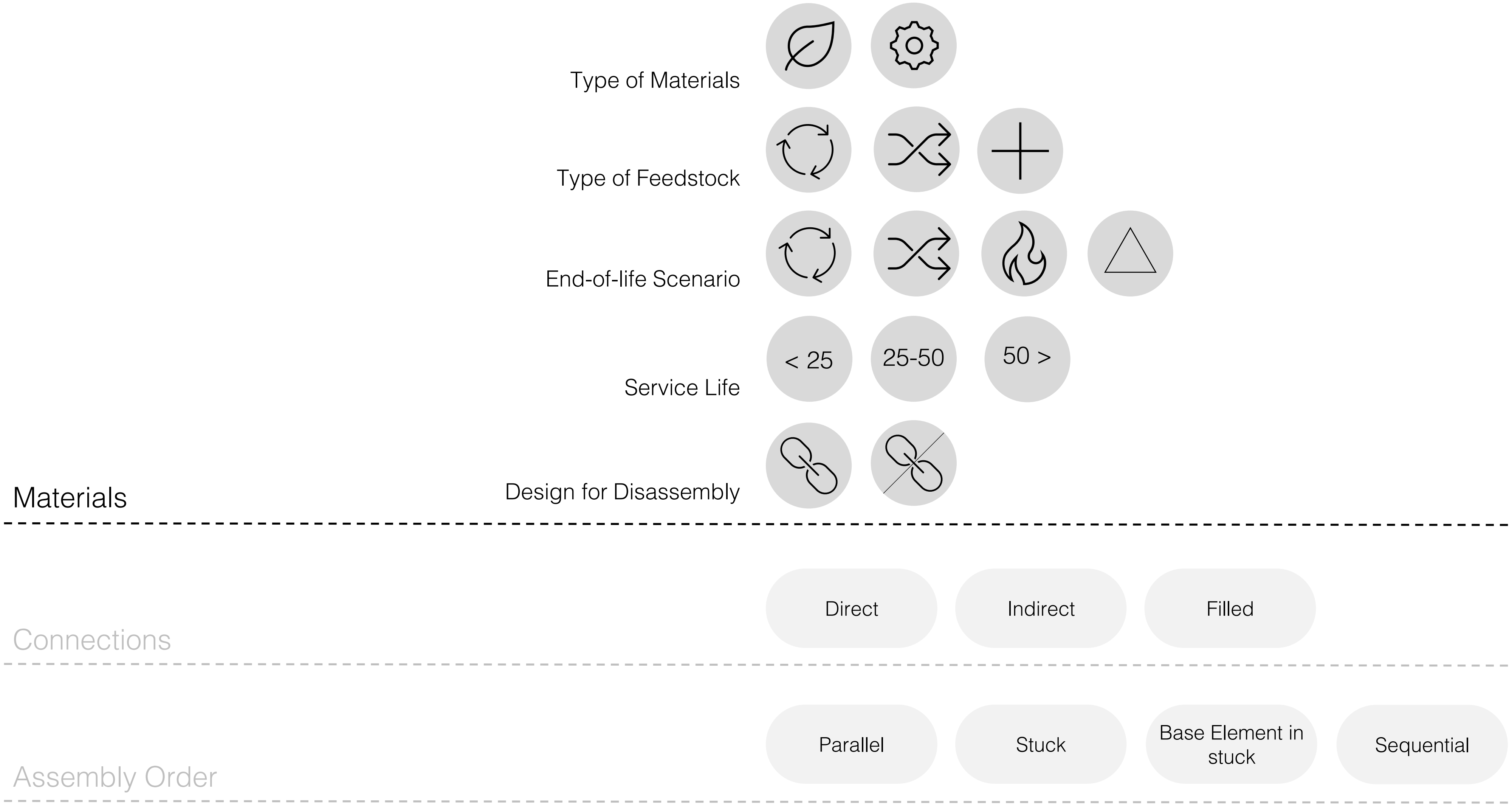
Planning and Design Process

10R Framework

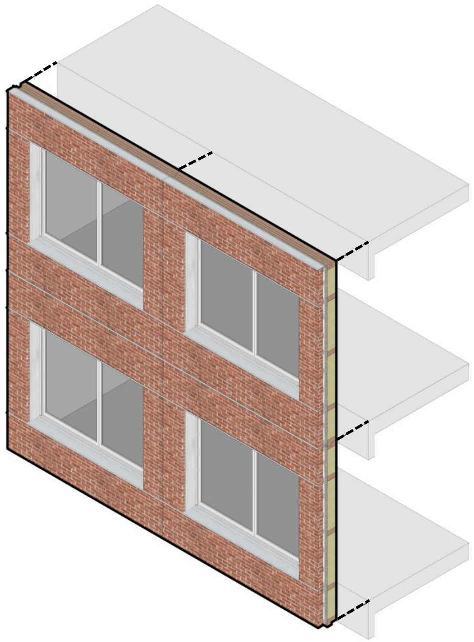
	Refuse	prevent raw material use
narrowing loops	Reduce	decrease raw material use
narrowing loops	Renew	redesign product in view of circularity
slowing loops	Reclaim	use product again
	Repair	maintain and repair product
	Refurbish	revive product
	Remanufacture	make new product from second-hand
	Repurpose	reuse product with a different function
closing loops	Recycle	salvage material streams with highest possible value
	Recover	incinerate waste with energy recovery

(Vermeulen, et.al. 2019)

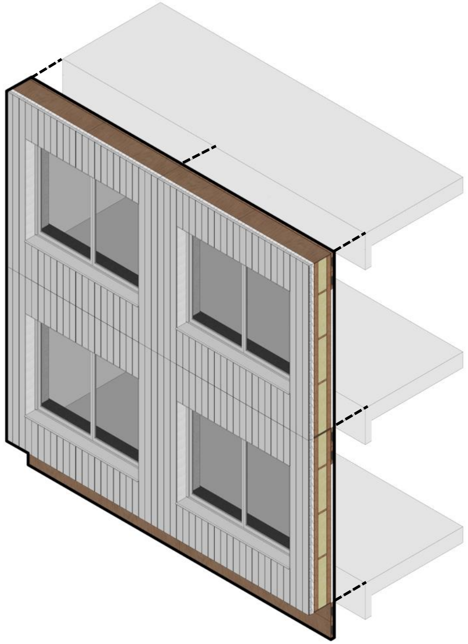
Materials


Type of Materials
Type of Feedstock
End-of-life Scenario
Service Life
< 25
25-50
50 >
Design for Disassembly
Materials
Direct
Indirect
Filled
Connections
Parallel
Stuck
Base Element in stuck
Sequential
Assembly Order

