

Measuring reuse potential and waste creation of wooden façades

Authors:
Renata Androsevic,
Elma Durmisevic and
Maurizio Brocato





Source: www.bamb2020.eu

Problem of pollution is getting bigger and bigger!
Waste generation is growing more and more!

Building industry produces 38% of total waste and 40% of total CO2 emissions and uses 50% of all natural resources (EIB 2015).



Ruined building facade, Sarajevo, B&H
Source: www.commonswikimedia

Bosnia and Herzegovina continues to have a problem regarding **building regulations and waste management**.

Unfortunately, many countries in Europe and the countries all over the world are in the same situation.



Ruined building facade,
Mostar, B&H, Source:
www.m.pogled.ba



Ruined building facade,
Ljubuski, B&H, Source:
www.ljubuski.net

If there were **guidelines** for buildings to be **designed/redesigned** with capacity to be **restored/modified** and **used longer**, more stakeholders would be interested in their **reconstruction** and **sustainable reuse**. They would not be turned into waste on the landfills.



Change in design culture



Change in value definition



Change in collaboration



Source: bamb2020.eu

We should make a plan and measures for the process of **designing** future building structures **for adaptability**.

How?

By using the methodology developed within Buildings as Material Banks (BAMB) project.

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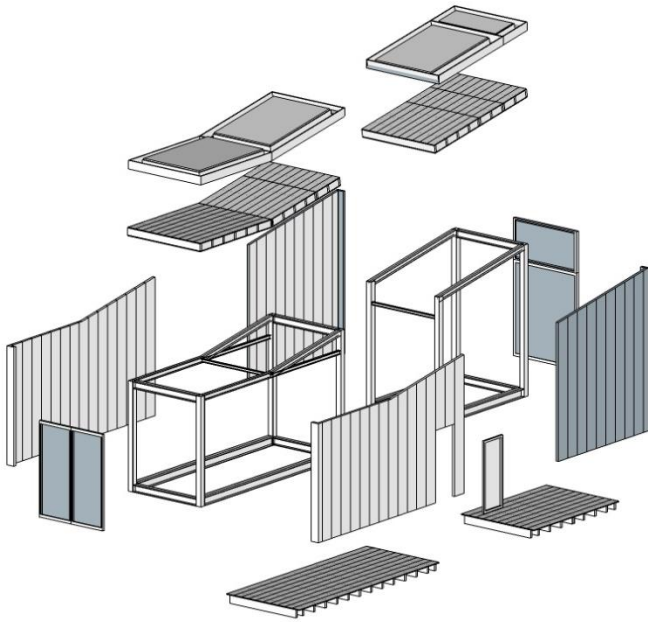
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Different parts
of the building
have different
life expectancies

Source: BAMB pilot project - exploded module GDC Mostar,
E. Durmisevic & R. Androsevic



Ruined building facade, Sarajevo, B&H
Source: www.drukci.ba

Decreasing the waste from any part of the building will help reducing total waste during the building's life span.

The **enclosure systems** are the ones that are the most exposed to physical damages and require frequent reparations.

The main focus of this research is **façade** and how to construct it in **more reversible** and therefore **more sustainable** way.

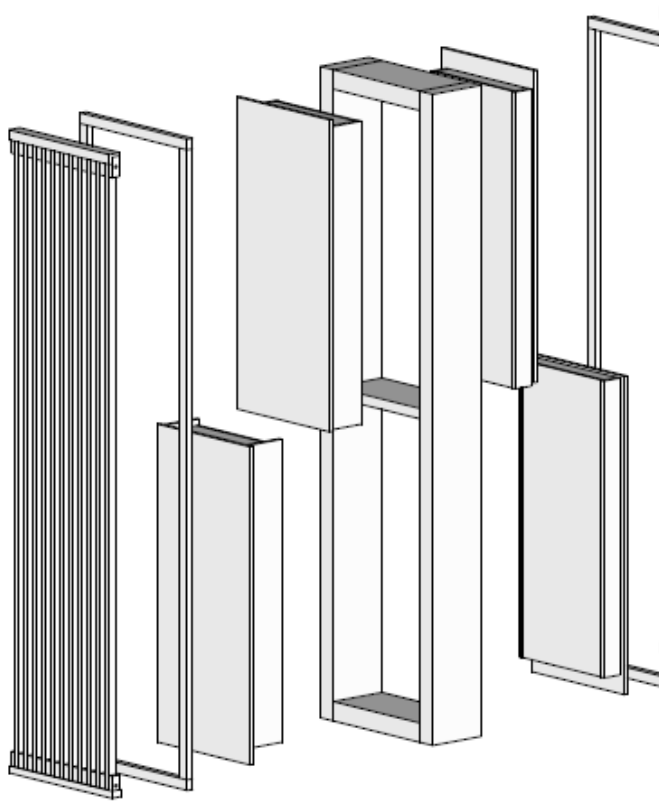
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Source: BAMB pilot project – exploded external wall of GDC Mostar,
E. Durmisevic & R. Androsevic

The goal:
include all parts of the enclosure system in circular low waste building industry and circular economy!

When the requirements change, all parts of the wall should:

- be easily disassembled and removed without affecting surrounding systems and elements,
- allow the additional layers to be added and attached to the wall system,
- make it easy to disassemble and assemble all parts together in the system again.

„Cyclic processes must replace linear ones to create sustainable development“

Agenda 21

This strategy aims to **extend functional lifespan** of external envelope.

This would:

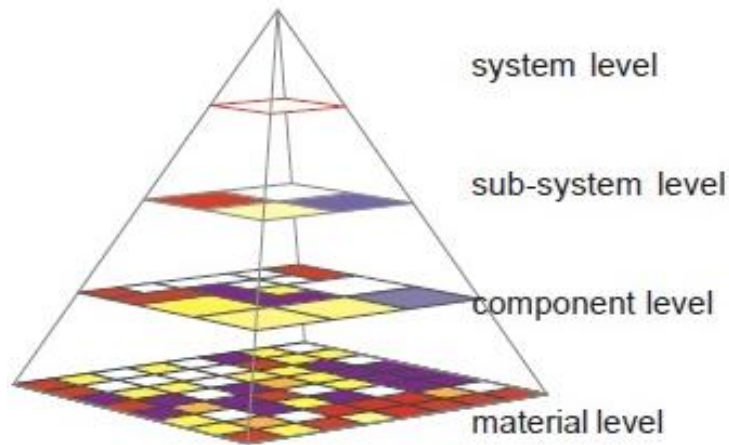
- reduce the amount of consumed resources,
- reduce generated waste during the construction, maintenance, transformation and demolition.

