



Design and environmental load assessment
of multi-use construction kits for temporary applications
based on 4Dimensional Design

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Design and environmental load assessment of multi-use construction kits for temporary applications based on 4Dimensional Design

Introduction

Design of MUC kits

Environmental assessment of MUC kits

Feedback





“current built environment is characterised by an INEFFICIENT use of material and energy resources”

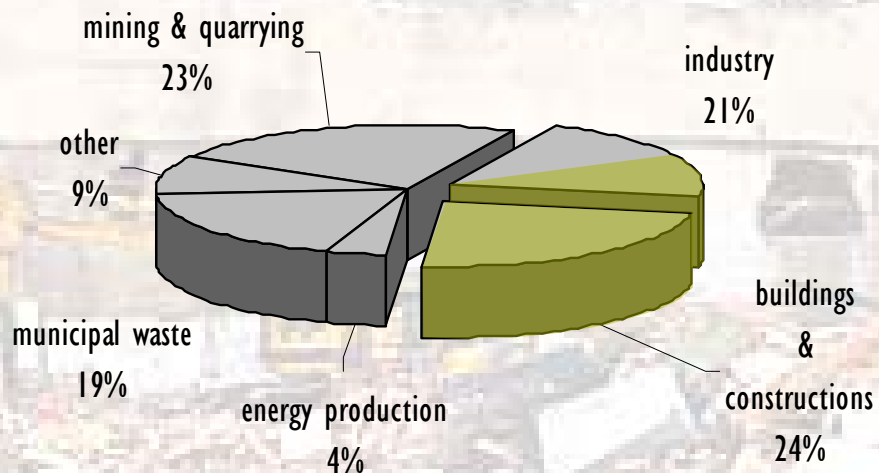
“we need EFFECTIVE design measures to create healthy and sustainable building solutions”