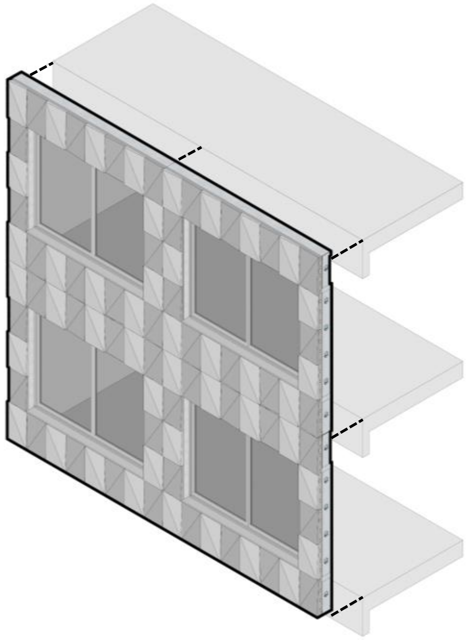
Design Options



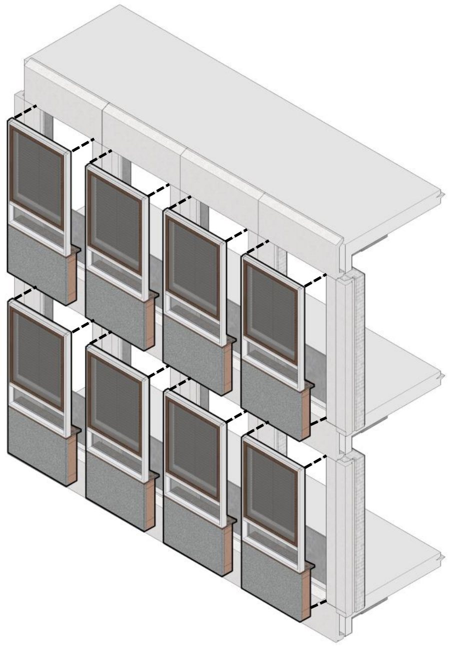
1 Option 1 : **Reclaim**



2 Option 2 : **Renew**



3 Option 3 : **Recycle**

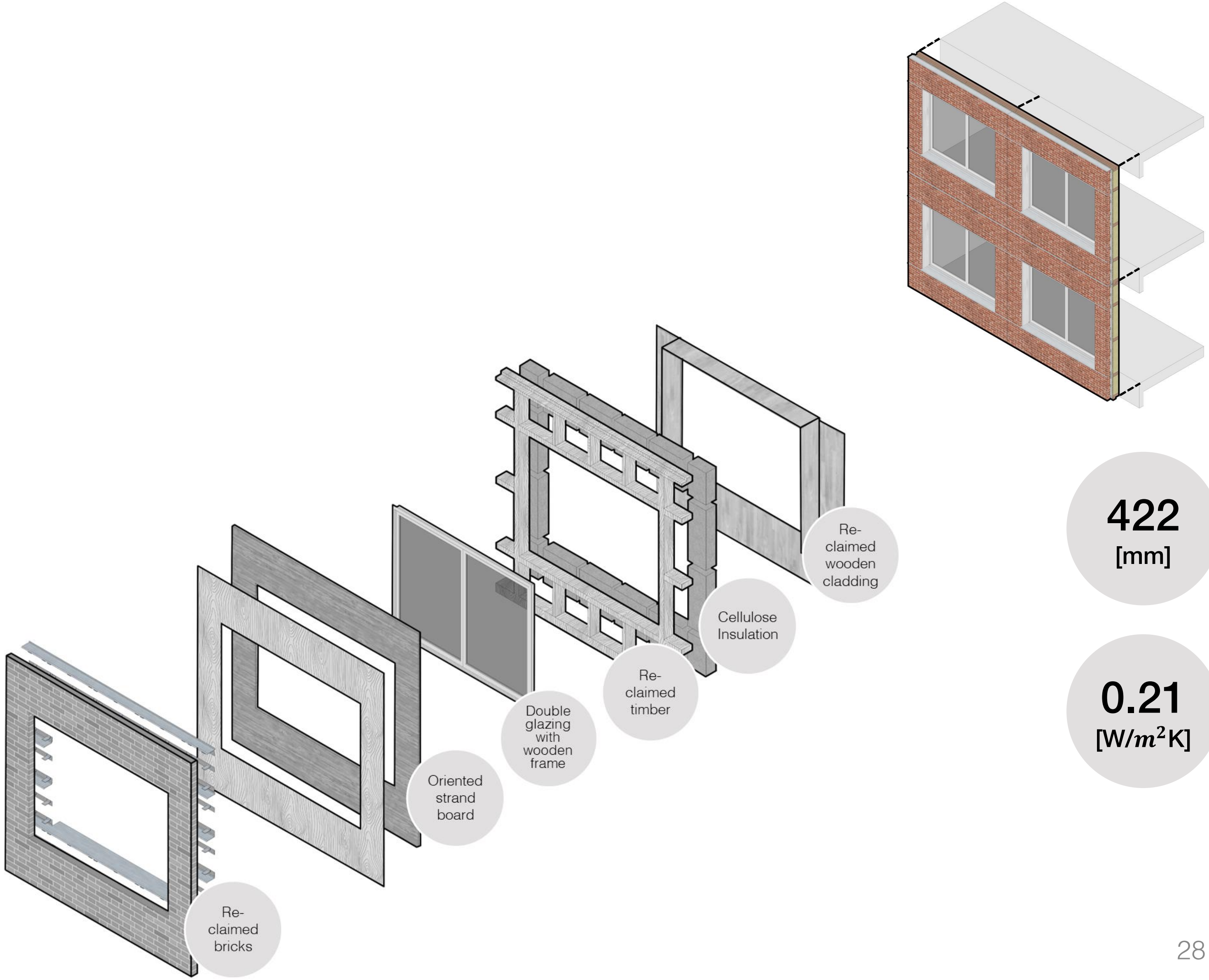


4 Option 4 : **Reduce**

Reclaim

Reclaimed
Timber frames

Reclaimed
Bricks



422
[mm]

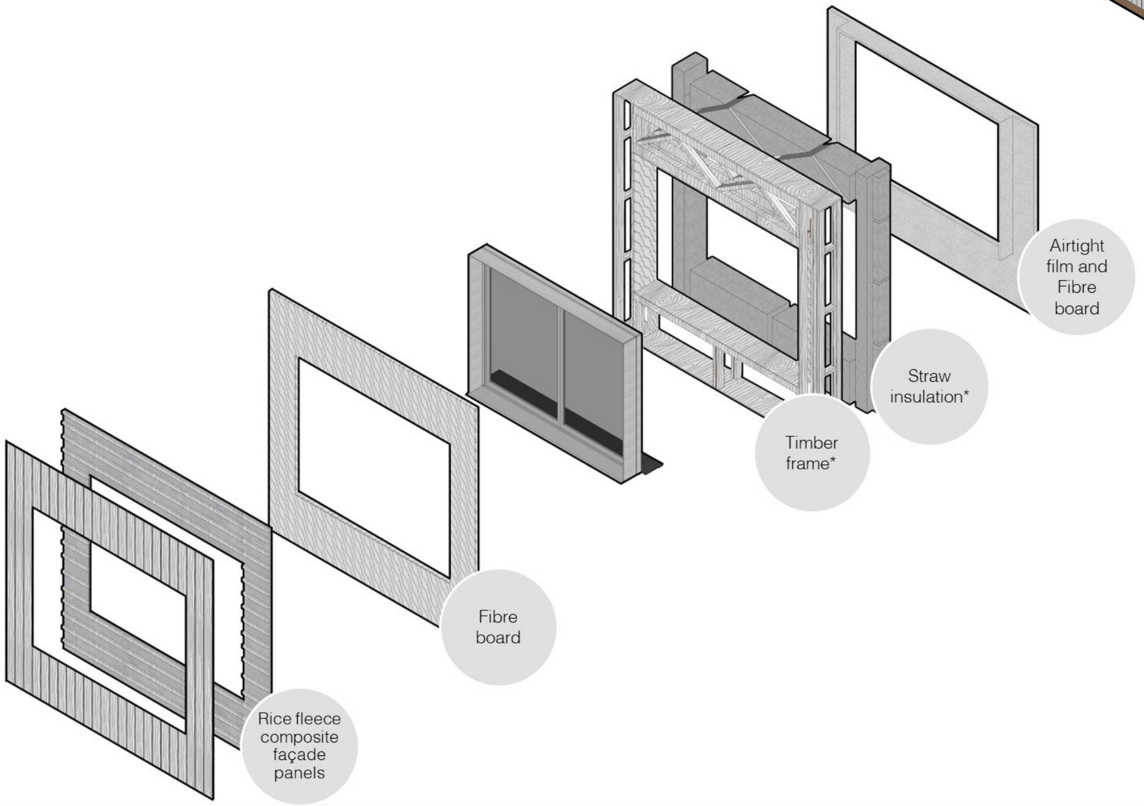
0.21
[W/m^2K]

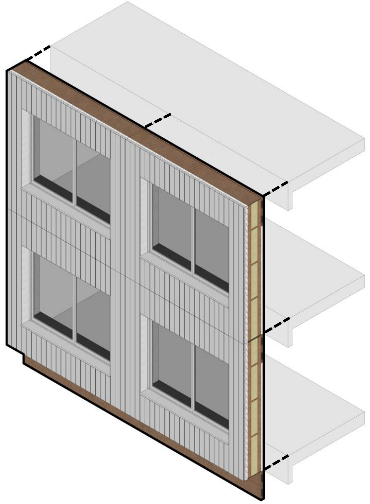
Renew

Straw insulation

Rice Fleece
Composite Panels

Cross Laminated
timber boards



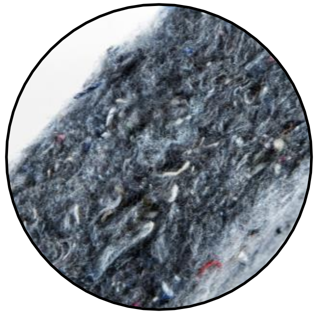


262
[mm]

0.24
[W/m^2K]