Façade should follow **transformations** of the building

- **without waste creation**
- **without causing** large financial or environmental **impacts** during its total life cycle.



This study is using **method Durmisevic** for designing and assessing reversibility and reuse potential of a building.



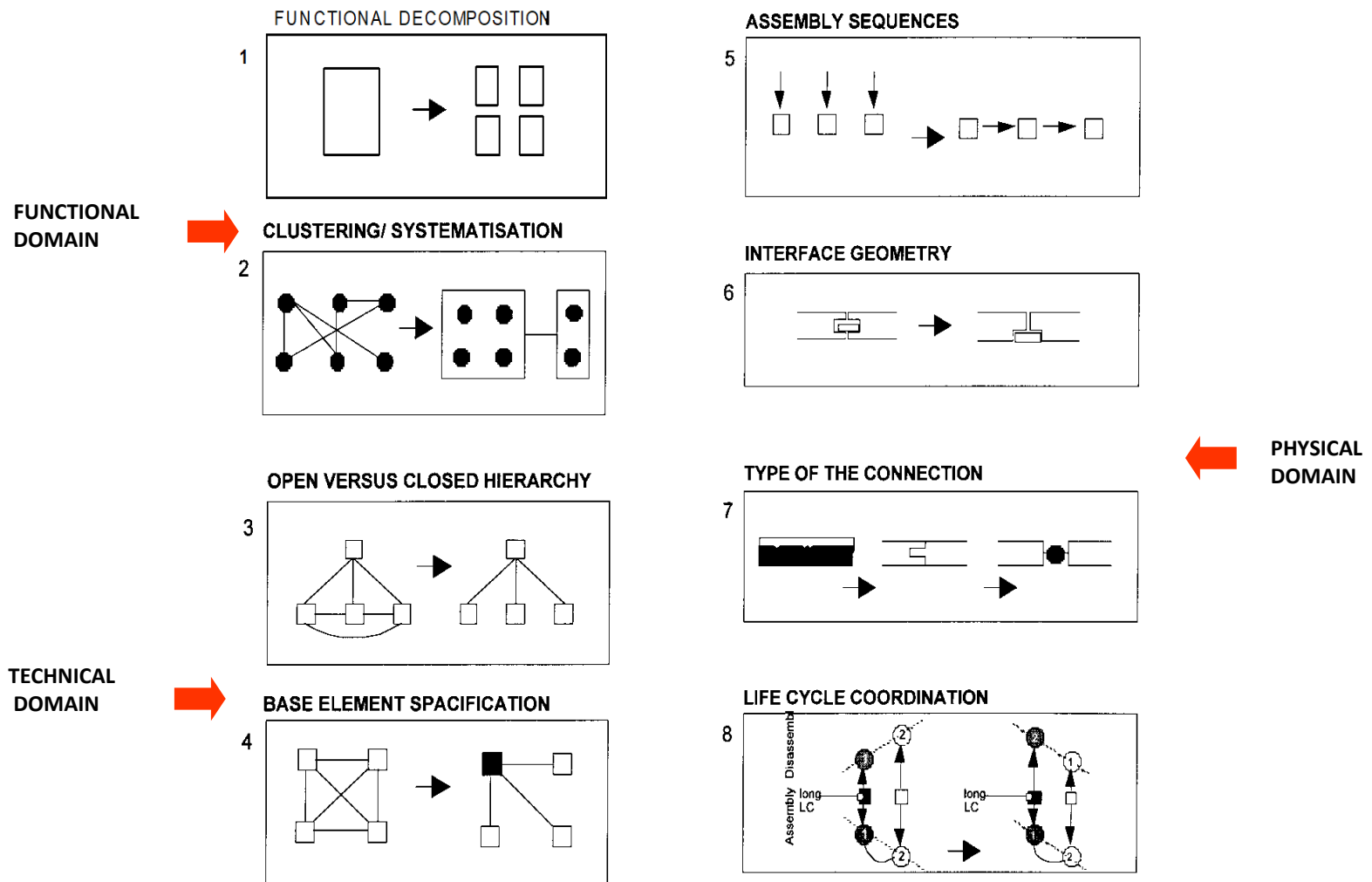
Source: „Transformable building structures“ E. Durmisevic

The assessment measures:

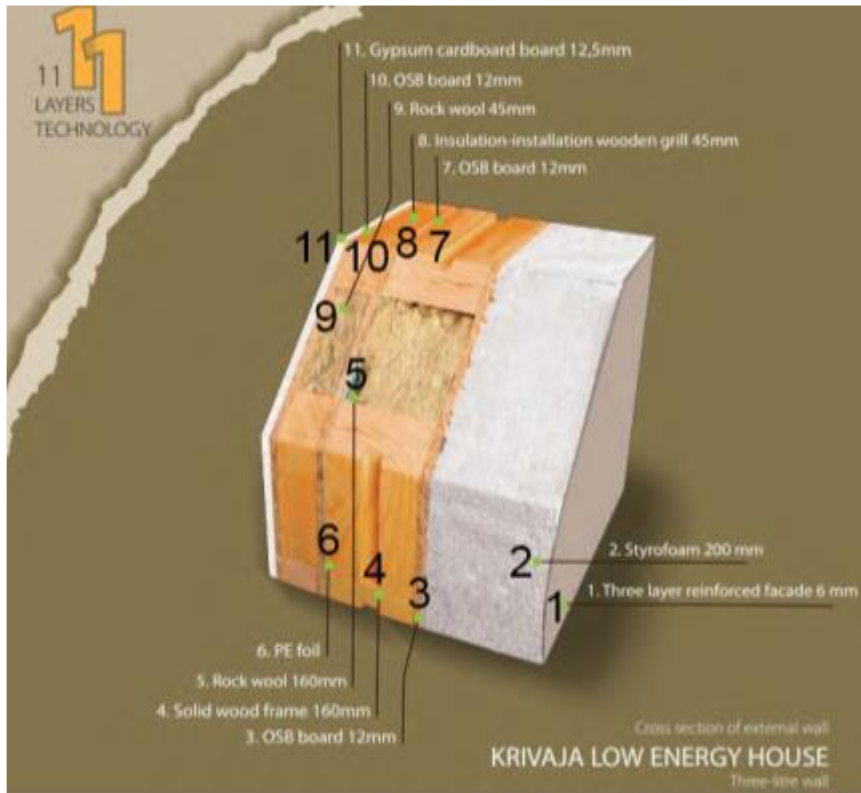
1. functional,
2. technical and
3. material (physical) dependences