WASTE

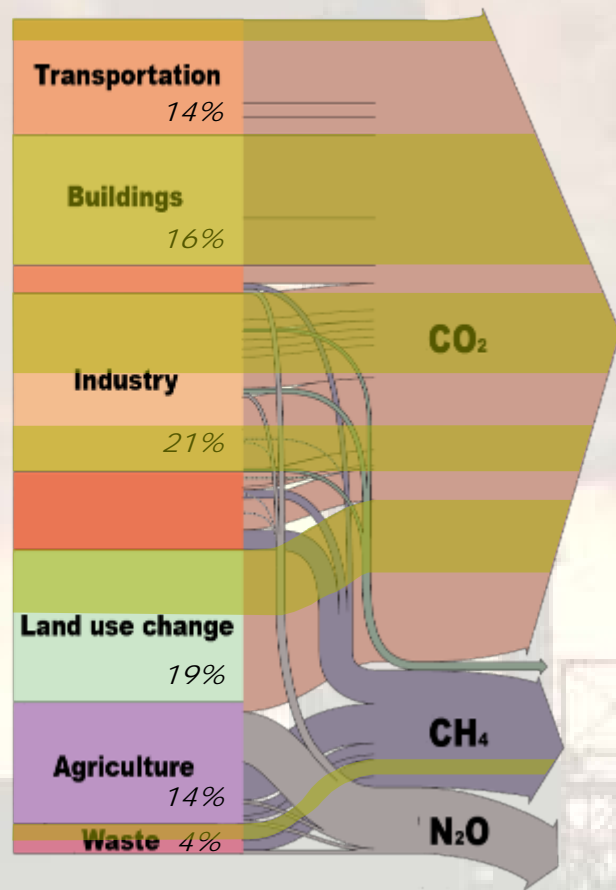
Source: EUROSTAT & EEA



Total waste generation in EU-25:
1400 million tons per year

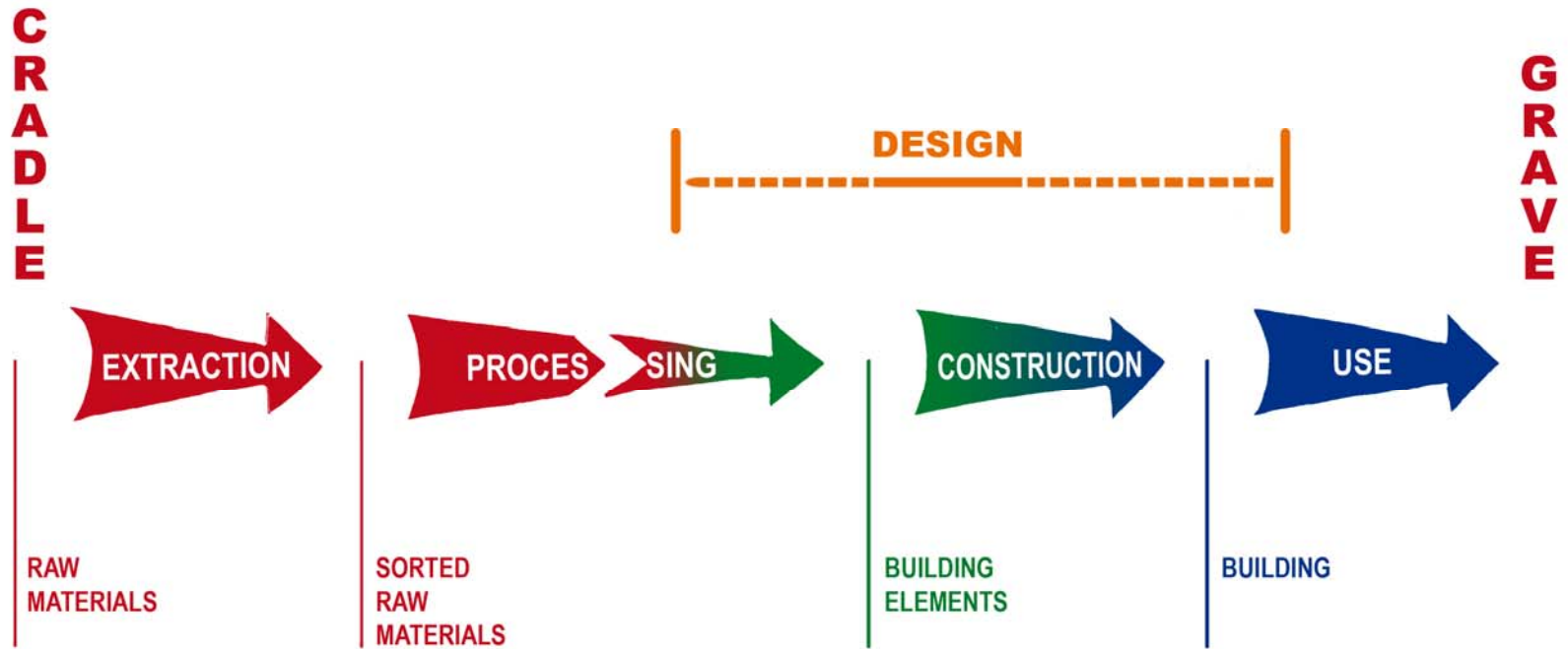
GREENHOUSE GAS EMISSIONS

Source: WRI



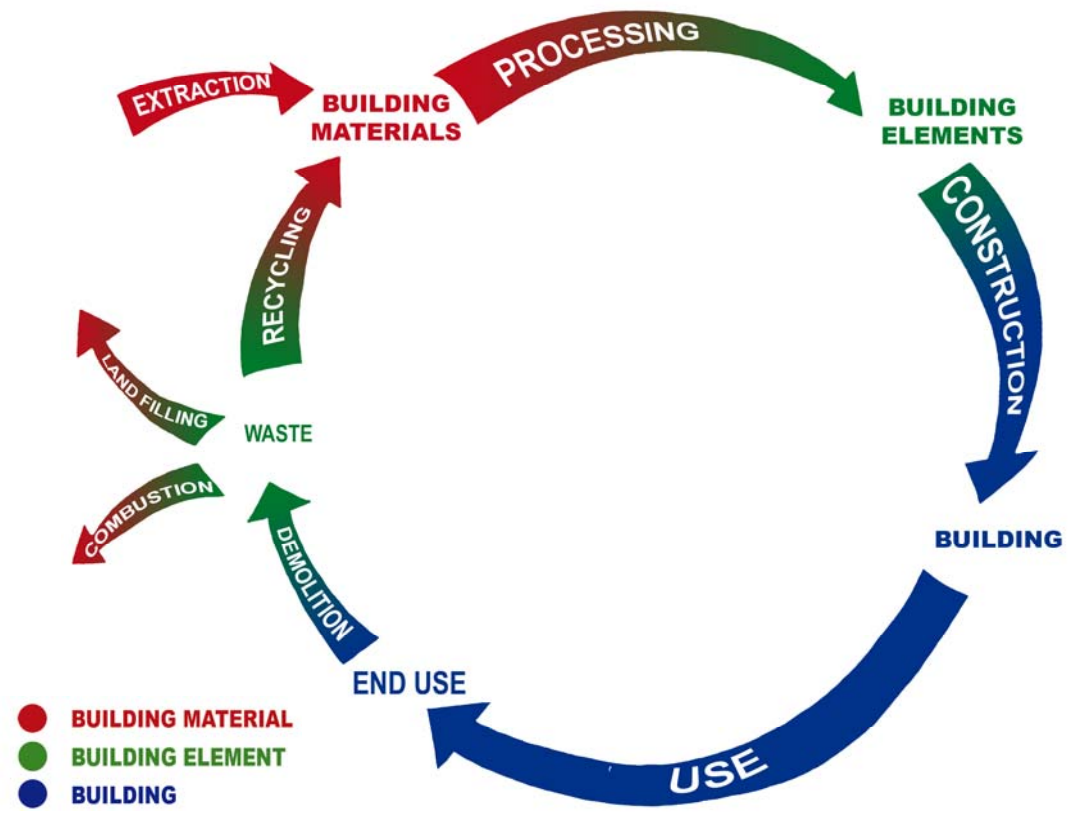


CURRENT DESIGN VIEW



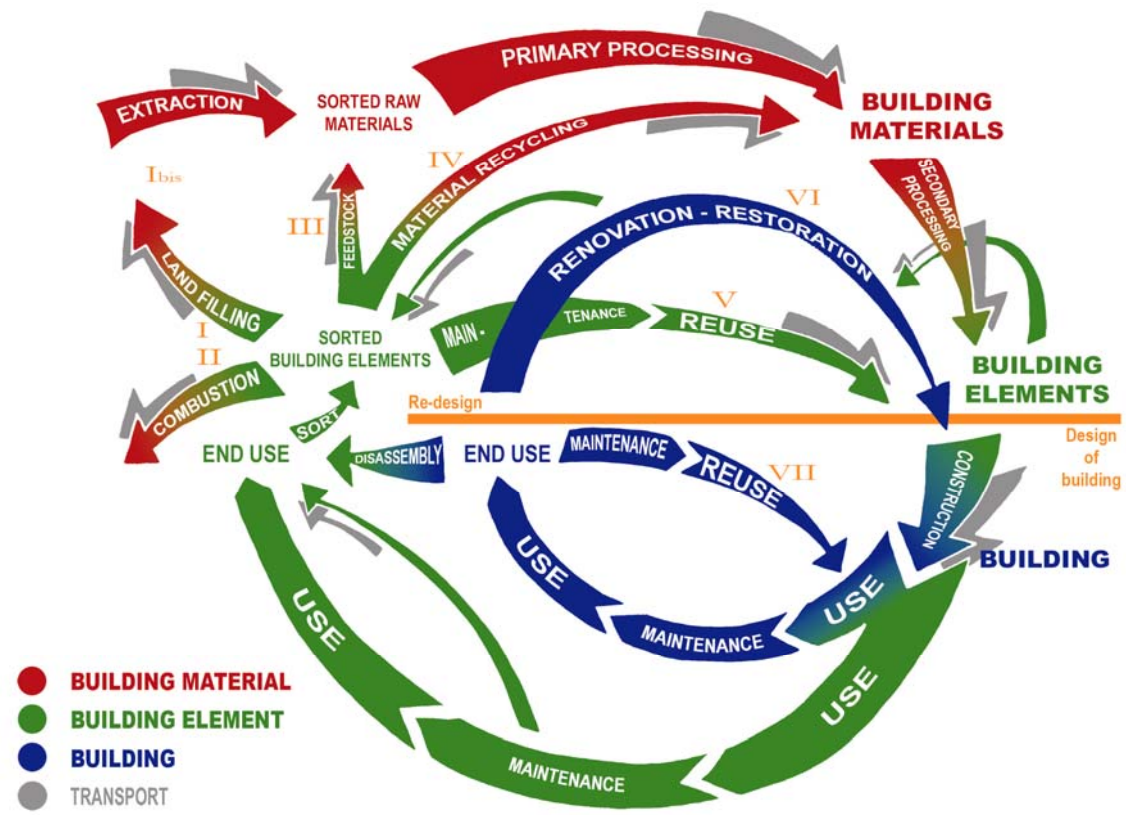


LIFE CYCLE THINKING





LIFE CYCLE THINKING



SCOPE





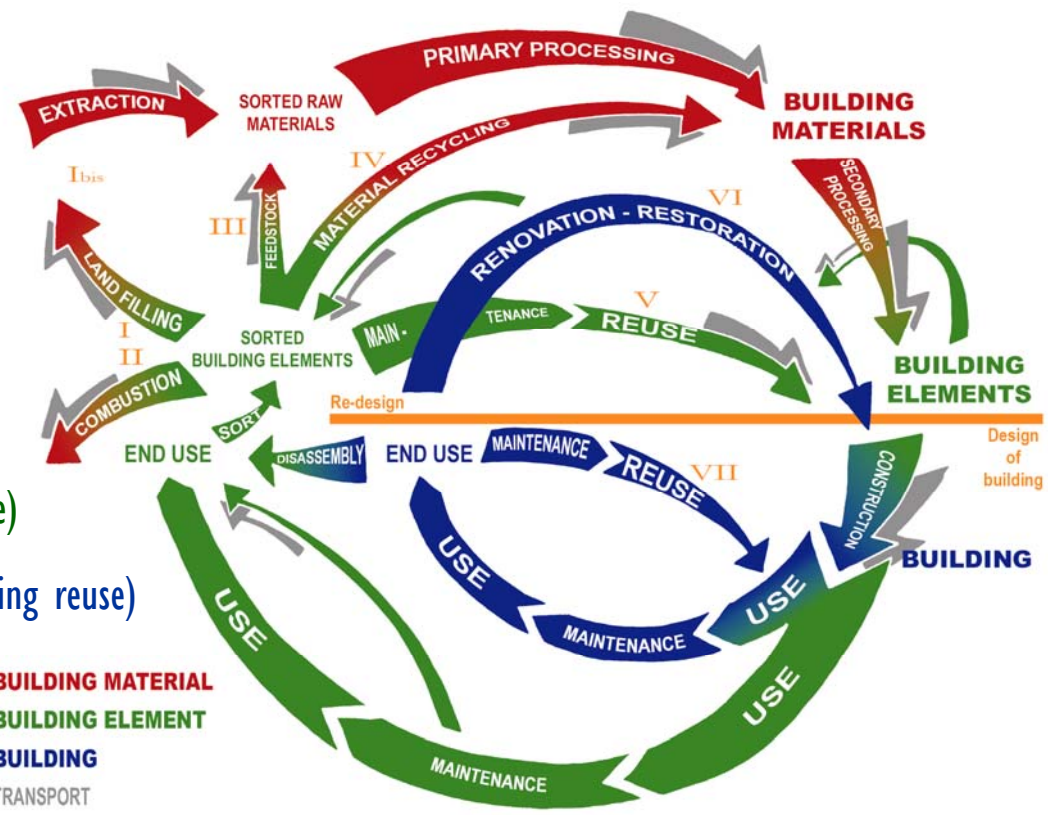
LIFE CYCLE THINKING

Design for QUALITATIVE USE

+

Design for TRANSFORMATION

- Design for DISMANTLING (material reuse)
- Design for DECONSTRUCTION (component reuse)
- Design for ADAPTABILITY & VERSATILITY (building reuse)



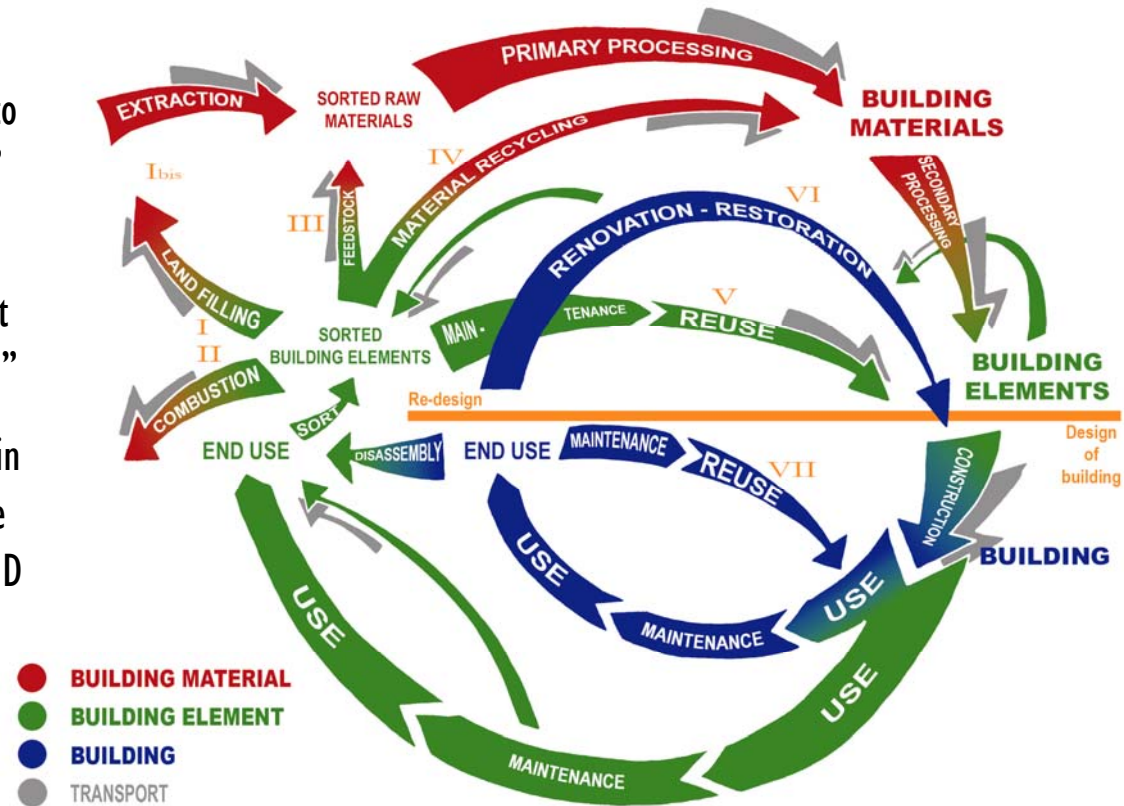


4DIMENSIONAL DESIGN

“...it refers to an ATTITUDE of the designer, through which he uses his horizontal knowledge to provide an artefact with a sustainable character”

“ a 4D designer accepts that not only building materials and components degrade over time, but that also the context of the building will CHANGE”

“he/she has to provide a DYNAMIC answer, wherein buildings , components and materials support the process of changing events, instead of creating END PRODUCTS”





4D APPROACHES

✓ “Cradle-to-Cradle” approach (McDonough & Braungart)

design for DISMANTLING

(material reuse)

✓ SAR approach (Habraken)