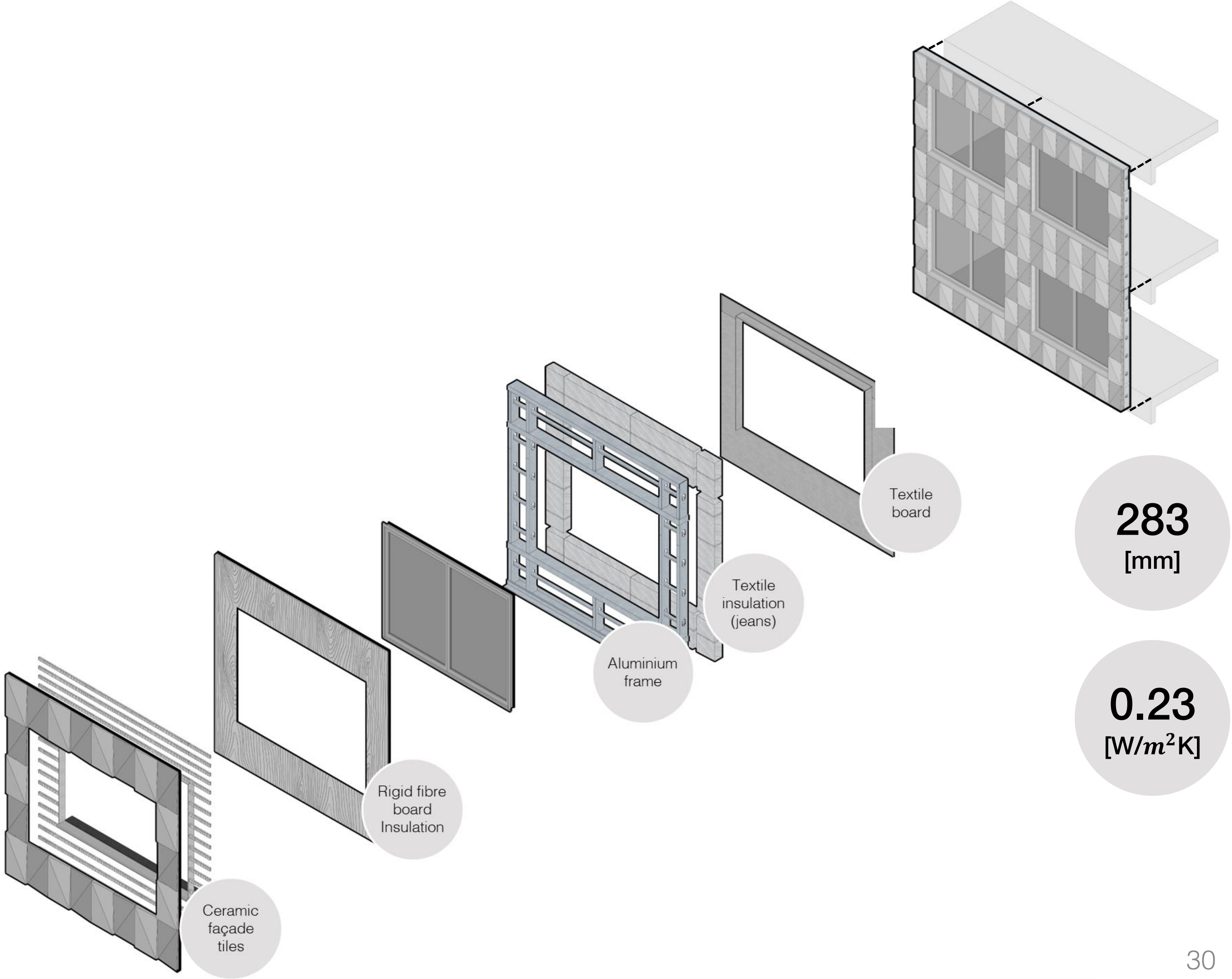
Recycle

Ceramic
Façade Tiles

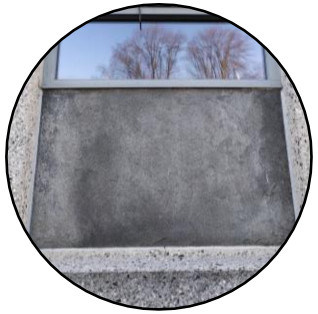


Recycled Textile
Insulation

Recycled
Aluminum

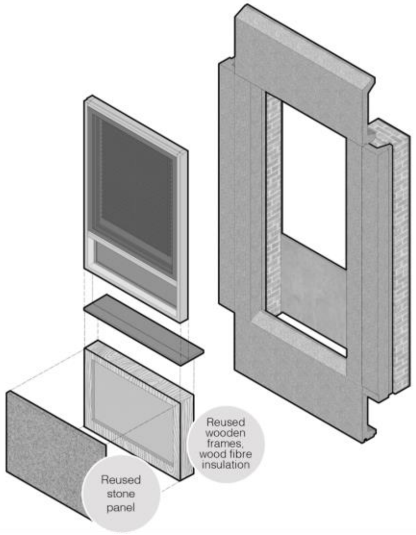


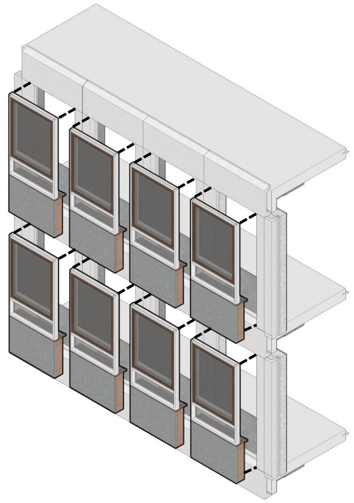
Reduce



Reused stone panel

Reused timber frames

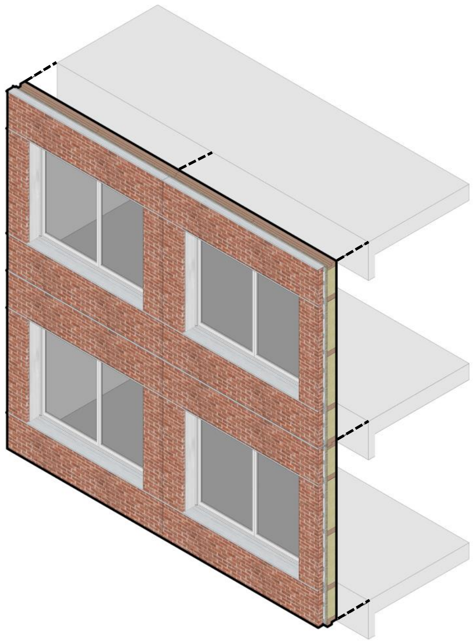


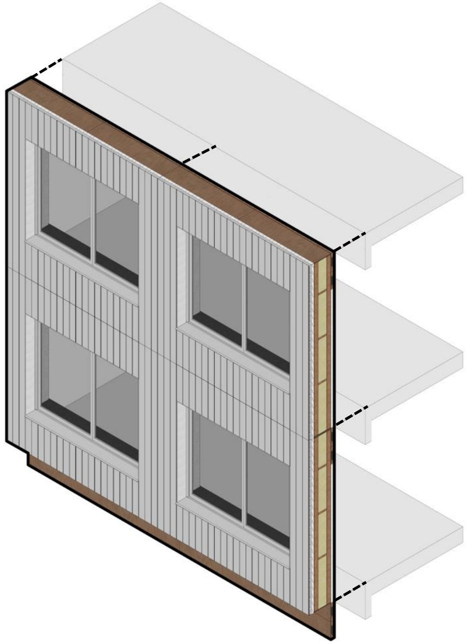


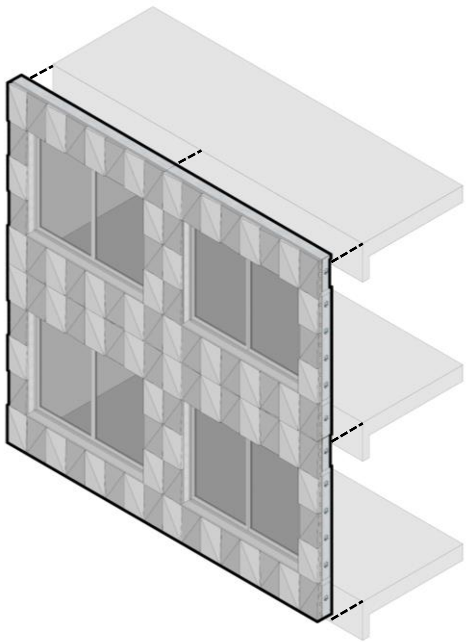
255
[mm]

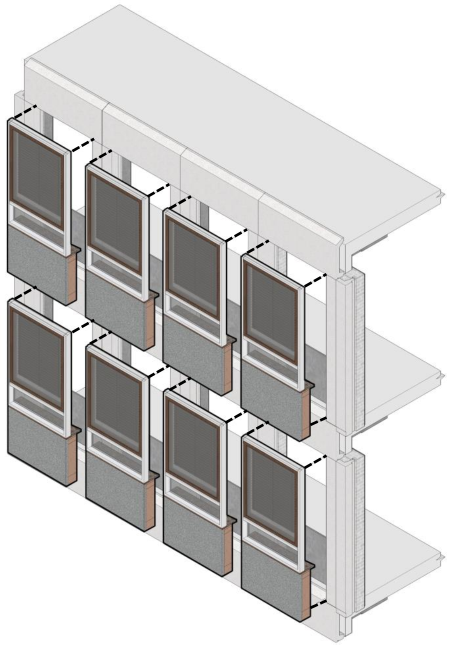
0.23
[W/m^2K]

Design Options









1 Option 1 : **Reclaim**

422 [mm]

0.21 [W/m^2K]

2 Option 2 : **Renew**

262 [mm]

0.24 [W/m^2K]

3 Option 3 : **Recycle**

283 [mm]

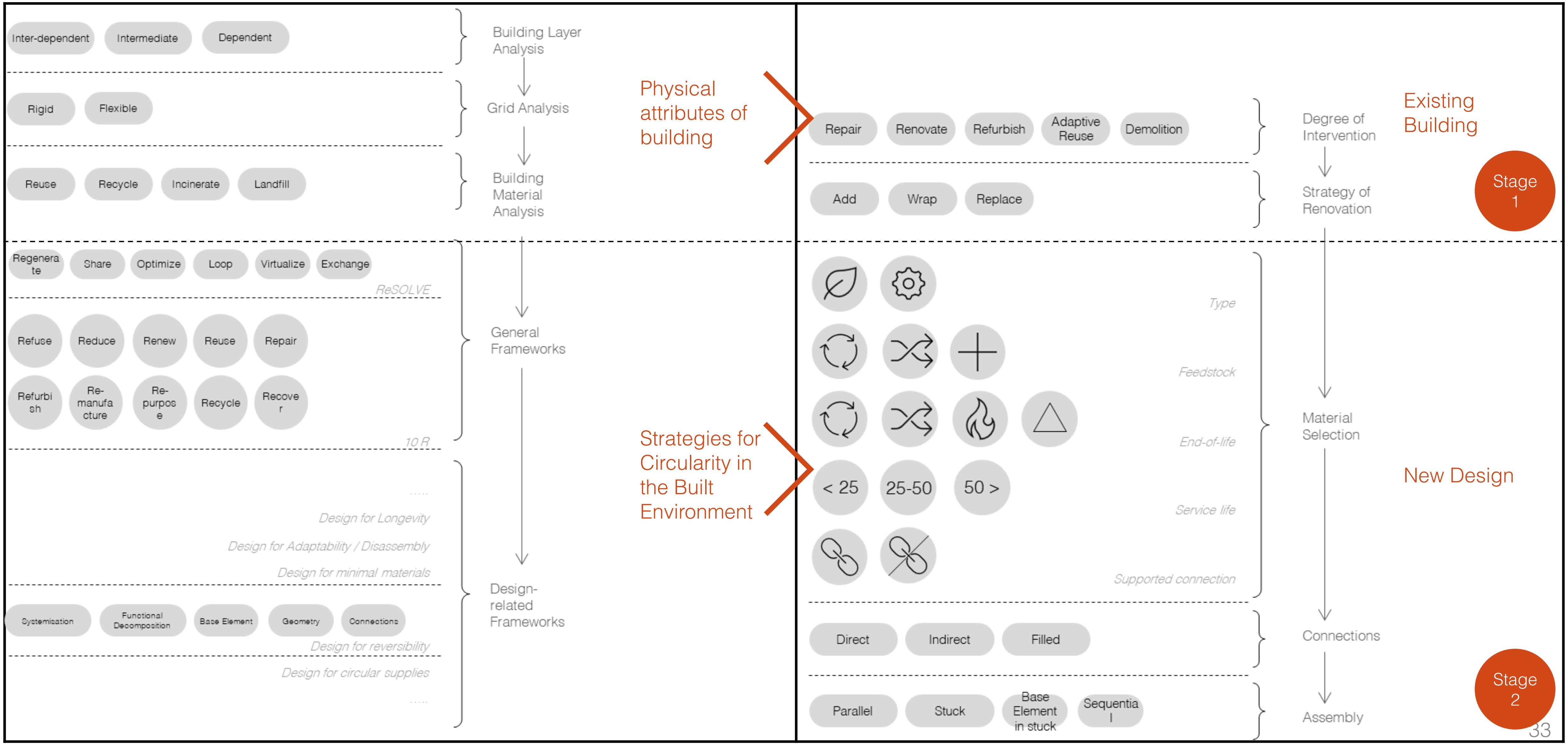
0.23 [W/m^2K]

4 Option 4 : **Reduce**

255 [mm]

0.23 [W/m^2K]

Design Framework



Evaluation and Recommendations

Life Cycle Approach

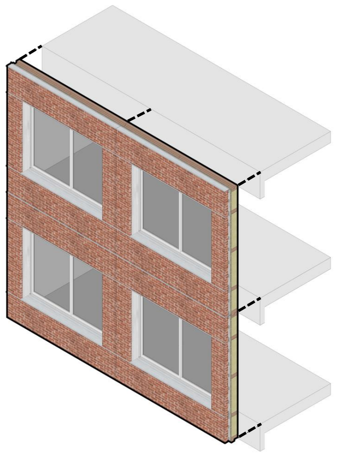
Product Stage			Construction Process Stage		Use Stage							End-of-Life Stage				Benefits and Loads beyond the System Boundary		
Raw material supply	Transport	Manufacturing	Transport to building site	Installation into building	Use/application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D

(OneClickLCA, 2020)

Life Cycle Approach

Variable for each Option	
Material Quantity Embodied Carbon (as per EPD) Transport Distance (as per EPD) Service Life Reused	Acidification Eutrophication Ozone depletion Potential Global Warming Potential (Embodied Carbon) kgCO2eq/sqm
Common for all Options	
Energy used (same for all options) Calculation Period (same for all options) Service Life of Building	

Life Cycle Approach



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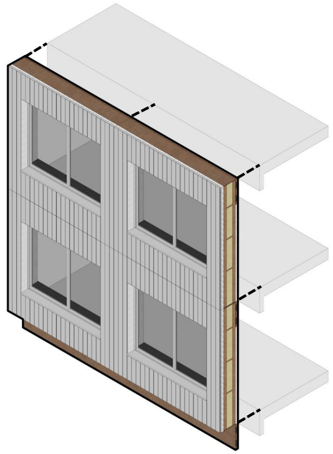
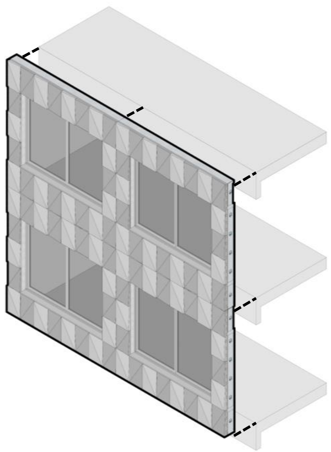
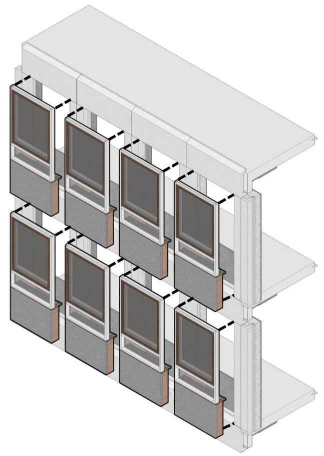