on three levels of a building's composition:

- building
- system
- component.



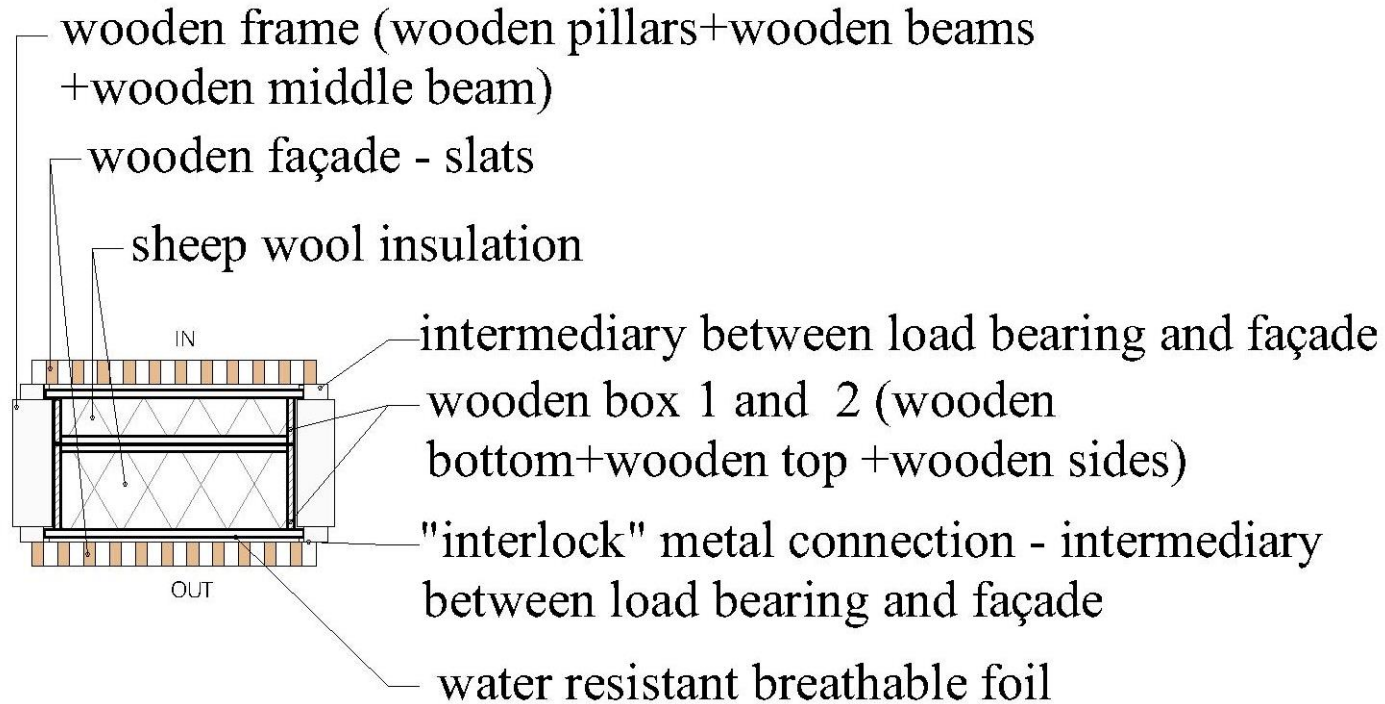
Eight indicators for reversibility and reuse potential from model Durmisevic (2006)



1. Three layer reinforced façade 6mm
2. Styrofoam 200 mm
3. OSB board 12 mm
4. Solid wood frame 160 mm
5. Rock wool 160 mm
6. PE foil
7. OSB board 12 mm
8. Insulation-installation wooden grill 45 mm
9. Rock wool 45 mm
10. OSB board 12 mm
11. Gypsum cardboard board 12,5 mm

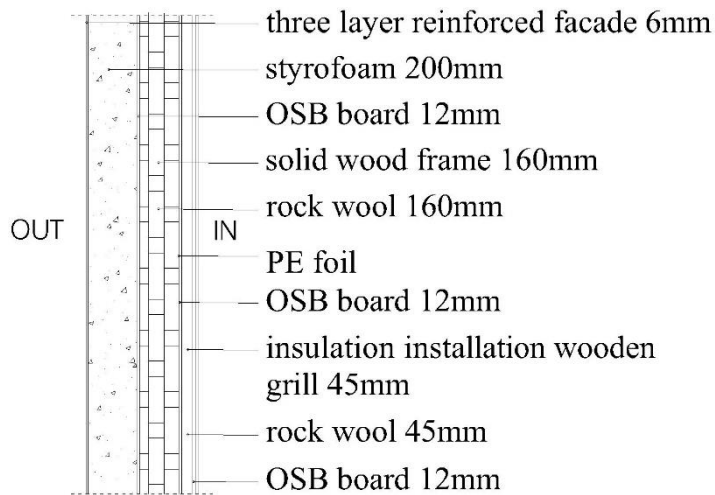
Source: www.krivajahomes.com

The first case study, a **conventional façade system in wood**, consists of primarily fixed multilayer panels made for quick assembly on site.