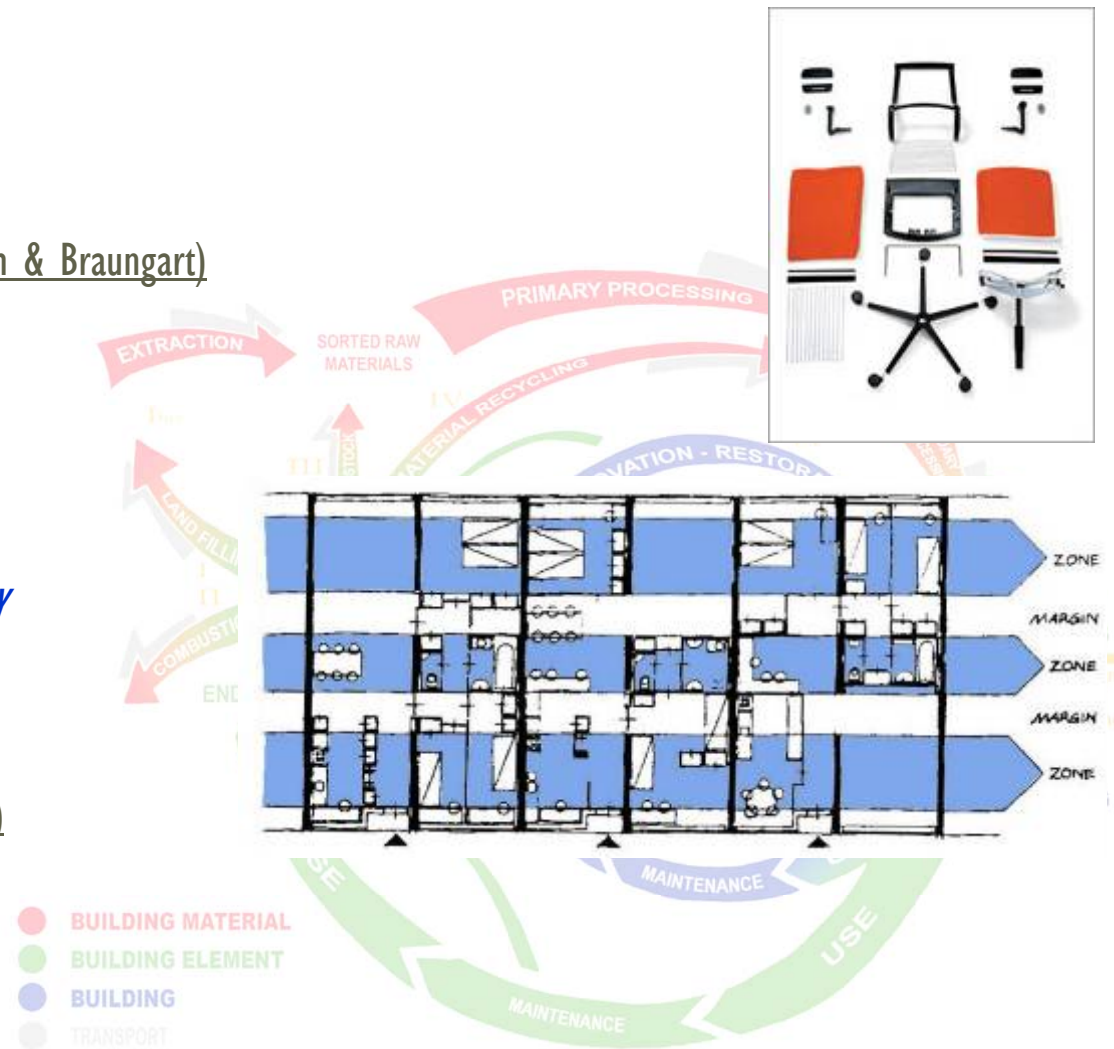
design for ADAPTABILITY & VERSATILITY

(building reuse)

✓ Hendrickx-Vanwalleghem approach (VUB)

design for DECONSTRUCTION

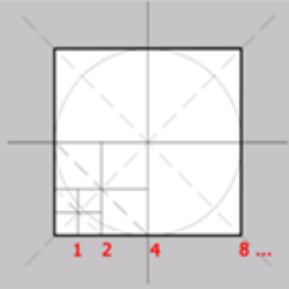
(component reuse)



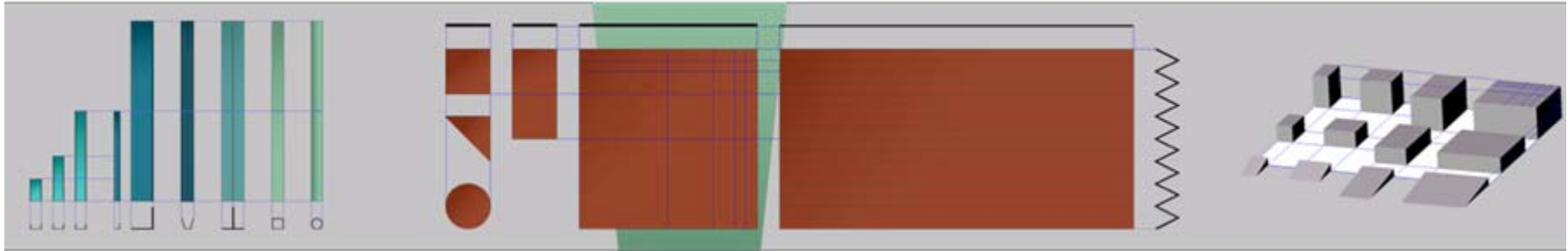
SCOPE



CONCEPTUAL



dikte plaat				...
aantal 'x'				...
hoogte				...



MATERIAL

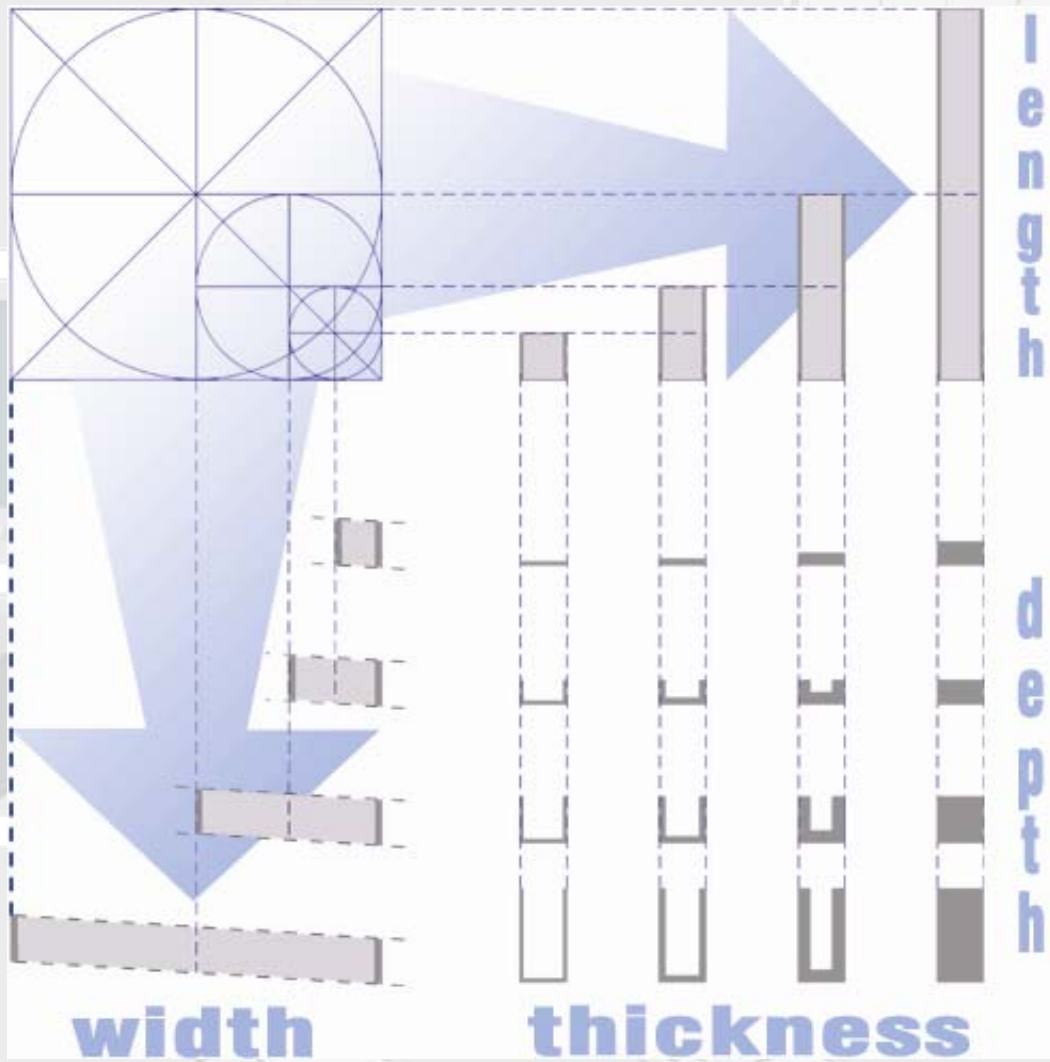


SCOPE





CONCEPTUAL



MATERIAL

SCOPE





PROOF OF CONCEPT of HENDRICKX-VANWALLEGHEM DESIGN APPROACH:

- *study the technical feasibility*
- *determine the related environmental benefits and drawbacks*

CASE STUDIES: *TEMPORARY CONSTRUCTIONS*

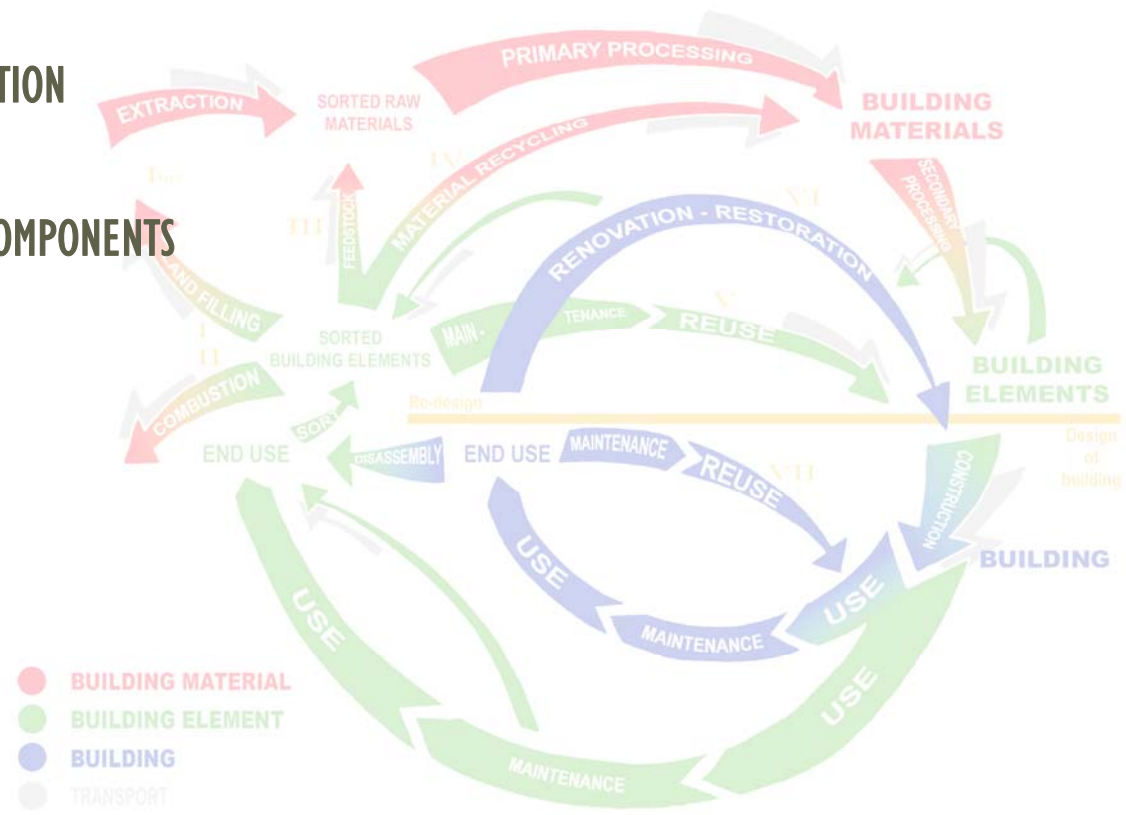
- Peace Supporting Operations (PSO)
- Mobile Transitory Dwellings (MTD)