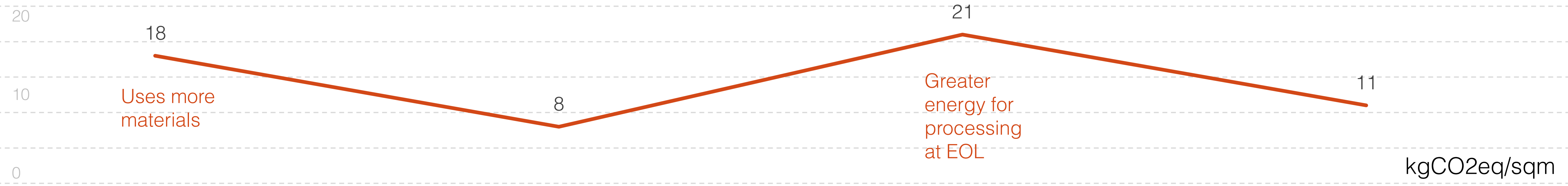
2 Option 2 : **Renew**



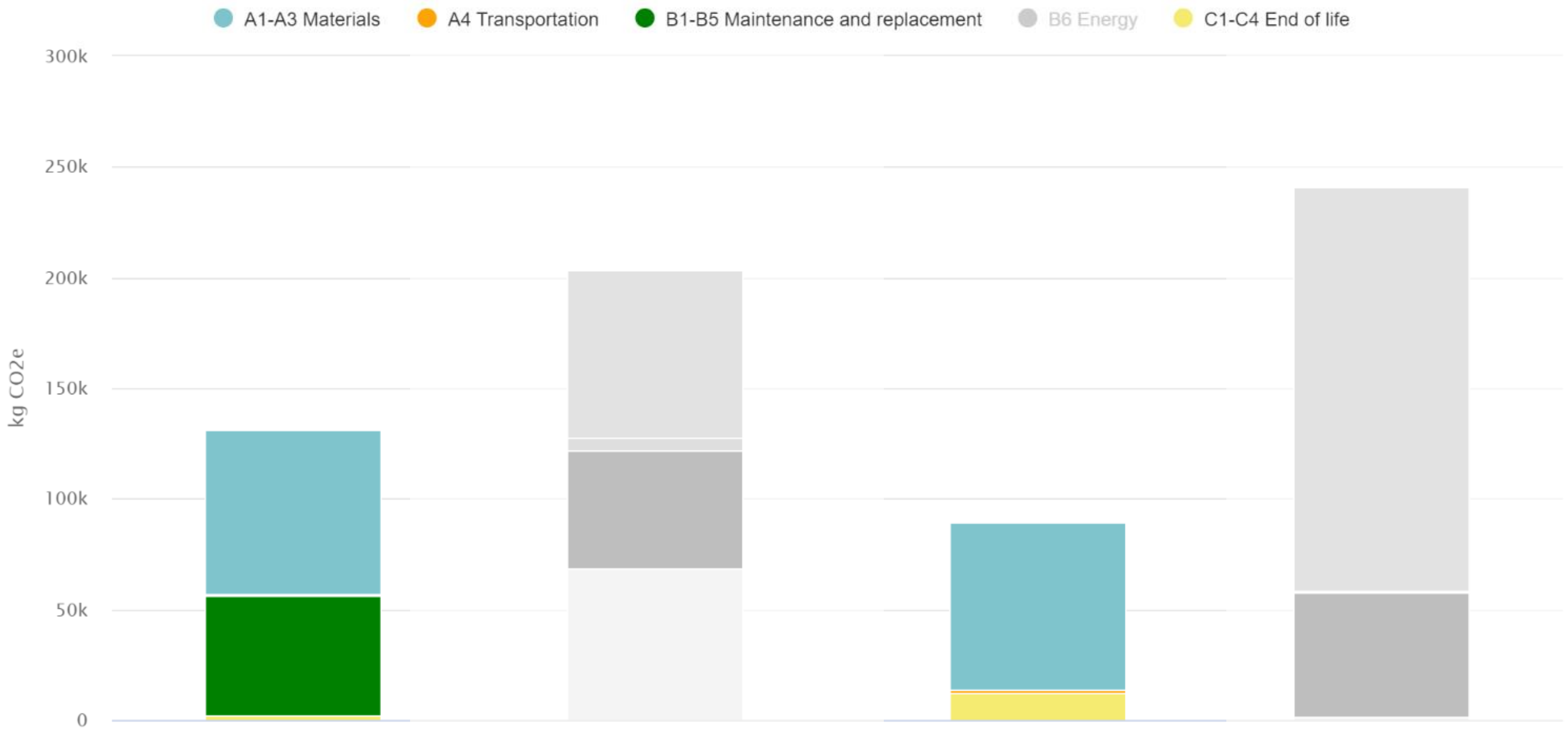
3 Option 3 : **Recycle**



4 Option 4 : **Reduce**



Life Cycle Approach



4 Option 4 : **Reduce**

Greater maintenance/
repair/ refurbishment

2 Option 2 : **Renew**

More waste processing
due to complex
disposal

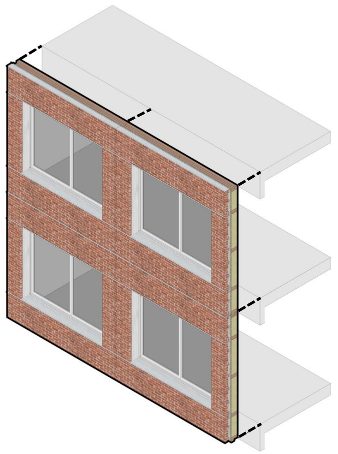
(OneClickLCA, 2020)

Building Circularity

<table>
<tr><td>Variable for each Option</td><td rowspan="4">Building Circularity – Materials Used and Recovered

%</td></tr>
<tr><td>Material
Quantity
Service Life
Content (recycled, reused, renewable)
Wastage during construction
DfD
DfA
EOL Process</td></tr>
<tr><td>Common for all Options</td></tr>
<tr><td>Weighing factors
Calculation Period</td></tr>
</table>

Building Circularity



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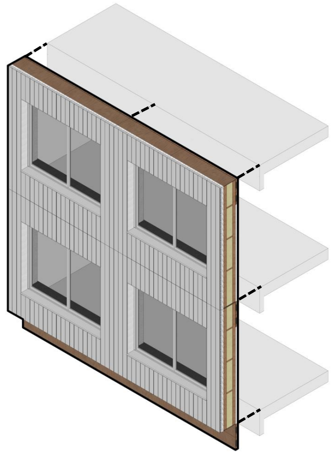
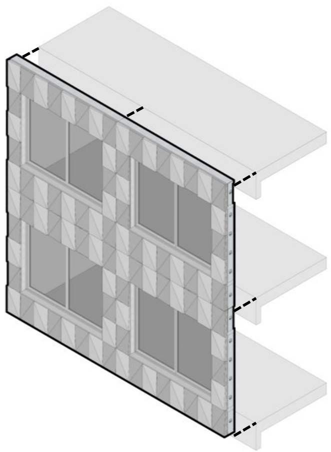
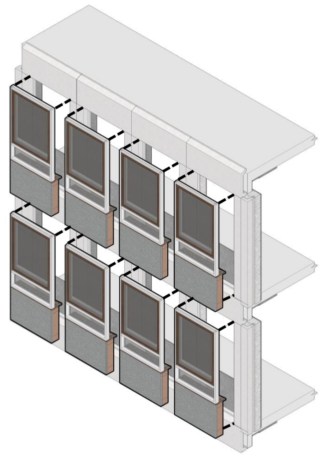