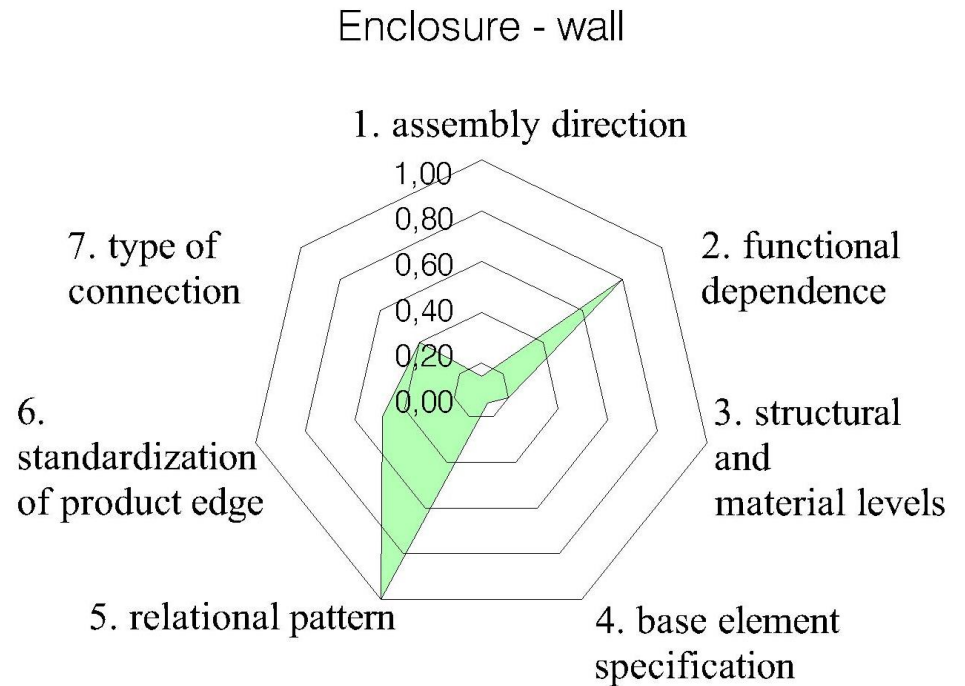


Source: BAMB pilot project – external wall of GDC Mostar, horizontal section, E. Durmisevic & R. Androsevic

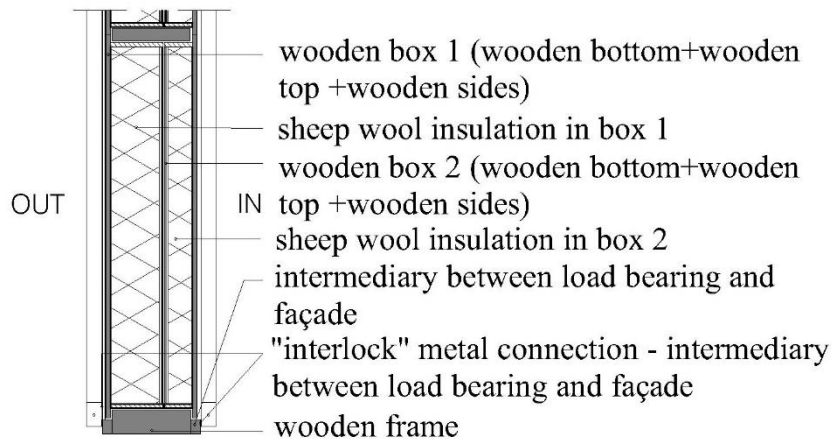
The second case study is **the prototype façade system made of wood**, developed for the Green Design Center in Mostar.



Vertical section of the 11 layers wall - prefabricated façade system in wood

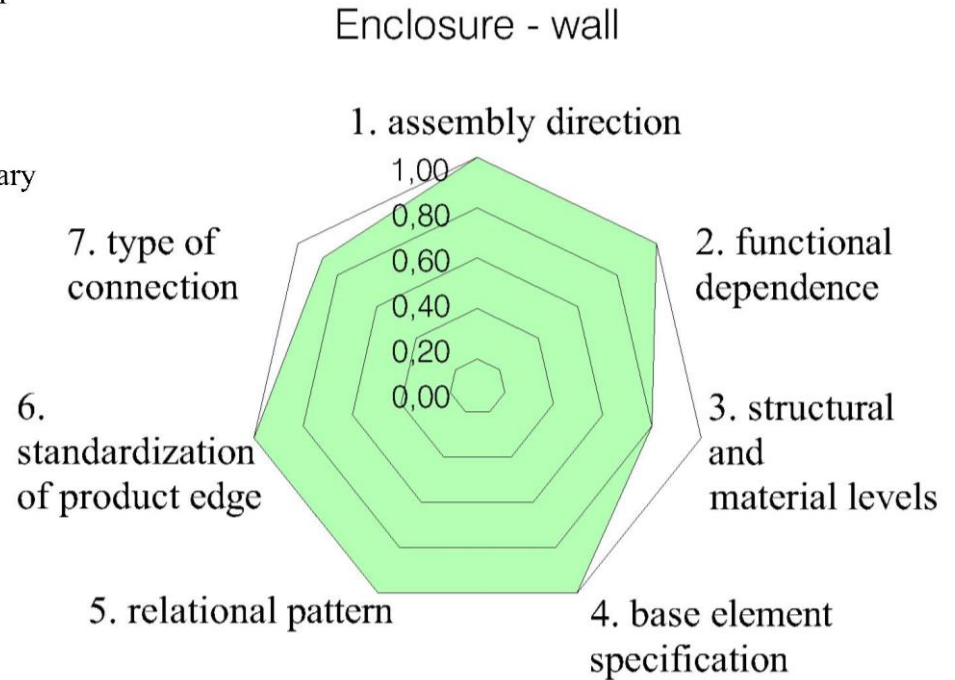


The overview of the main criteria of reversibility and the final score of the reuse potential of 11 layers wall - **prefabricated façade system in wood** using **method Durmisevic**



Vertical section of the developed façade system wall of the GDC

Source: BAMB pilot project – external wall of GDC Mostar, vertical section, E. Durmisevic & R. Androsevic