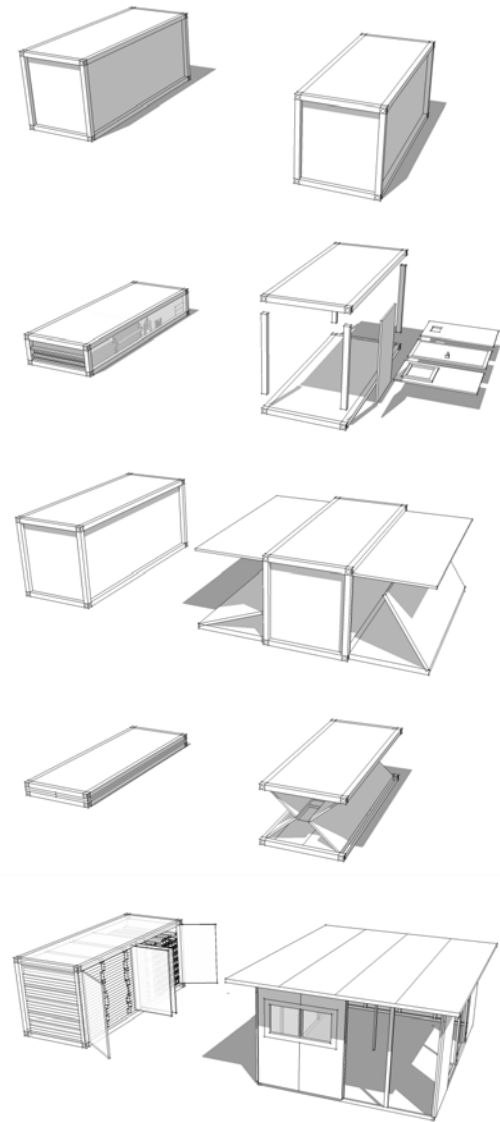
DESIGN REQUIREMENTS

- ADAPTABILITY
- CONSTRUCTION and DECONSTRUCTION
- MAINTENANCE
- REUSE of CONSTRUCTIONS and COMPONENTS
- TRANSPORT
- COMFORT
- STRUCTURAL CAPACITY
- COST
- ENVIRONMENTALLY SOUND





PEACE SUPPORTING OPERATIONS

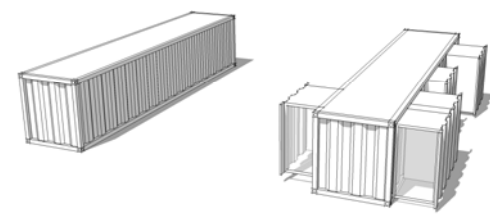
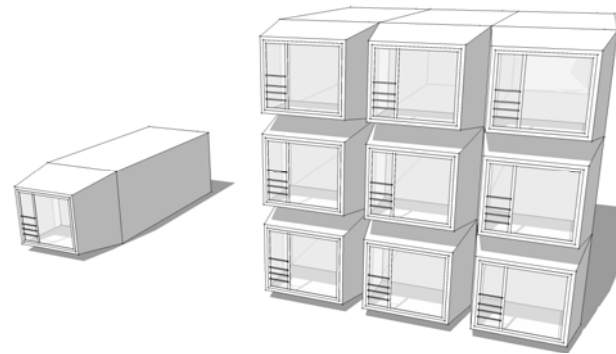
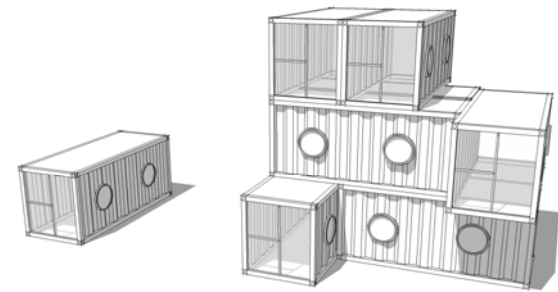
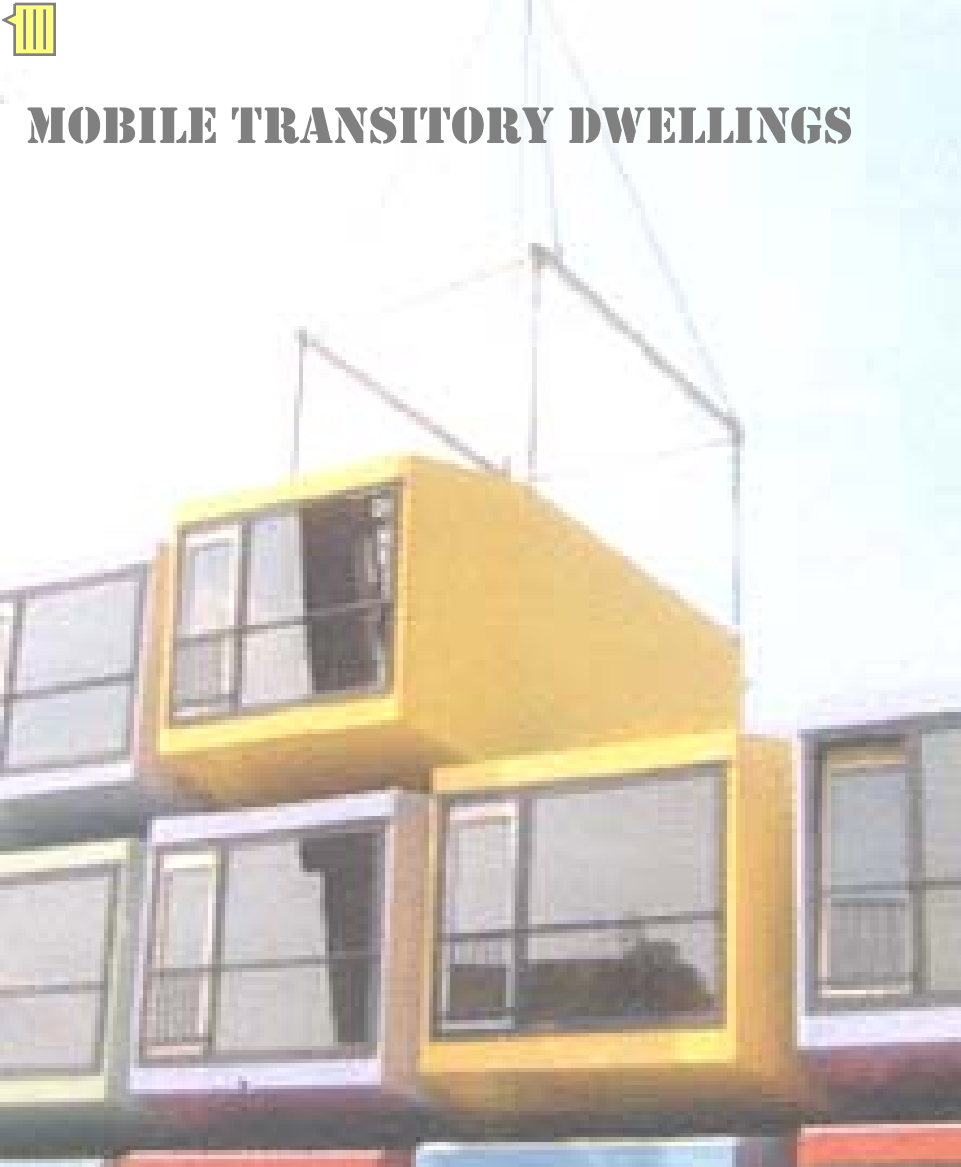