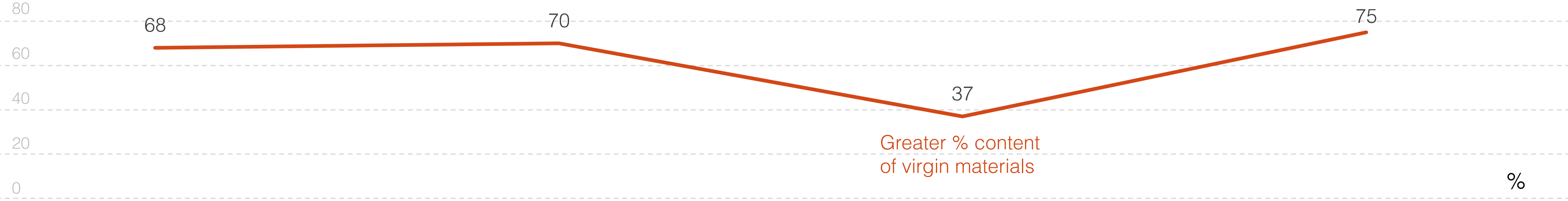
2 Option 2 : **Renew**



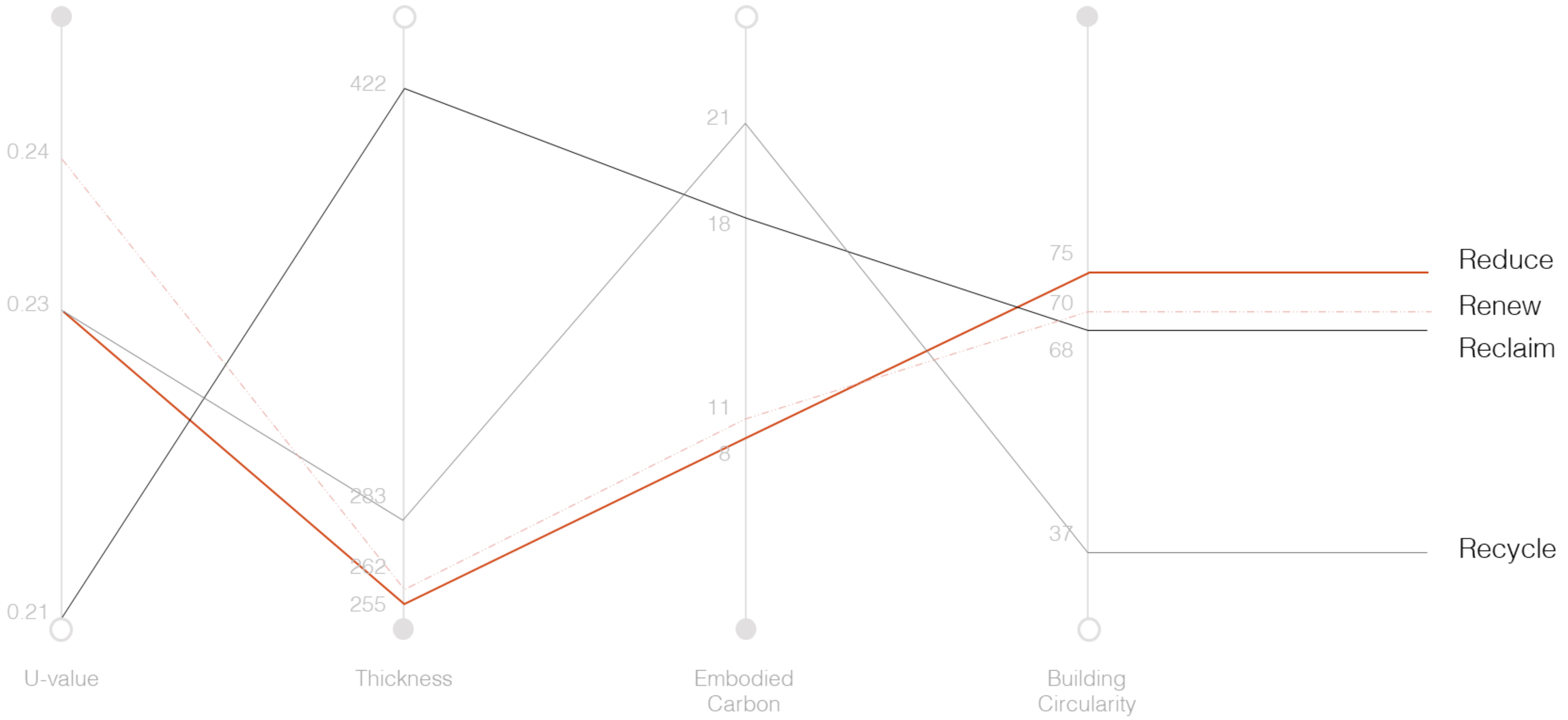
3 Option 3 : **Recycle**



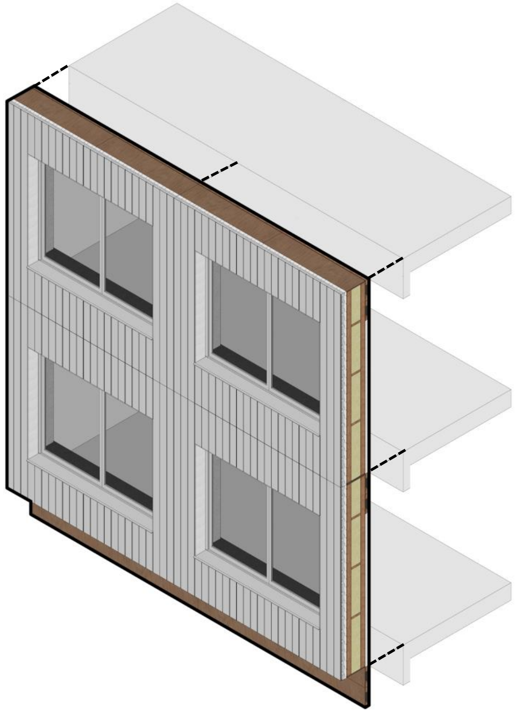
4 Option 4 : **Reduce**



Overview


422
21
0.24
18
75
Reduce
0.23
70
Renew
Reclaim
68
11
8
283
37
Recycle
262
255
0.21
U-value
Thickness
Embodied Carbon
Building Circularity

Final Design



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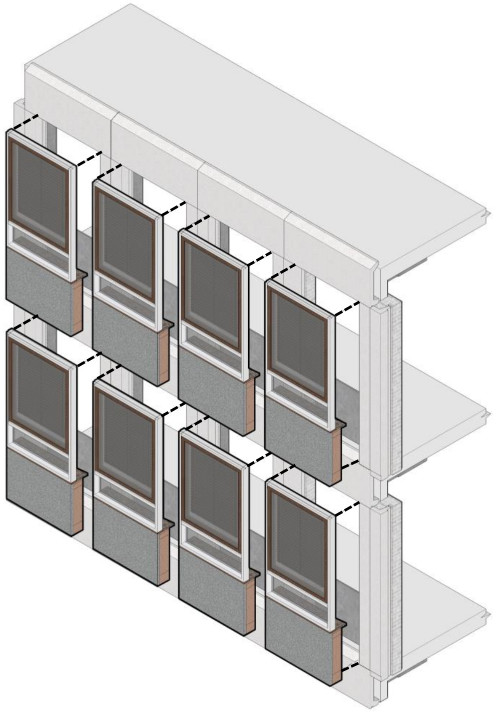
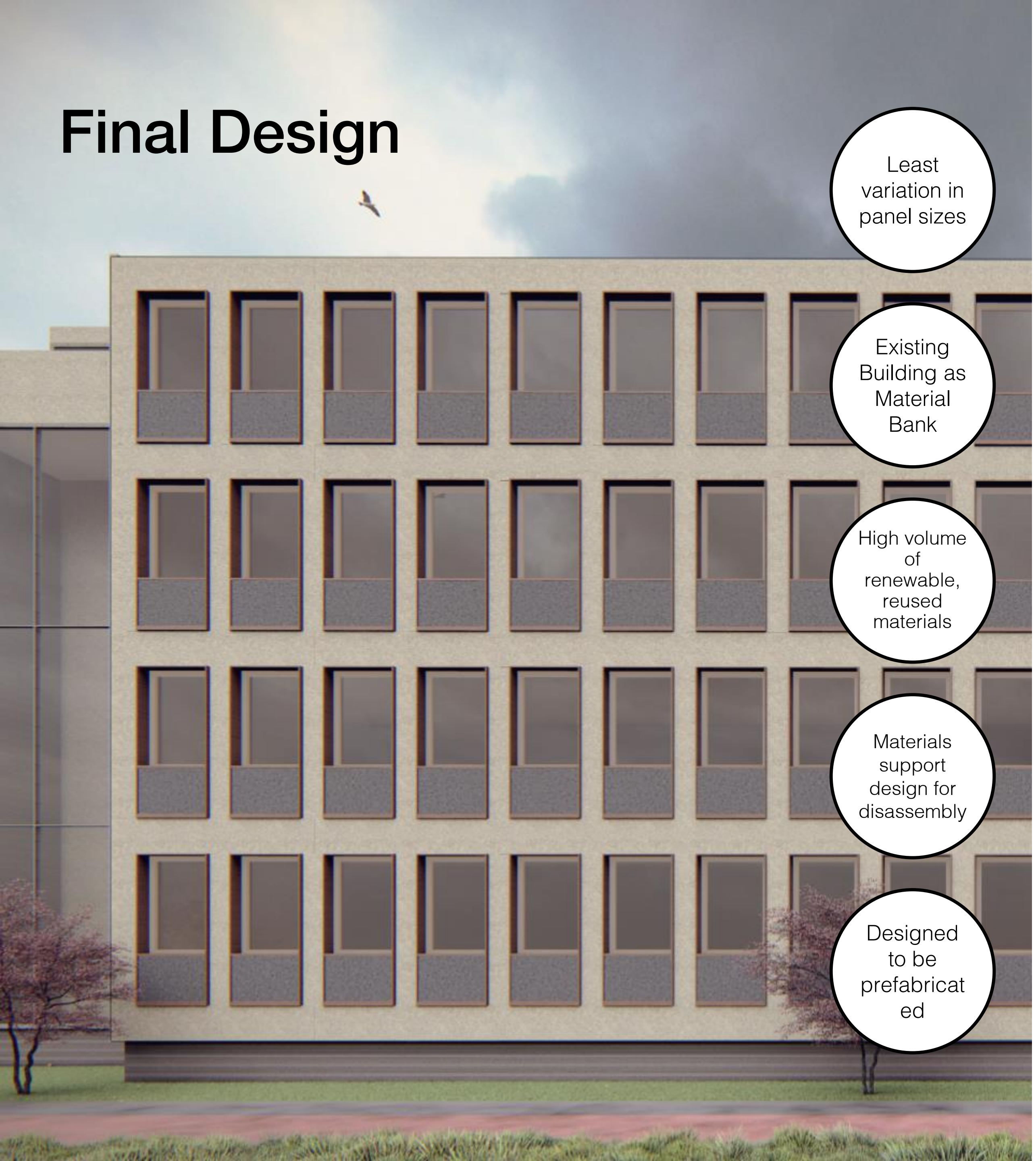
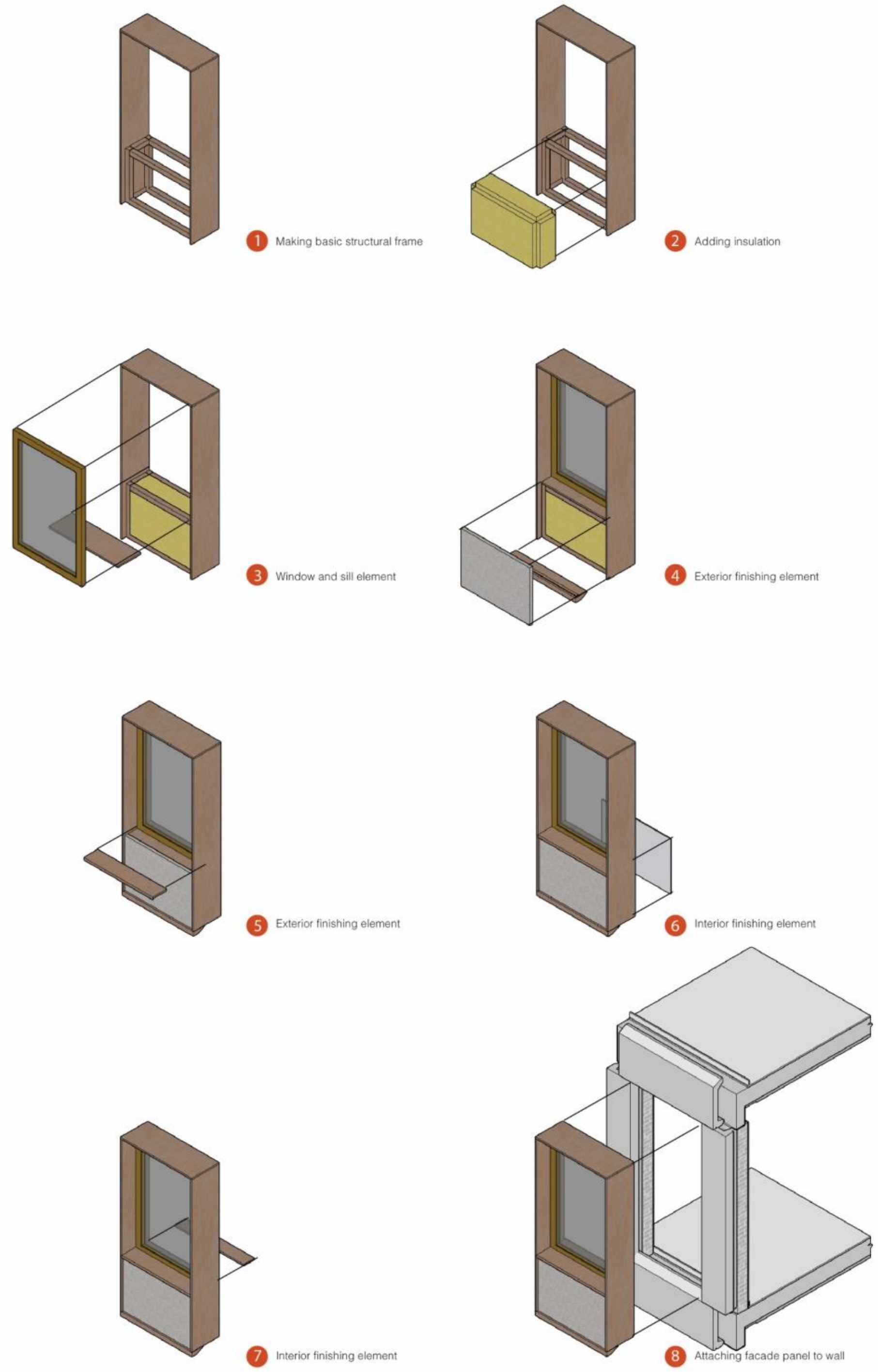