The overview of the main criteria of reversibility and the final score of the reuse potential of **the GDC wall - developed façade system** using **method Durmisevic**

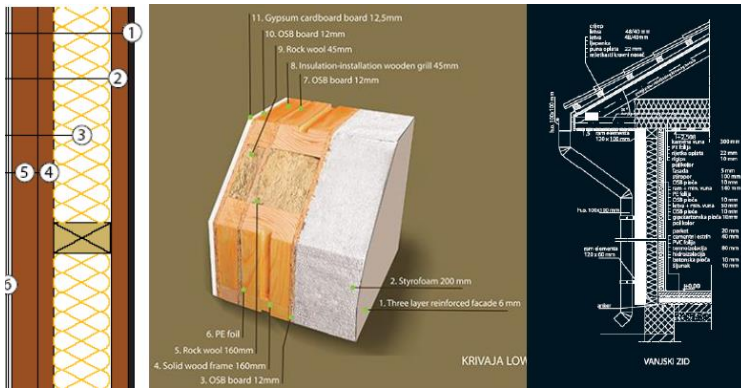
	Traditional	GDC	weight
assembly	0,1	1	0,8
FD	0,8	1	1,4
systematisation	0,2	0,8	0,8
BE	0,1	1	1,4
RP	0,1	1	1,4
GE	0,5	1	0,8
Type Connections	0,2	0,87	1
extendability	0,2	0,6	0,7
space for upgrada bility	0,2	0,6	0,7
	0,28	0,91	9

Evaluation of systems' reversibility per indicator

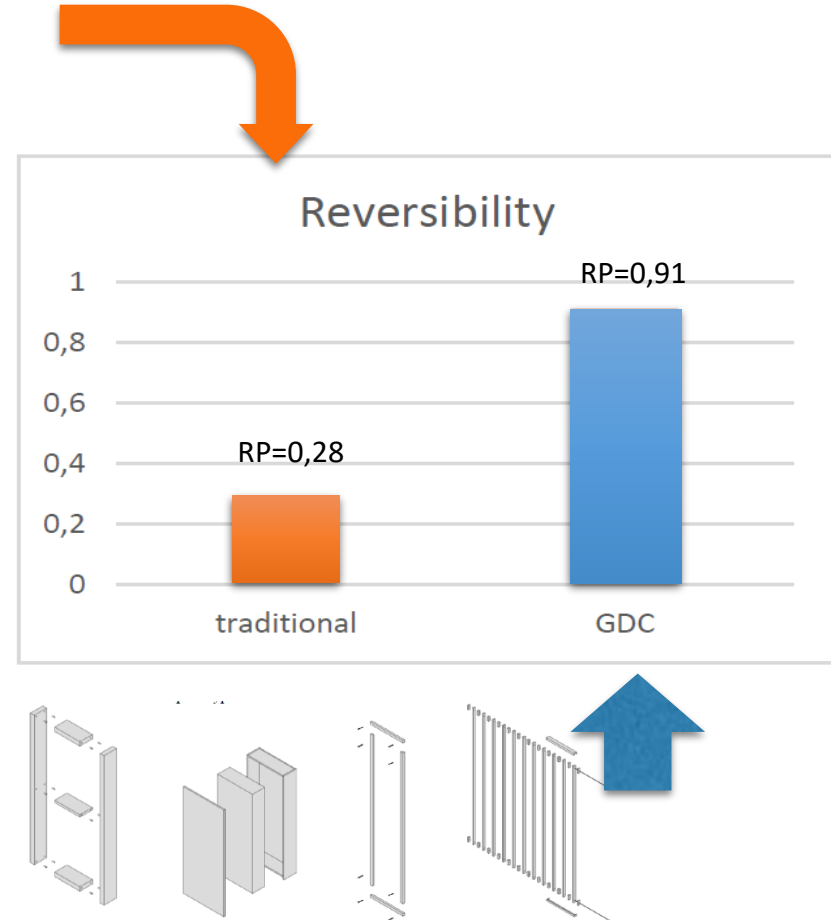
The results are divided into three categories:

- (1) if $R_p < 0.3$, than this system will be characterized as **irreversible** and the end of life option is **recycling/down cycling**;
- (2) if $0.3 > R_p < 0.6$, then its end of life options would be **repair, direct reuse** and **remanufacturing**;
- (3) If $R_p > 0.6$, than besides direct **reuse** and **repair** of its parts, the system can be **reconfigured** and **upgraded** and its dimensions **adjusted** to fit new requirement.

Application of Reversible Building assessment with focus on Reuse Potential (method Durmisevic)



Source: www.krivajahomes.com



Application of Reversible Building assessment for evaluation of the reversibility (method Durmisevic)

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First scenario

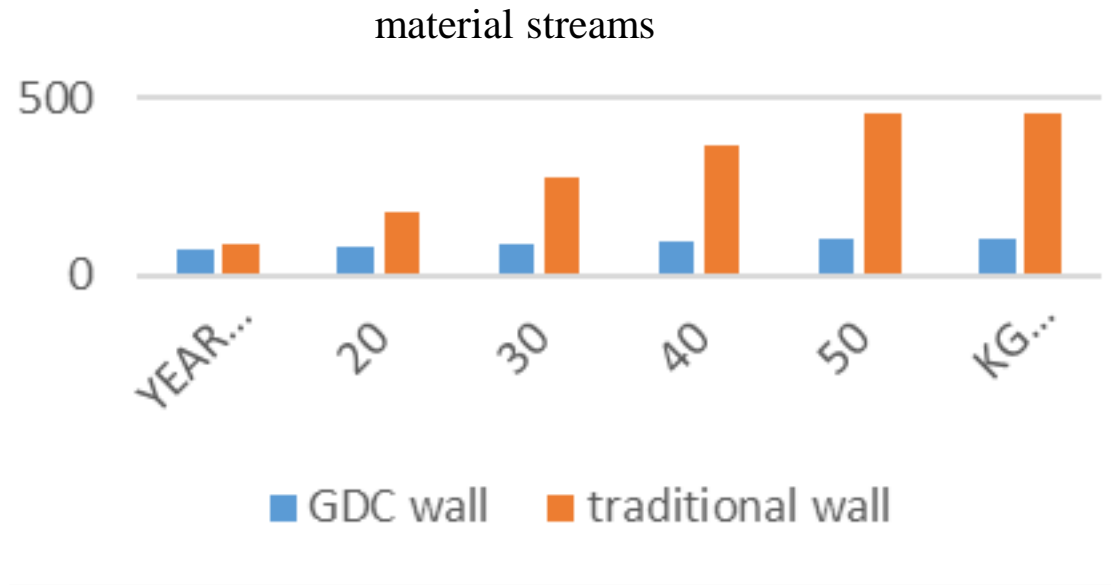


Second scenario



Third scenario

For transformation scenario, it has been considered that the the window will not be necessary any more at the existing position - window position can be changed. Third scenario shows that the window has been replaced with a wall.