DESIGN OF MUC KITS

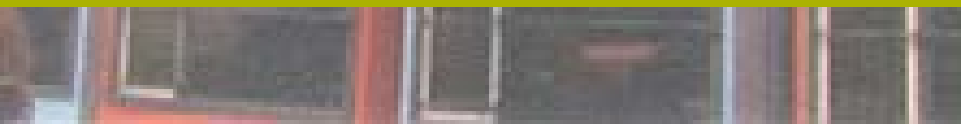


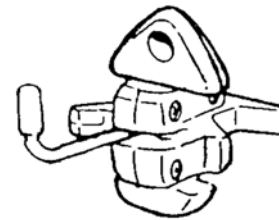
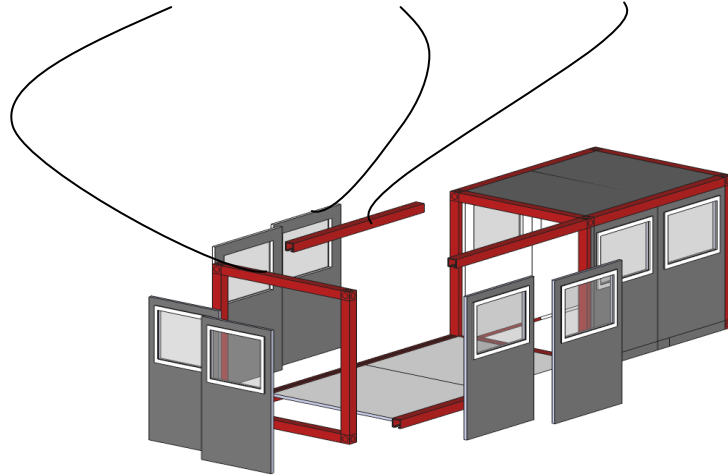
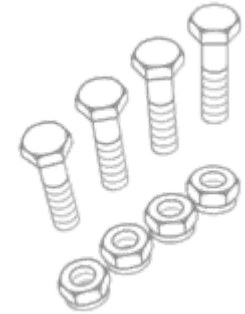
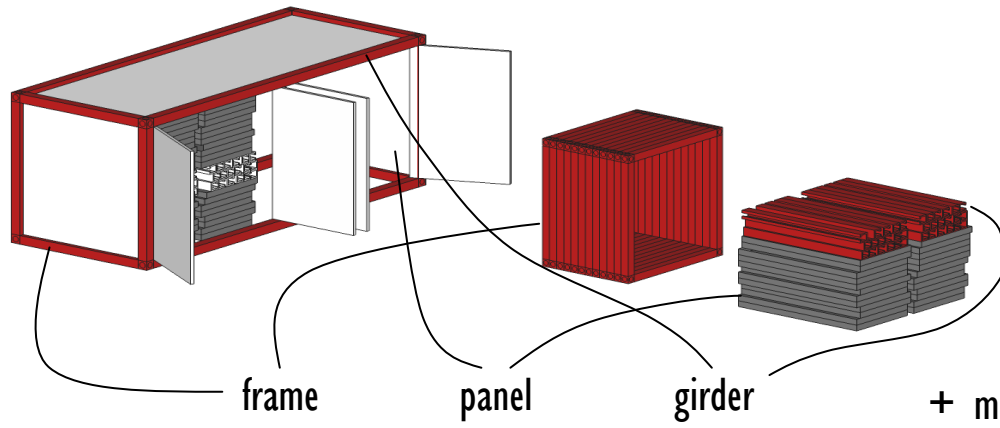


MOBILE TRANSITORY DWELLINGS

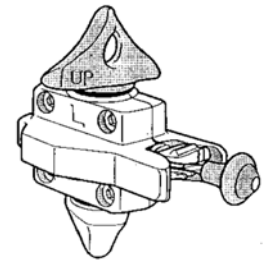


DESIGN OF MUC KITS





manual



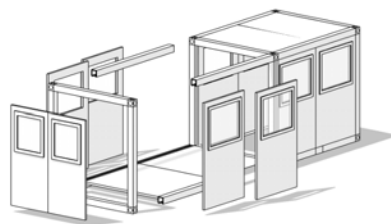
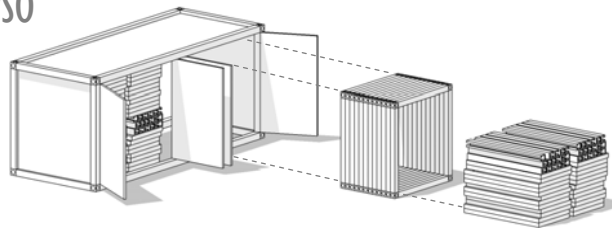
semi-automatic

DESIGN OF MUC KITS

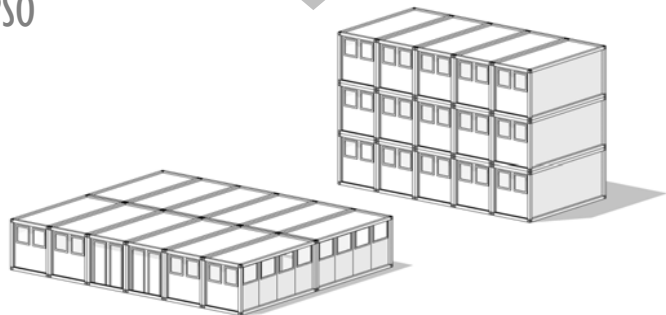




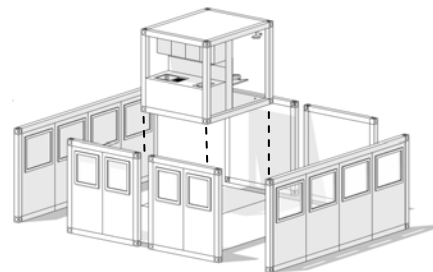
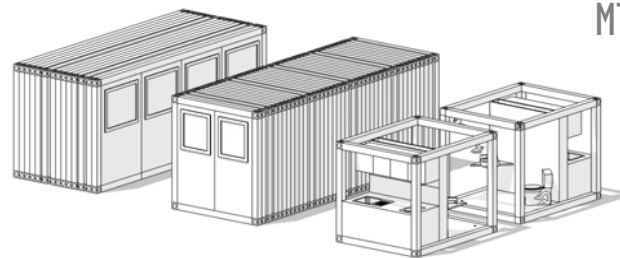
PSO



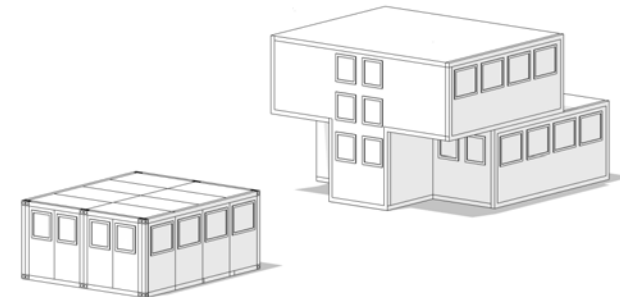
PSO

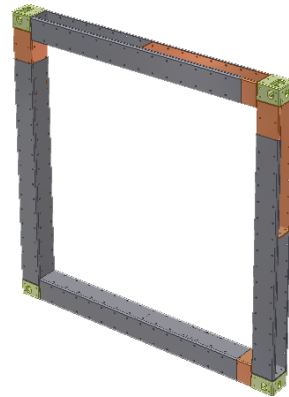
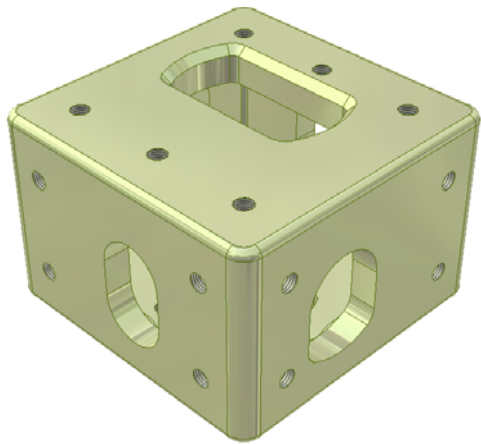


MTD



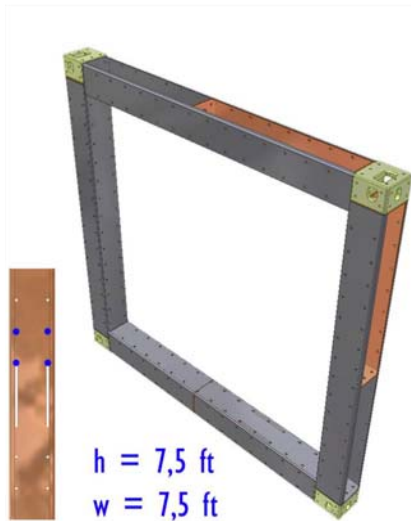
MTD



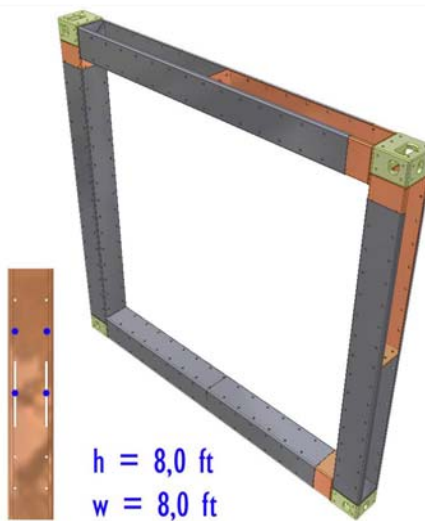


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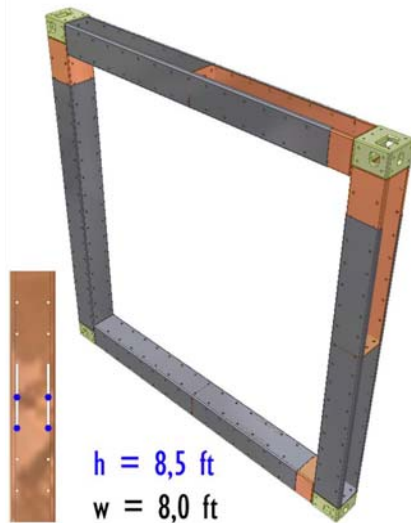
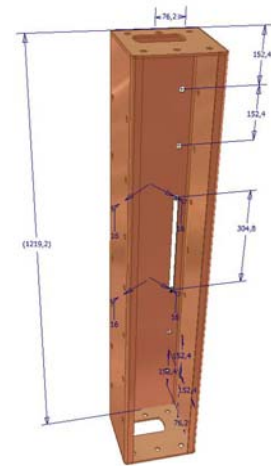




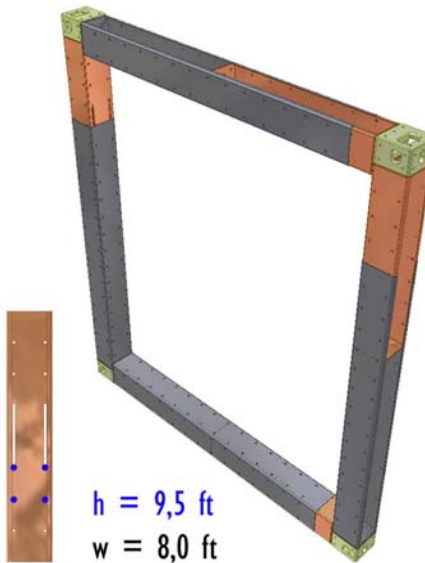
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 $w = 7,5 \text{ ft}$