Materials used
- Biobased
- Renewable

Extent of Intervention
- Window
- Parapet

Final Design





Conclusions

A Circular System

Strategic Definition

Design

Construction

End-of-Life

- Demolition audit, information of harvested materials
- Research on creative use of materials
- Development of circular material databases / detailed information

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- Efficient prefabrication
- Facade disassembly plan
- Creative end of life design
- Incorporate business models specific for the facade
- BIM, Digital twin to monitor performance of facade elements
- Renovation & materials passport for facade

- Market development of circular materials,
- Skilled teams for disassembly of facade
- Educate, learn; Policy making and Certifications

(multiple sources)

Answering the Research Question

"How can we implement circularity in façades during the planning and design processes of building renovation projects in the Netherlands?

Answering the Research Question

Planning

Thorough analysis of building conditions

Material specific information flow; low embodied energy / material composition

Develop design framework

Design

Systematic approach, layer wise breakdown of components

Reduced virgin resource use and reduced waste generation

Higher volume of reused and bio-based materials

Support disassembly

Discussion

Information

The most significant information about the product is the embodied carbon and material feedstock composition.

$kgCO_2eq/sqm$

%

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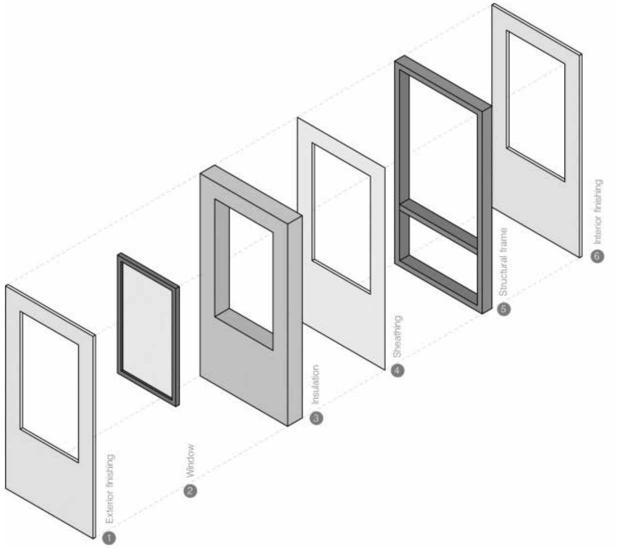
Façade System

Component should be broken down into layers, for systematic design. This can be applied to other building components also.



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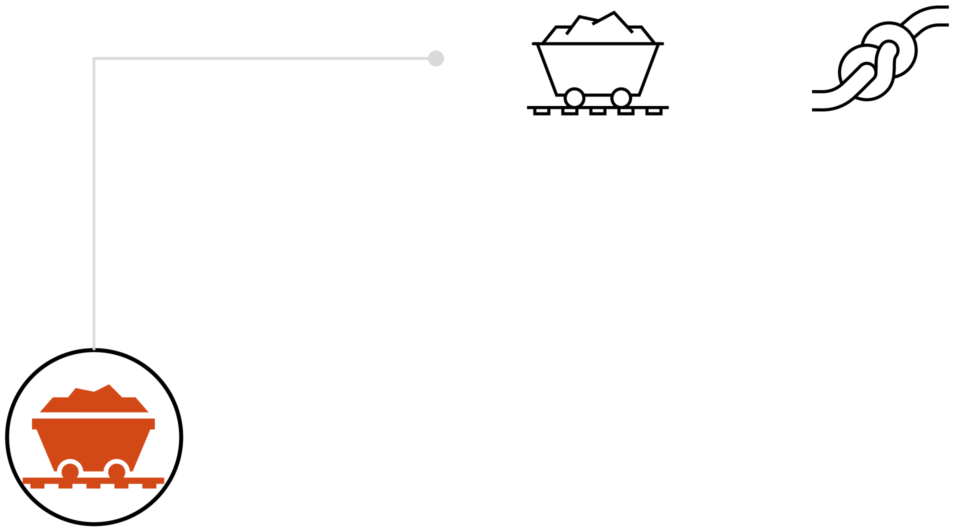
Materials

1. Materials need to be prioritized greatly in the design of facades. They have a significant impact on embodied carbon. This is followed by the connections.



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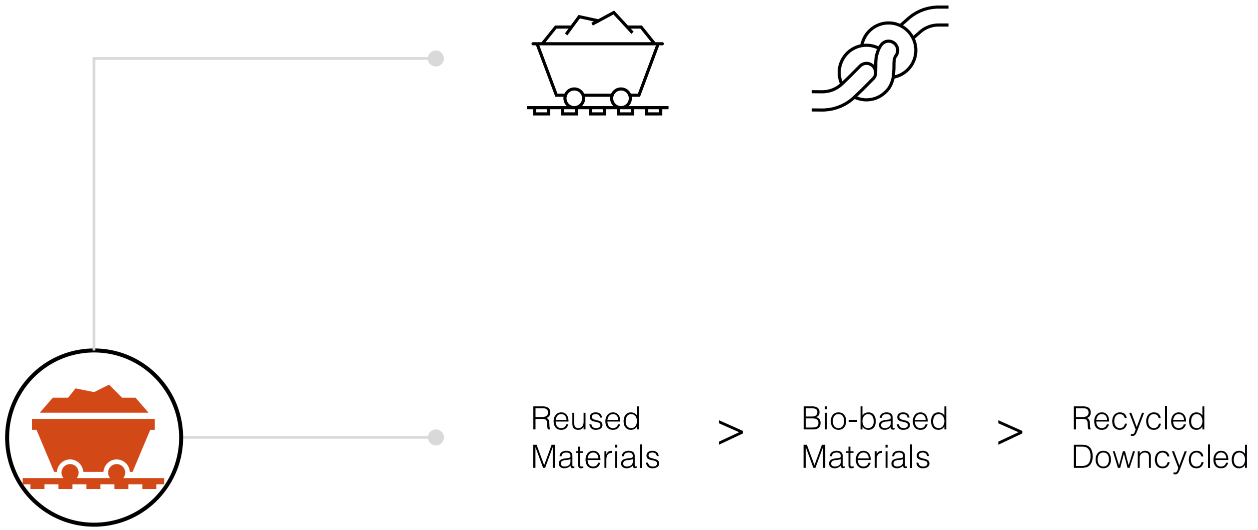
2. Within materials, priority should be given to first reused materials, then biobased, lastly recycled and downcycled.



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3. The compatibility of materials within layers is dependent on the service life, and end-of-life scenarios.

Limitations

Design Oriented (Impacting the measurable results)

1. **Exact information not available**
   For reused materials, even some circular materials.

2. In some cases, to receive a **comparable thermal performance value**, the thickness of material marginally modified (manufacturer data)

Research Oriented (Challenge in answering RQ)

1. There is **no ideal design framework**!
   Can vary from building to building, especially in renovations.

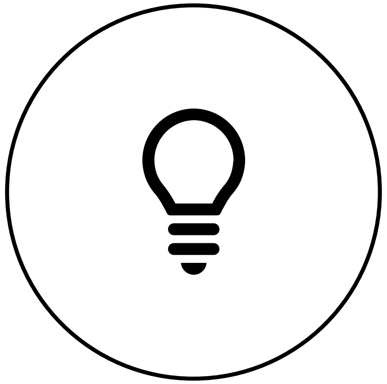
2. **All strategies not explored**
   Add / Wrap it interventions might have different functions of layers, therefore different materials.

Future Work

Need for Innovation

In reused material applications and end-of-life solutions.

Through research and experimentation.



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All circular materials – biobased and reused, need more technical information which can be used in databases – development of EPD’s.
Though testing of products.

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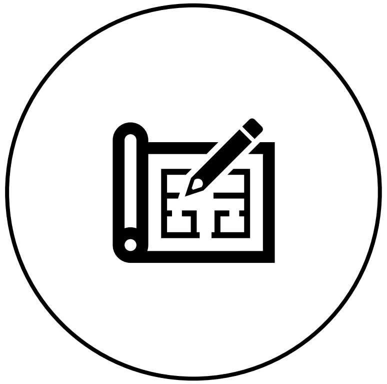
Through documentation.



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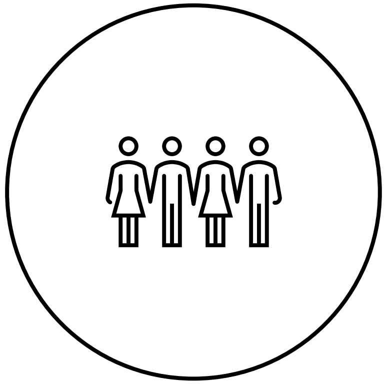
Processes related to sustainability – product and building to make roadmaps, frameworks.
Through workshops.



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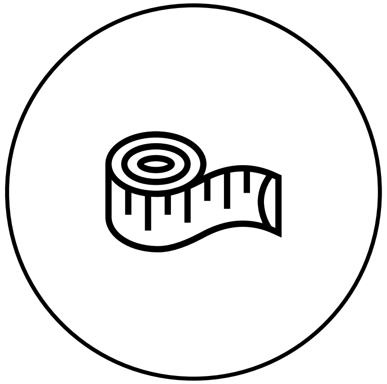
Standard Evaluation
Developing benchmarks, scorecards to evaluate circularity in design of building components
Through research and application.