Material stream analyses indicate that the GDC wall system can perform transformations without creating waste in comparison with the existing passive façade system on the market.

Application of Reversible Building assessment for material use during transformations (method Durmisevic)

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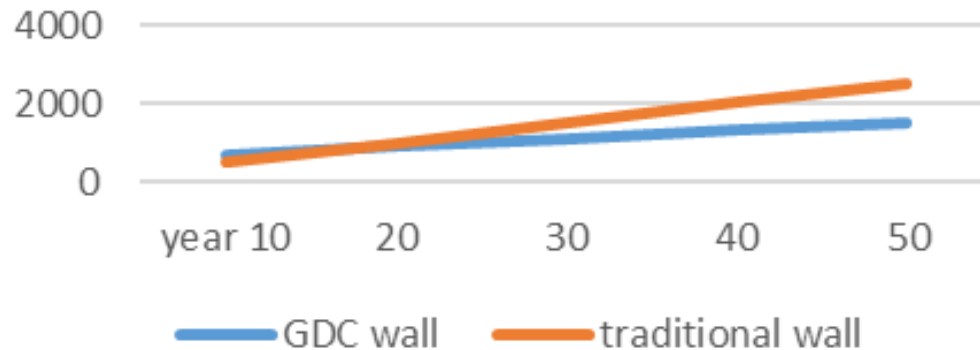


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transformation costs



Material and assembly costs during transformations

The scenario that has been considered for both case studies (GDC and existing wall) is that the transformation will take place every 10 years, in the period of 50 years.

Application of Reversible Building assessment for evaluation of the transformation costs (method Durmisevic)

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Source: www.krivajahomes.com

As the results show, the first case study, **existing wooden façade** has **low reuse potential**, which means:

- it **does not allow separation** of components, elements and materials,
- it **does not allow transformation** of façade without waste creation.



Source: www.krivajahomes.com

Most of the existing prefabricated wooden façade systems developed so far:

- use many synthetic materials,
- have similar structural problems when it comes to transformation and reuse,
- are designed as energy positive buildings, but they are very fixed,
- do not accommodate easy adaptations.

As a result, **transformation is linked to demolition, waste creation and purchase of new material.**



The prototype of the **GDC reversible façade** is designed to have **high reuse potential** but can still be improved.

Indicator for the structure and material level can be high if the elements are clustered into prefabricated independent components.

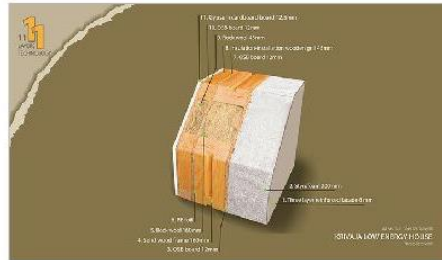
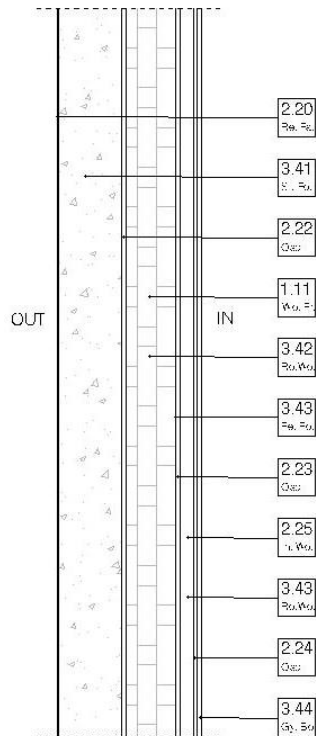
The importance of the **type of the connections** in each façade system is noticeable.

The connections have a big role:

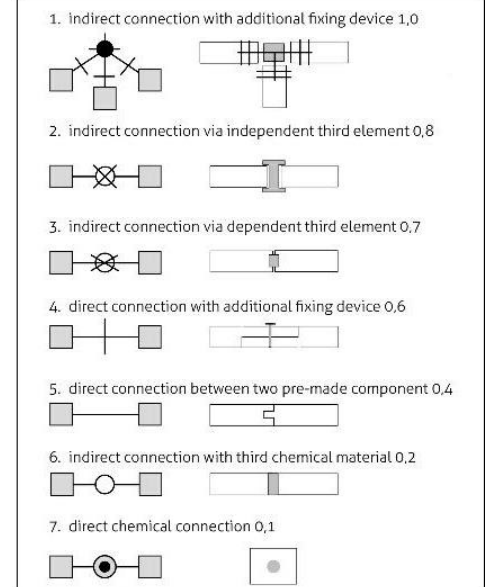
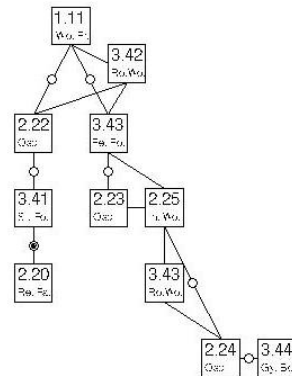
- **for assembly**
- **for disassembly** of the system and
- regarding the **waste creation**.