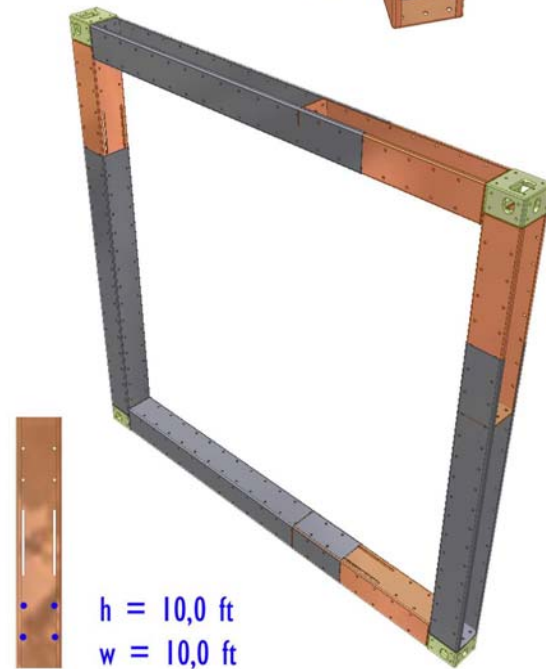
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 $w = 8,0 \text{ ft}$



$h = 8,5 \text{ ft}$
 $w = 8,0 \text{ ft}$



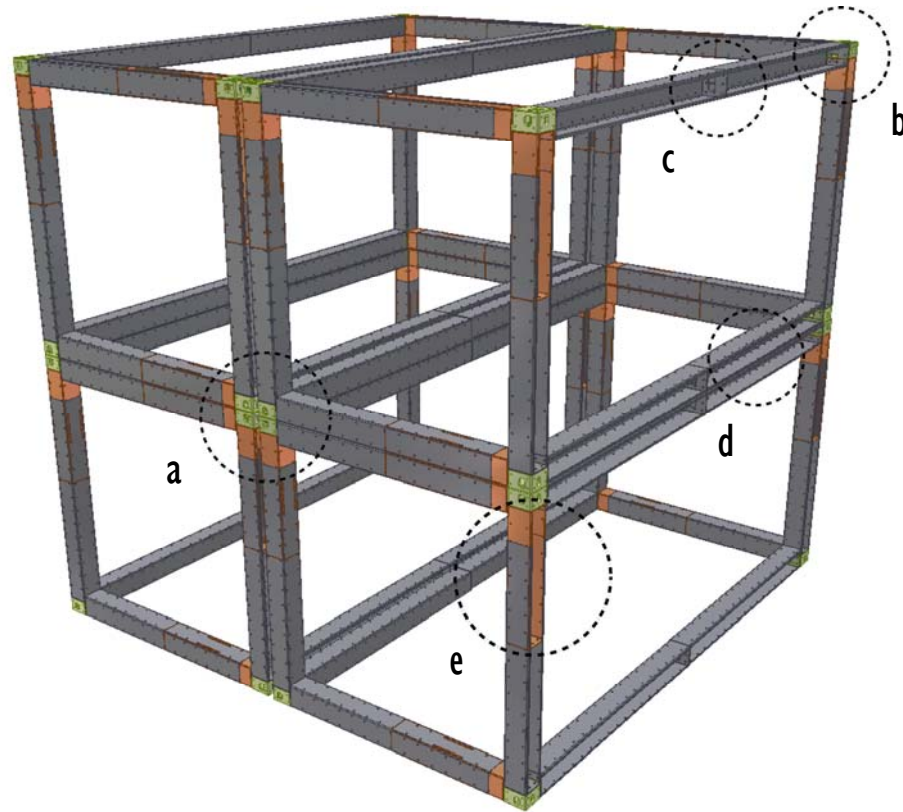
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$h = 10,0 \text{ ft}$
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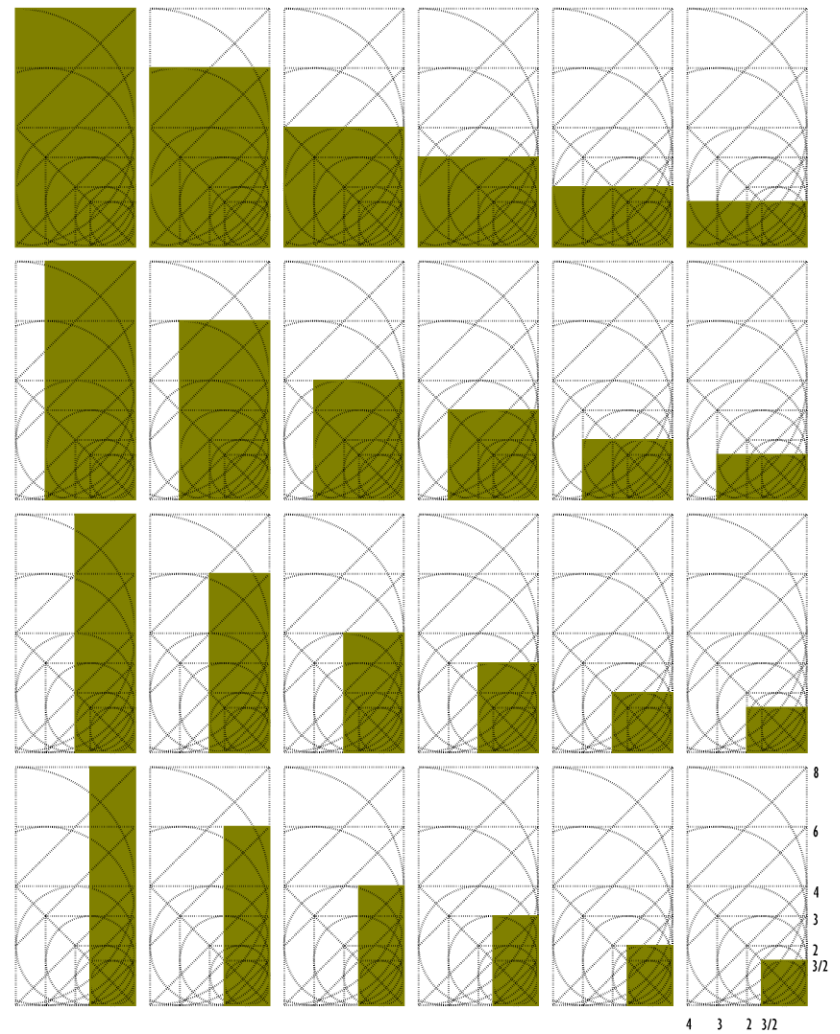
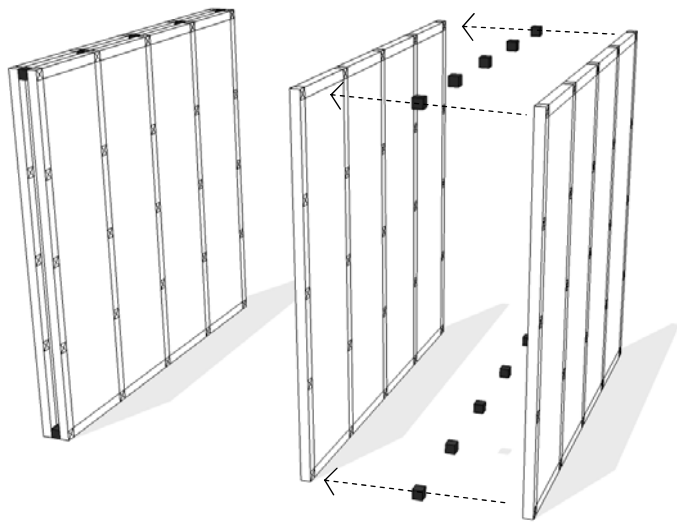
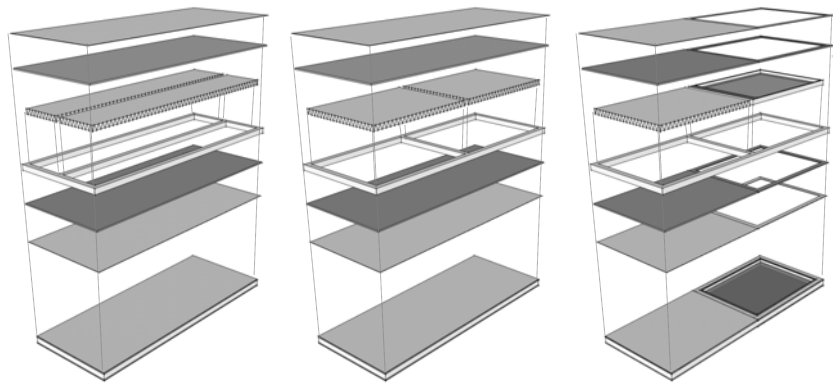
DESIGN OF MUC KITS