Thank you.

Questions?

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3. What is the design process to implement circularity during façade renovation projects?

2. What are the design strategies applicable for circular facade design?

"How can we implement **circularity** in façades during the planning and design processes of building **renovation** projects in the Netherlands?

4. What steps undertaken in the pre-design and post-design stages of the building renovation process influence the circularity of the façade

1. What is the state of the art of non-residential building renovations especially for the building facade, in cold countries like the Netherlands?

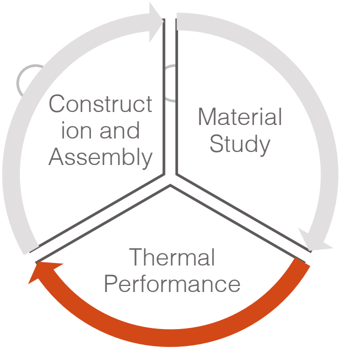


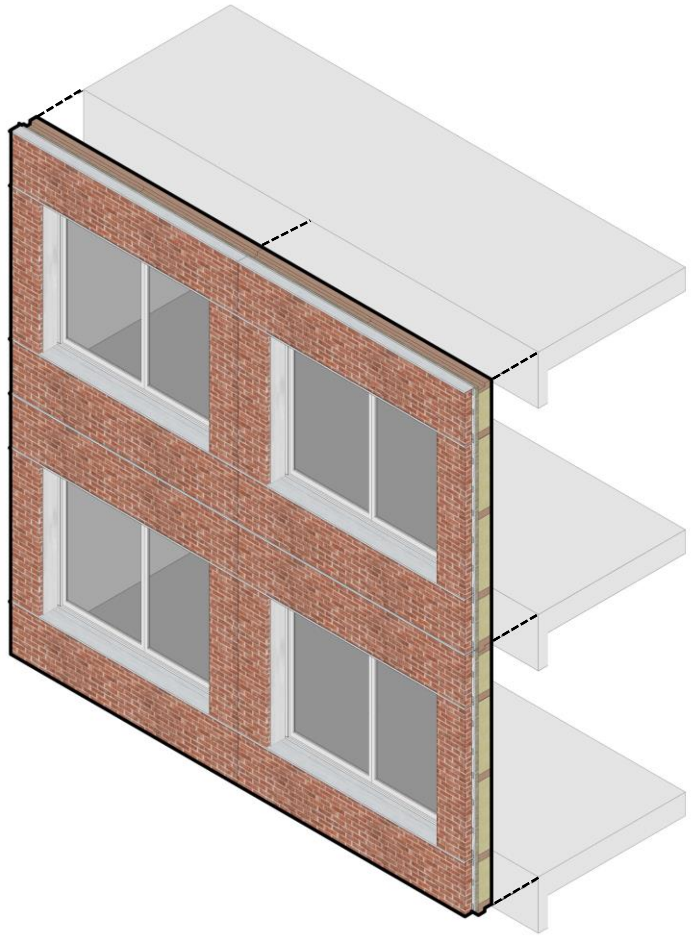


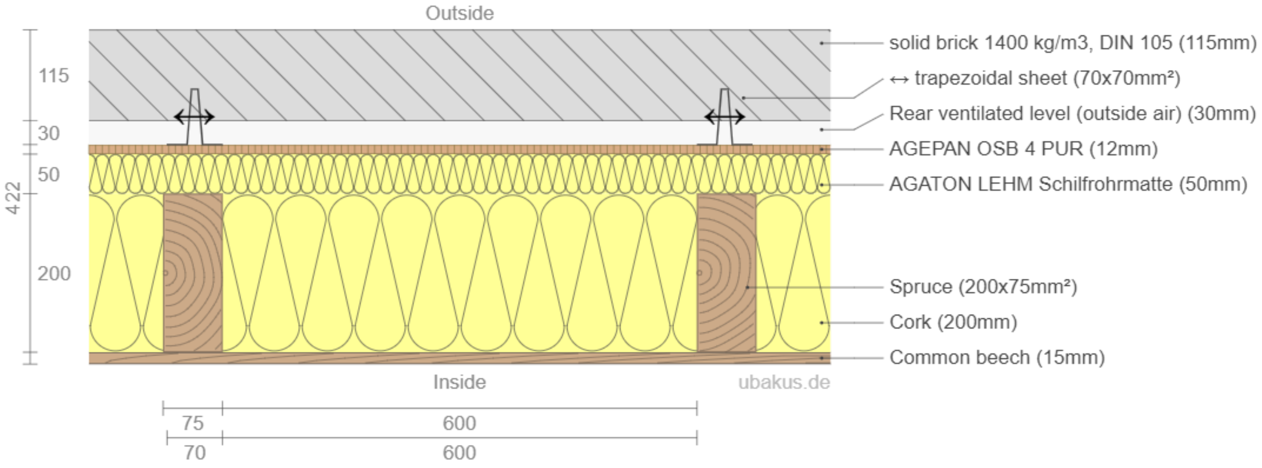


Beton element C.

Reclaim







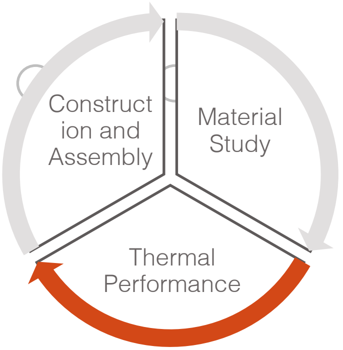
Source –U-value calculator | ubakus.com

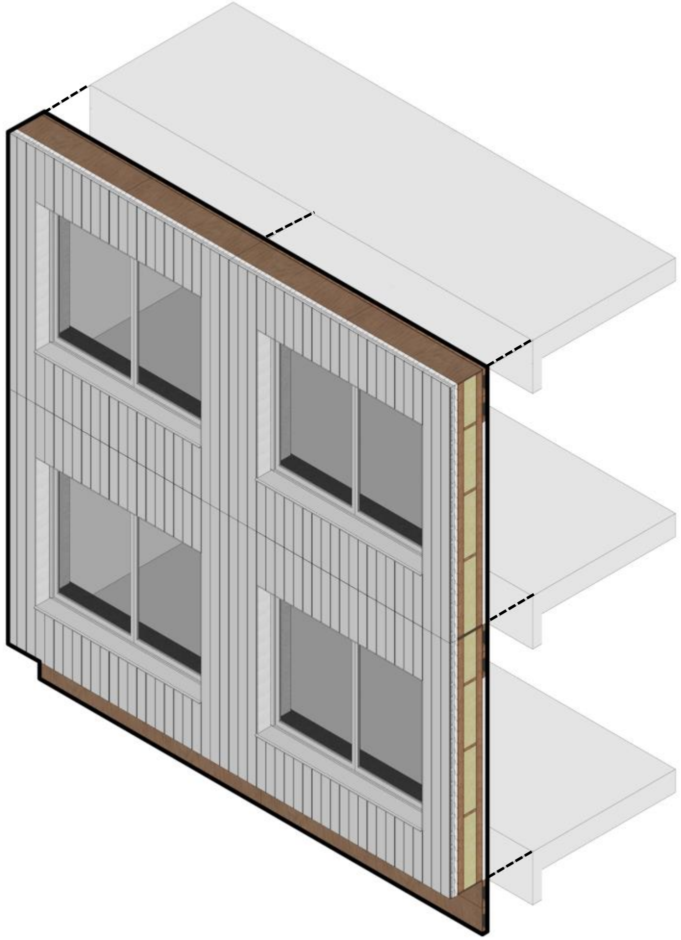
0.21 [W/m^2K]

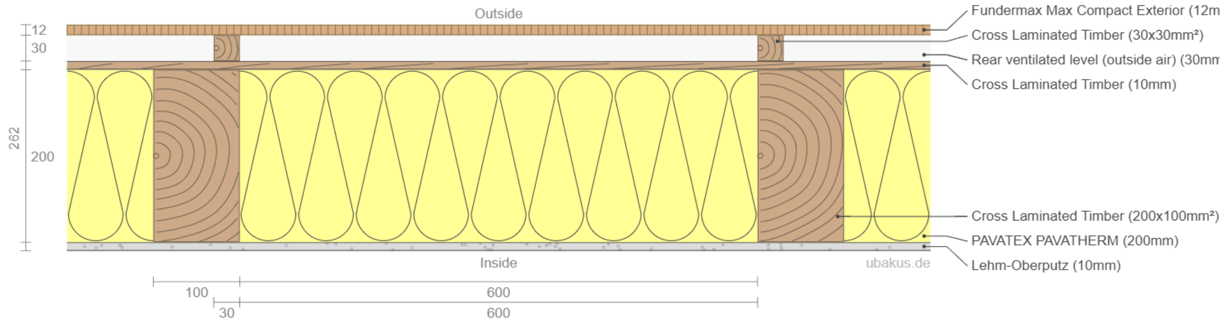
422 [mm]

Code	Product	Layer	Quantity	Transport (1st Leg)	Service Life	Reused Material
DGW	Double glazing windows with wooden frame, 30.7 kg/m2, 1.4 W/m2K, biogenic CO2 not subtracted (for CML), FDES collective utilisable par toute entreprise qui produit en France des fenêtres et portes fenêtres, double vitrage acoustique ou standard, en bois tropicaux. (INSTITUT TECHNOLOGIQUE FCBA)	Windows	839 sqm	320	40	No
PST	Planed and strength-graded timber, pine or spruce, 460 kg/m3, planed timber: thickness 15-89 mm, moisture 8-15 ± 2%, strength-graded timber: thickness 34-89 mm, moisture 15-18 ± 2% (Stora Enso)	Structural Frame	75 cum	220	120	Yes
WCD	Wooden cladding and decking, pine or spruce, 445 kg/m3, 7-29 mm, 8-18%, moisture content (Stora Enso)	Interior Finish	1078 sqm	220	120	Yes
OSB	Oriented Strand Board (OSB), 6 - 40 x 590 - 1250 x 1840 - 6250 mm, 600 kg/m3, AGEPAN (Sonae Indústria)	Insulation	1078 sqm	340	120	No
LCI	Loose fill cellulose insulation, for wall application, L = 0.045 W/mK, R= 1.11 m2K/W, 50 mm, 3.25 kg/m2, 65 kg/m3	Insulation	1078 sqm	350	120	No
BCW	Bricks from construction waste, 210mm x 100mm x 50mm, 215mm x 102.5mm x 65mm, 228mm x 108mm x 55mm, 490/390/290mm x 90mm x 40mm, Caramel (StoneCycling)	Exterior Finish	215600 kg	60	120	Yes