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WALL
3d section view



7.Type of connection
Wall
- average 0,2



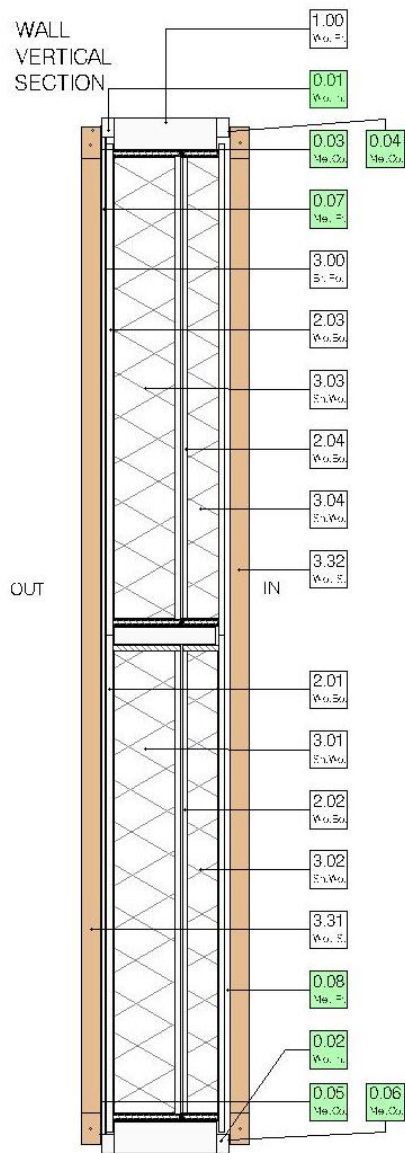
Assessment	
1. Indirect with additional fixing device	1,0
2. Indirect connection via independent third element	0,8
3. Indirect connection via dependent third element	0,7
4. Direct connection with additional fixing device	0,6
5. Direct connec. between two pre-made comp.	0,4
6. Indirect connection with third chemical material	0,2
7. Direct chemical connection	0,1



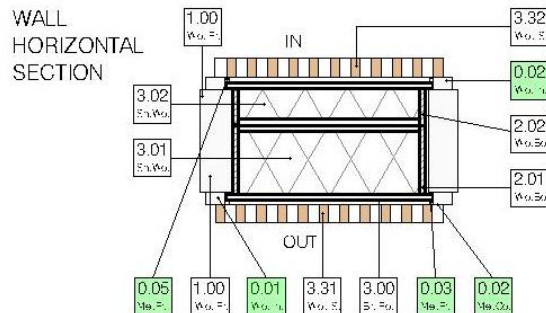
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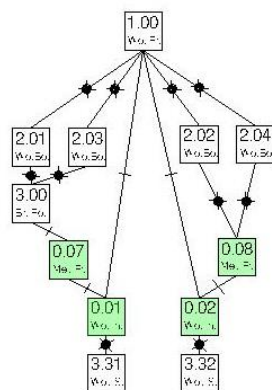
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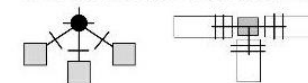
REUSE POTENTIAL OF THE WALL OF THE BUILDING GDC IN MOSTAR



7.Type of connection
Wall
- average 0,87



1. indirect connection with additional fixing device 1,0



2. indirect connection via independent third element 0,8



3. indirect connection via dependent third element 0,7



4. direct connection with additional fixing device 0,6



5. direct connection between two pre-made component 0,4



6. indirect connection with third chemical material 0,2



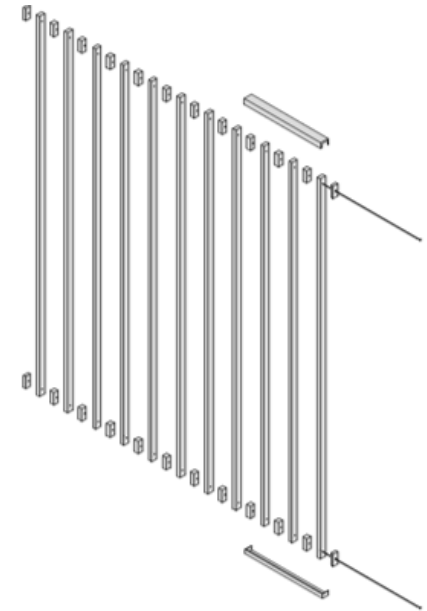
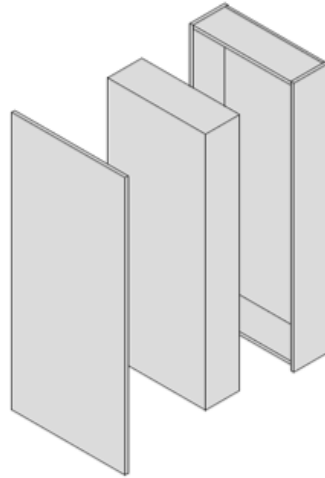
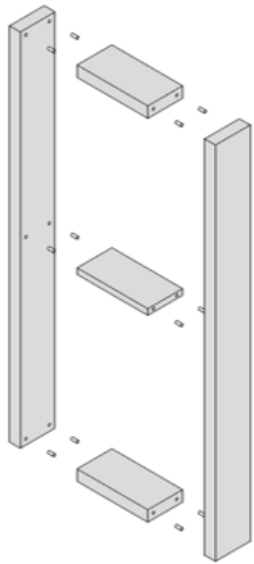
7. direct chemical connection 0,1



Assessment

1. Indirect with additional fixing device	1,0
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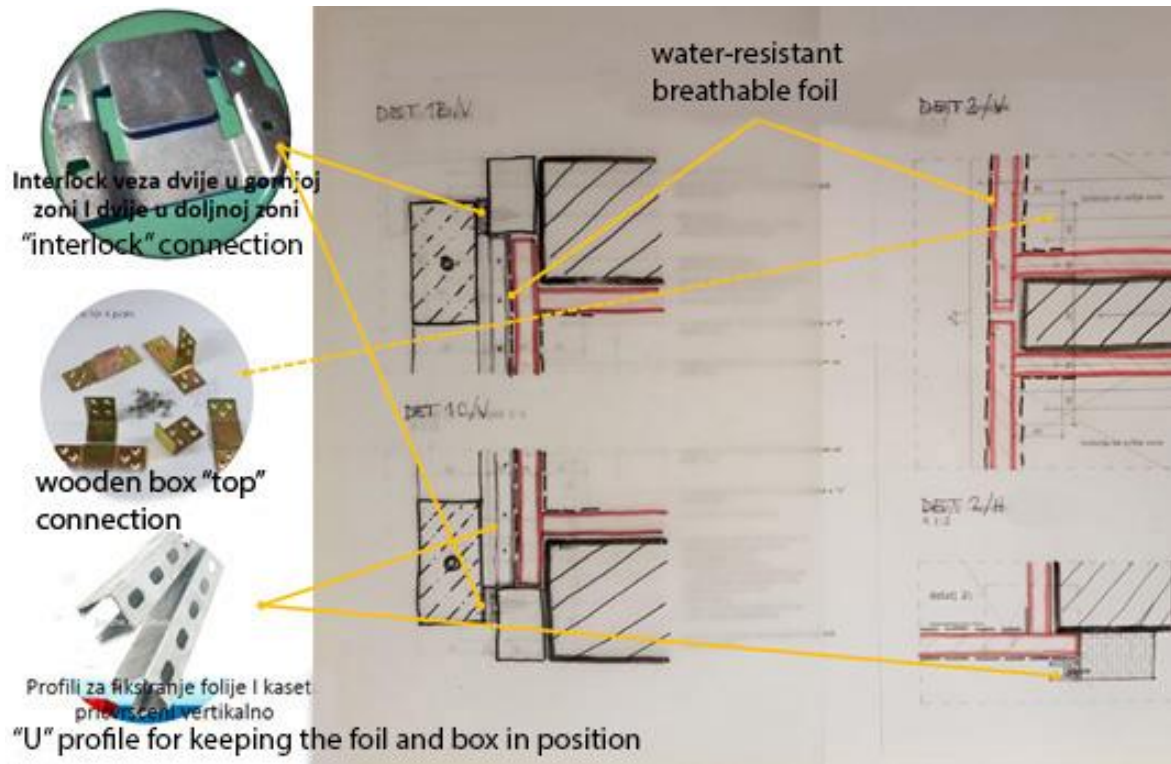


(1)main frame of the system (2) insulation box (3) intermediary (4) finishing of the system

Another **new approach** has been tested.

The **intermediary** is been introduced as a very important part for the transformation.

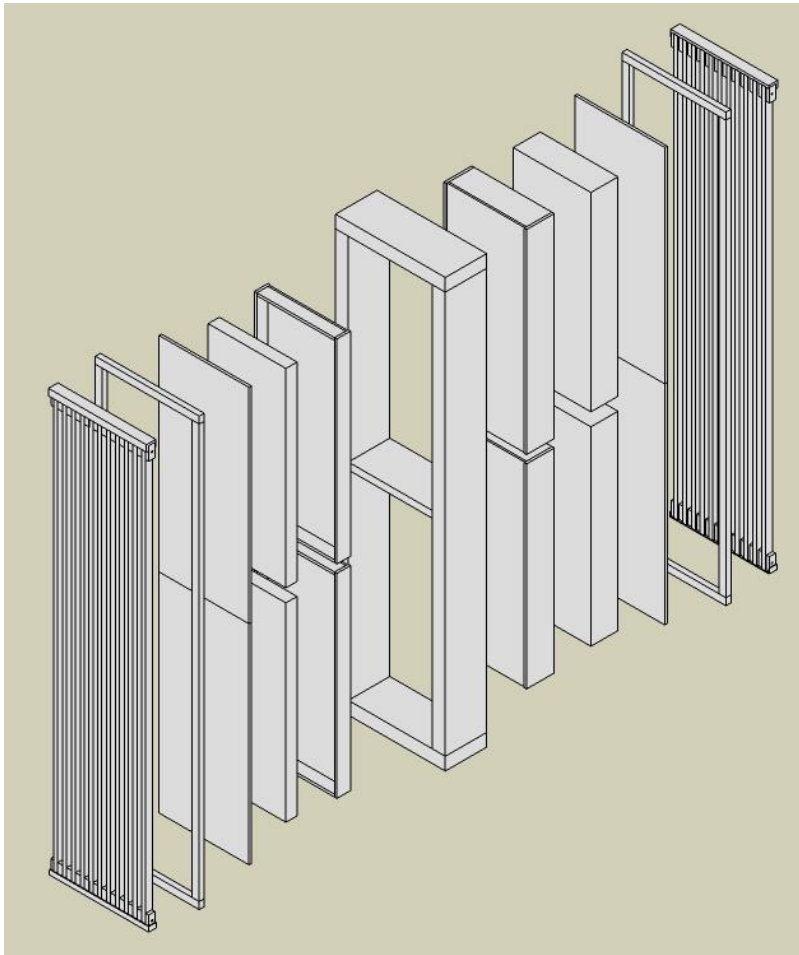
This is **the way to extend the life cycle of the components in the system.**



Source: BAMB pilot project – analyses of connections for GDC Mostar, E. Durmisevic & R. Androsevic

There are almost no reversible or easy connecting and disconnecting solutions.

Construction industry was, and is developing towards easy assembly, but not easy disassembly solutions.



This study illustrates:

- the importance of implementing **reuse potential design protocols** during design and evaluation phase in order to indicate what can be done in order to design reversible and sustainable building systems and how design solutions can be improved during the design process.
- there is a **close link between the reuse potential and construction waste**.
- If reuse and **transformation potential** is high, then the **construction waste** is low and vice-versa.



GDC existing

- The case studies of façade systems show the weak points in existing facades and the **way to design a façade with high reuse and transformation potential** with low environmental impact and create very low amount of waste during its lifecycle.



GDC planned

- The **selection of waste management and reuse methods and technologies** is crucial if a selected system is to be sustainable under the present economic and social conditions.



GDC site planned, project 4D Architects

Example of the existing and future façade systems in BiH and their reuse potential can open the eyes to the

- **new building design approach** and
- **new building design protocols!**