Renew







Source –U-value calculator | ubakus.com

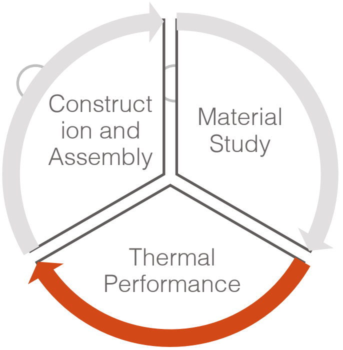
0.24 [W/m^2K]

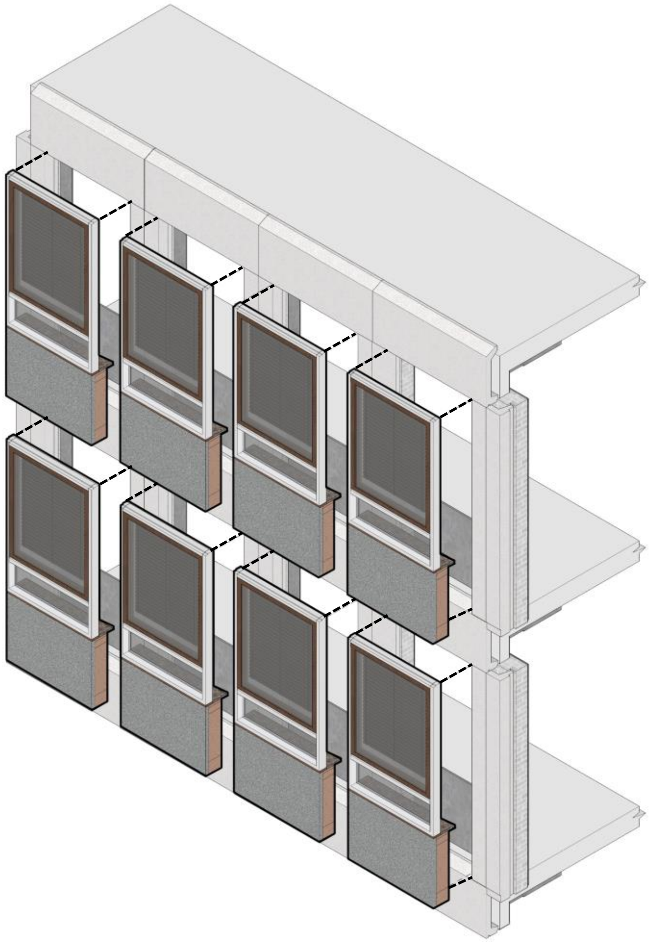
262 [mm]

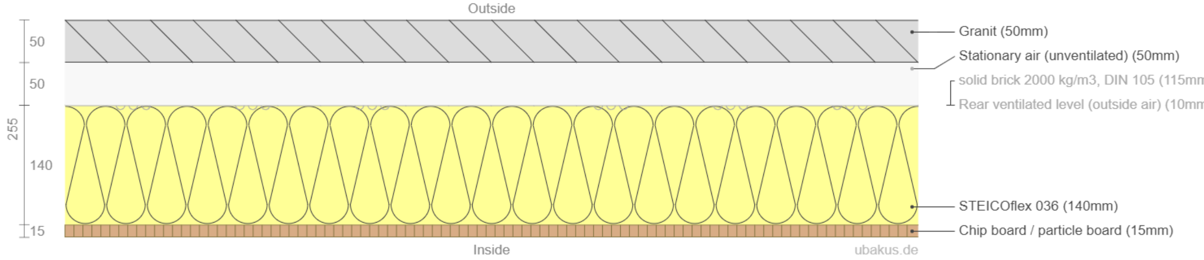
Code	Product	Layer	Quantity	Transport (1st Leg)	Service Life	Reused Material
SIP	Straw insulation panels for exterior walls, L = 0.0493 W/mK, R=8.1 m2k/W, 400 mm, 66.19 kg/m2, Lambda=0.0493 W/(m.K) (EcoCocon)	1078 sqm	Interior Finish, Insulation	350	60	No
DGW	Double glazing windows with wooden frame, 30.7 kg/m2, 1.4 W/m2K, biogenic CO2 not subtracted (for CML), FDES collective utilisable par toute entreprise qui produit en France des fenêtres et portes fenêtres, double vitrage acoustique ou standard, en bois tropicaux. (INSTITUT TECHNOLOGIQUE FCBA)	839 sqm	Windows	380	60	No
WCD	Wooden decking, cladding and planed timber for joinery applications, 755kg/m3, Moistr. 3-5%, Accoya Beech (Accsys Technologies PLC)	1078 sqm	Exterior Finish	220	60	No

Design Process

Reduce







Source –U-value calculator | ubakus.com

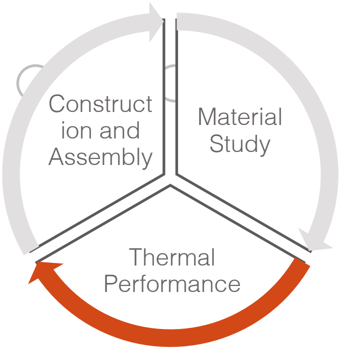
0.23
[W/m^2K]

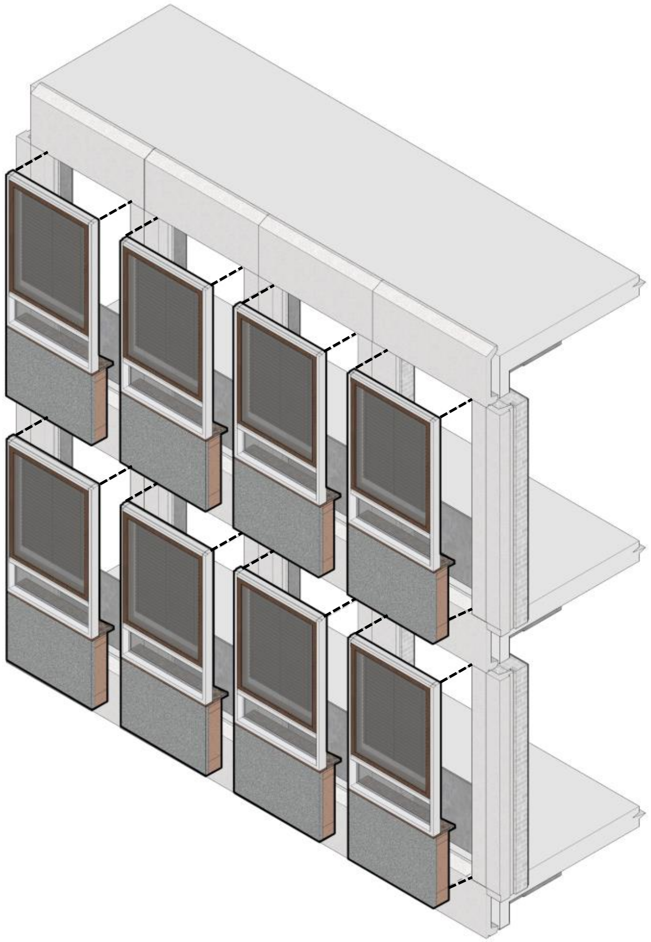
255
[mm]

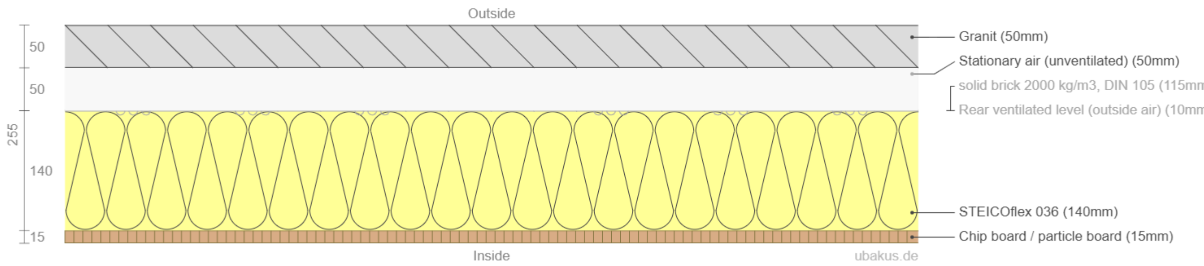
Code	Product	Layer	Quantity	Transport (1st Leg)	Service Life	Reused Material
ACT	Acoustic cladding from textile and cotton wool, 1.19 kg/m2, Vibrasto 15 (TEXAA)	Interior finish	1078 sqm	60	60	No
GSP	Galvanised steel profiles (studs) for internal wall framing, 0.7 mm, 0.9 kg/m, 37 mmx73.5 mm	Structural Frame	4484 m	370	60	No
RTF	Recycled textile and fabric insulation, blown, R=3.25 m2K/W, L= 0.046 W/mK, 150 mm, 2 kg/m2, 13.3 kg/m3, Lambda=0.046 W/(m.K), COTON-FRP DOMOSANIX NITA-COTON-FRP NITA-COTTON ISOTEXTIL INNOCOTON COTON SOLIDAIRE (RMT Isolation SL)	Insulation 1	1078 sqm	60	60	No
WFI	Wood fibre insulation boards, biogenic CO2 not substracted, L = 0.044 W/mK, 173 kg/m3, EPD coverage: 0.037-0.05 W/mK, 20-240 mm, 80-250 kg/m3 (Gutex)	Insulation 2	1078 sqm	350	60	No
AFW	Aluminum frame window, size: 1.23 x 1.48m, 27.69 kg/m2, double glazing, SUPREME S77 (Alumil)	Window	839 sqm	380	60	No
CGC	Ceramic façade cladding, 24 - 30 mm, 31 - 42 kg/m2, 2000 - 2200 kg/m3 (Argeton)	Exterior finish	1078 sqm	320	50	No

Design Process

Reduce







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0.23 $[W/m^2K]$

255 [mm]

Code	Product	Layer	Quantity	Transport (1st Leg)	Service Life	Reused Material
NSS	Natural stone massive slabs (EUROROC)	Exterior Finish	299 sqm	200 km	60 years	Yes
WFI	Wood fibre insulation boards, R= 3.26 m2K/W, 140 mm, 15.4 kg/m2, 110 kg/m3, STEICOtherm dry (Steico)	Insulation	42 cum	350 km	60 years	No
MDF	Medium density fiberboard (MDF), sound absorbing, 16 mm, 13.9 kg/m2, 866 kg/m3, αw = 0.75 (class C)	Interior Finish	299 sqm	340 km	60 years	No
DGW	Double glazing windows with wooden frame, 30.7 kg/m2, 1.4 W/m2K, biogenic CO2 not subtracted (for CML), FDES collective utilisable par toute entreprise qui produit en France des fenêtres et portes fenêtres, double vitrage acoustique ou standard, en bois tropicaux. (INSTITUT TECHNOLOGIQUE FCBA)	Windows	839 sqm	380 km	40 years	No
CLT	Cross Laminated Timber (CLT), Thickness: up to 400 mm, 470 kg/m3, 12% moisture content (Derix GmbH & Co)	Structural Frame	9 cum	220 km	60 years	No