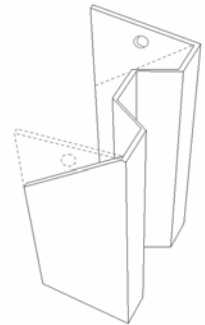
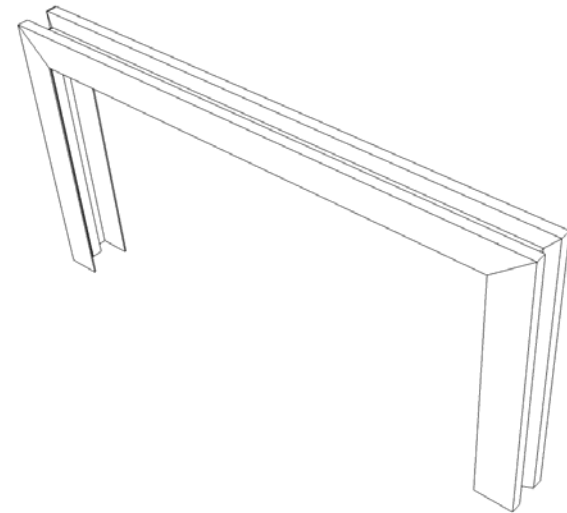
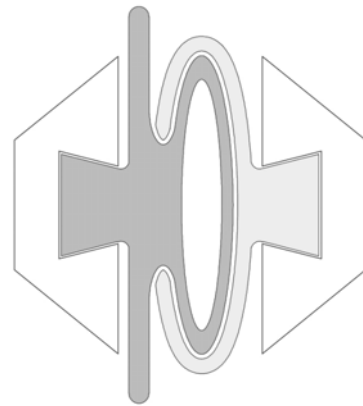
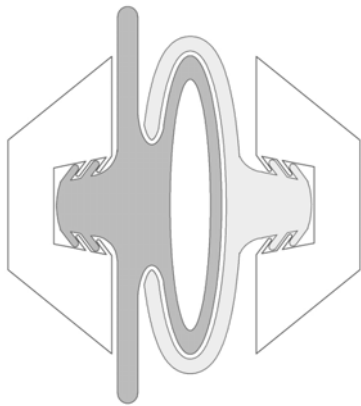
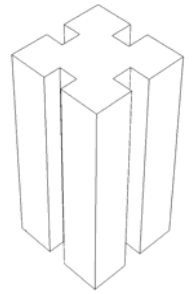
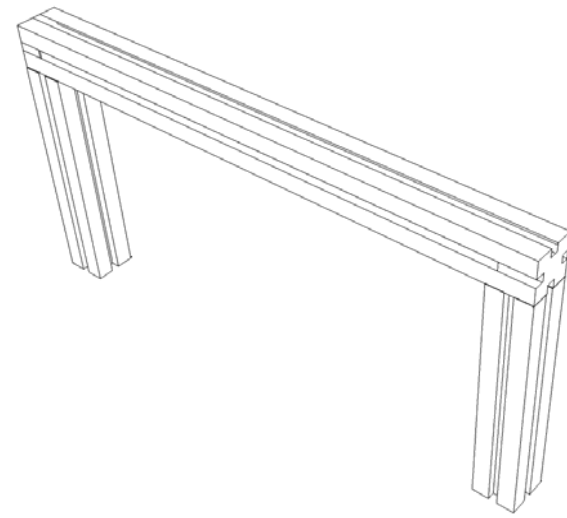
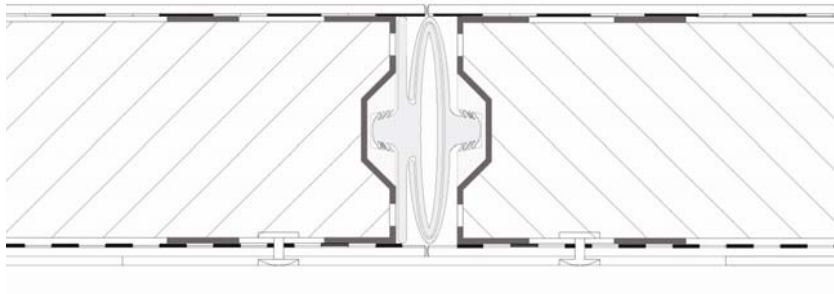
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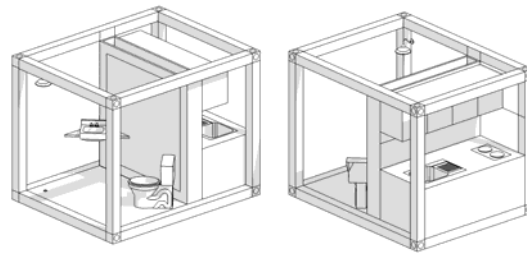
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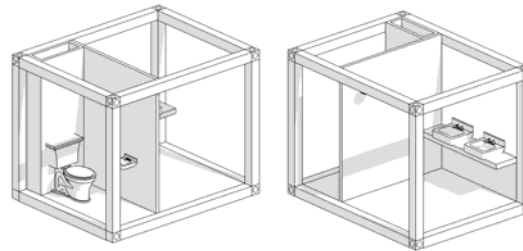


DESIGN OF MUC KITS

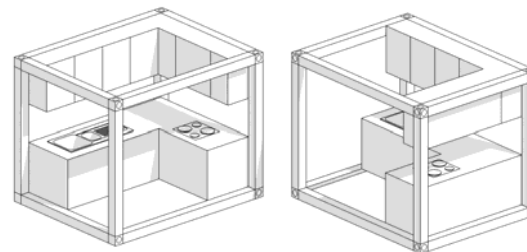




kitchenette - bathroom for
studio



bathroom for flat



kitchen for flat

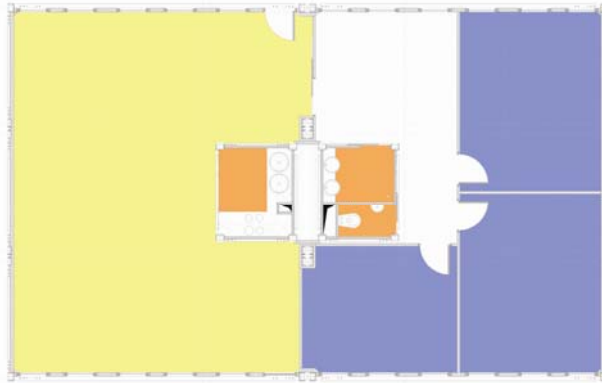




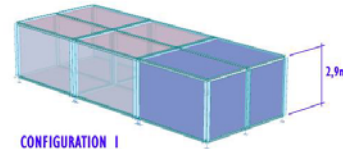
studio 1 person



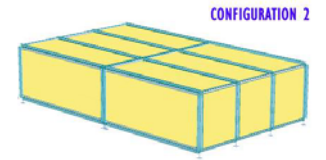
studio 2 persons



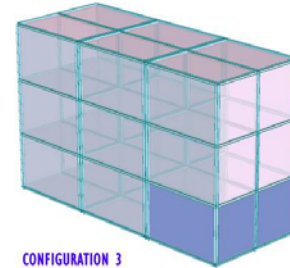
family flat



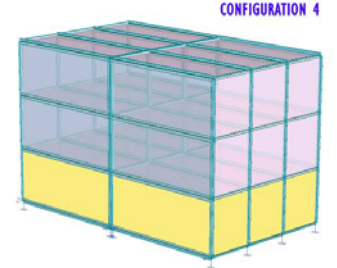
CONFIGURATION 1



CONFIGURATION 2

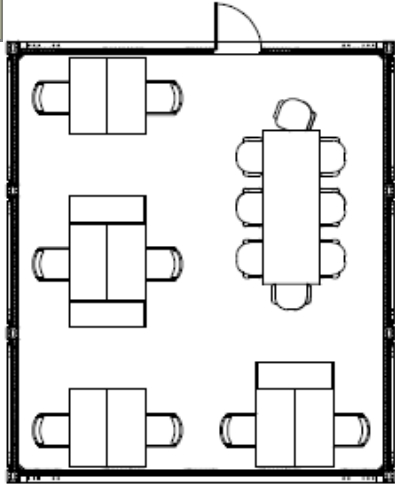


CONFIGURATION 3

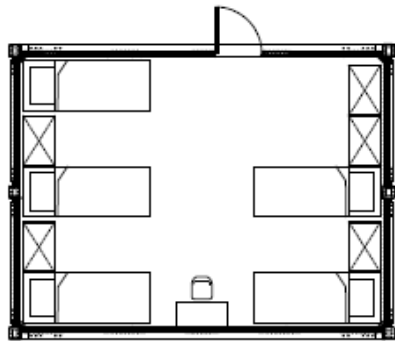


CONFIGURATION 4

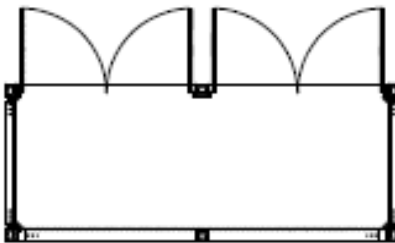




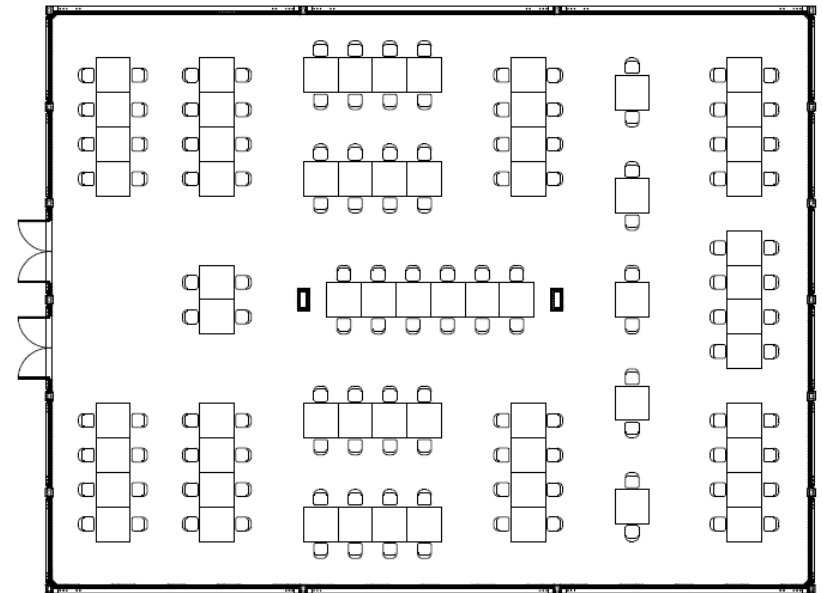
office



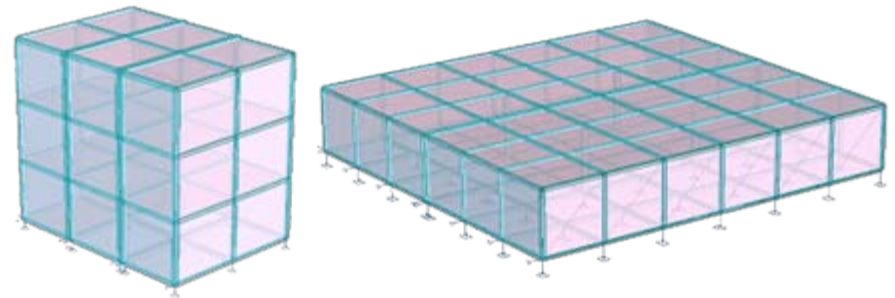
sleeping accommodation



transport container



canteen





ASSESSMENT METHODS

LCE:

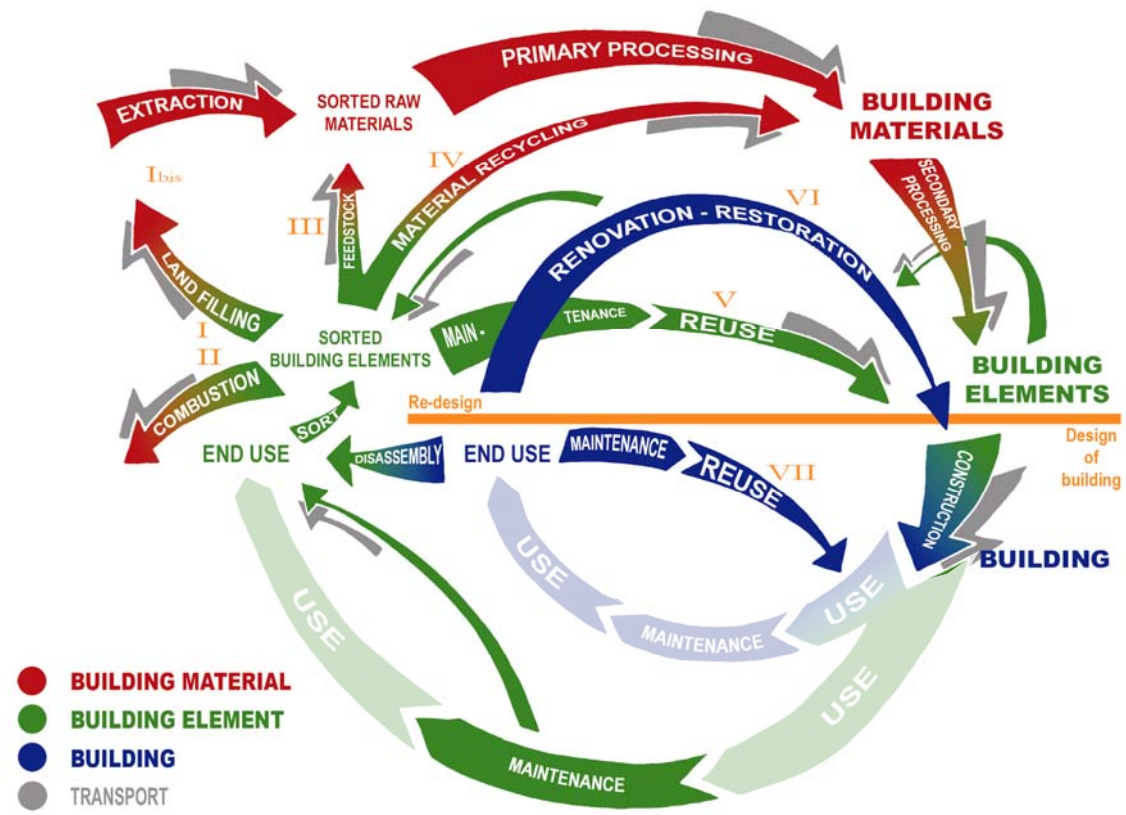
- whole life cycle
- only energy

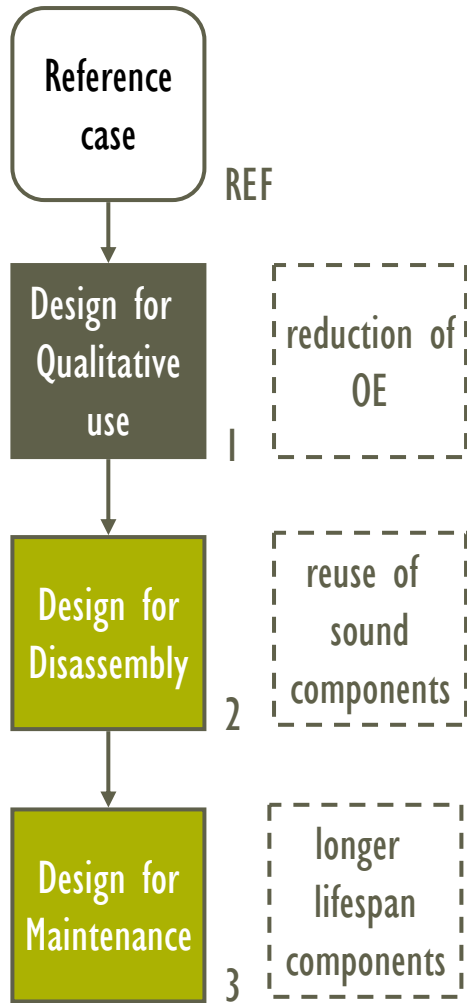
LCIA:

- whole life cycle
- resources and emissions

ΔEX:

- USE excluded
- resources





ENERGY

[MJ/m² floor]

[kg/m² floor]



REF 1 2 3

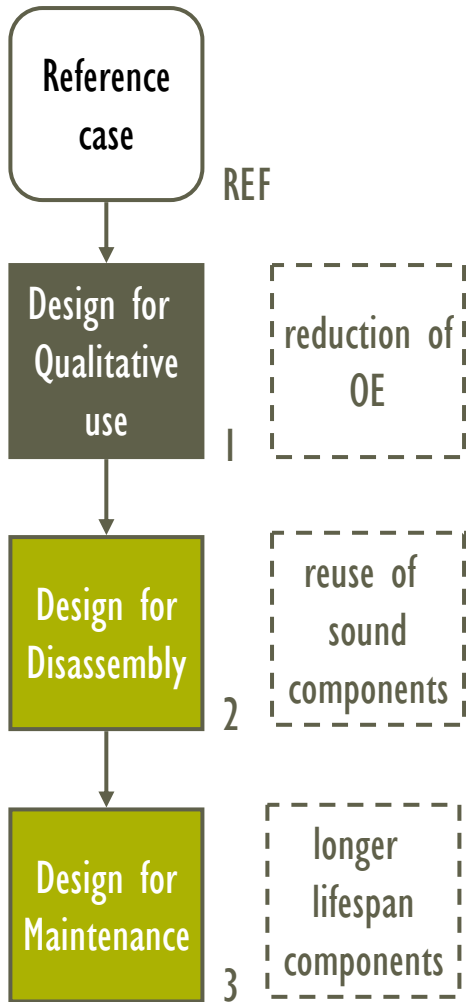


REF 1 2 3

ENVIRONMENTAL ASSESSMENT OF PSO KIT



PSO OFFICE



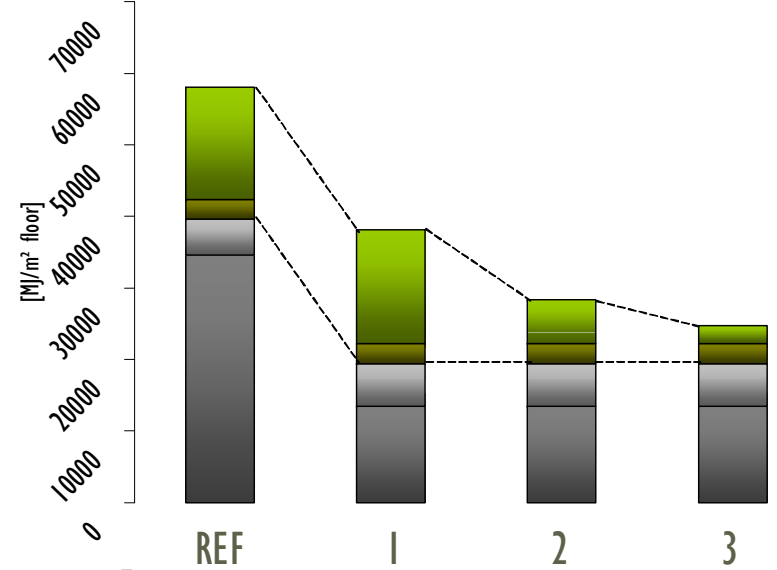
$\Delta EE_1 = 14\%$
 $\Delta Em_1 = 88\%$

$\Delta \Sigma EE_t = 2\%$
 $\Delta \Sigma Em_t = 51\%$

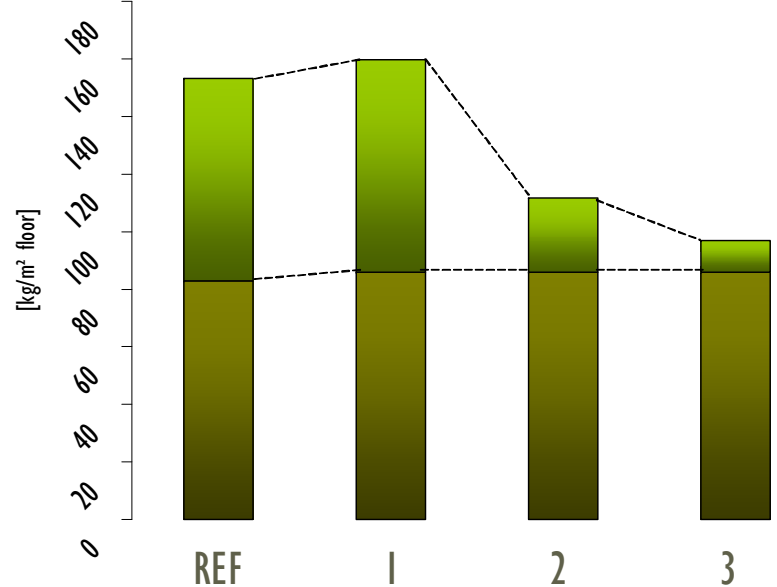
$\Delta \Sigma EE_t = 6\%$
 $\Delta \Sigma Em_t = 75\%$

$\Delta \Sigma EE_t = 14\%$
 $\Delta \Sigma Em_t = 87\%$

ENERGY

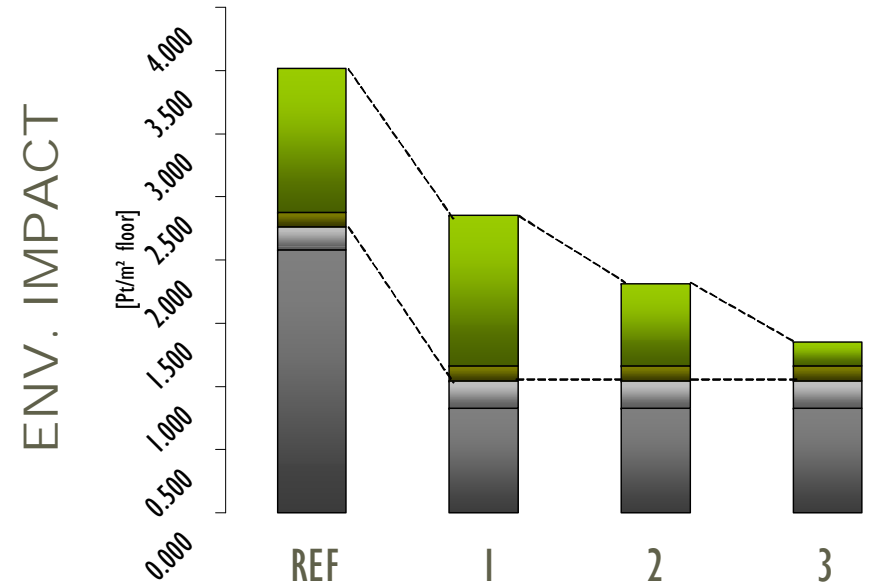
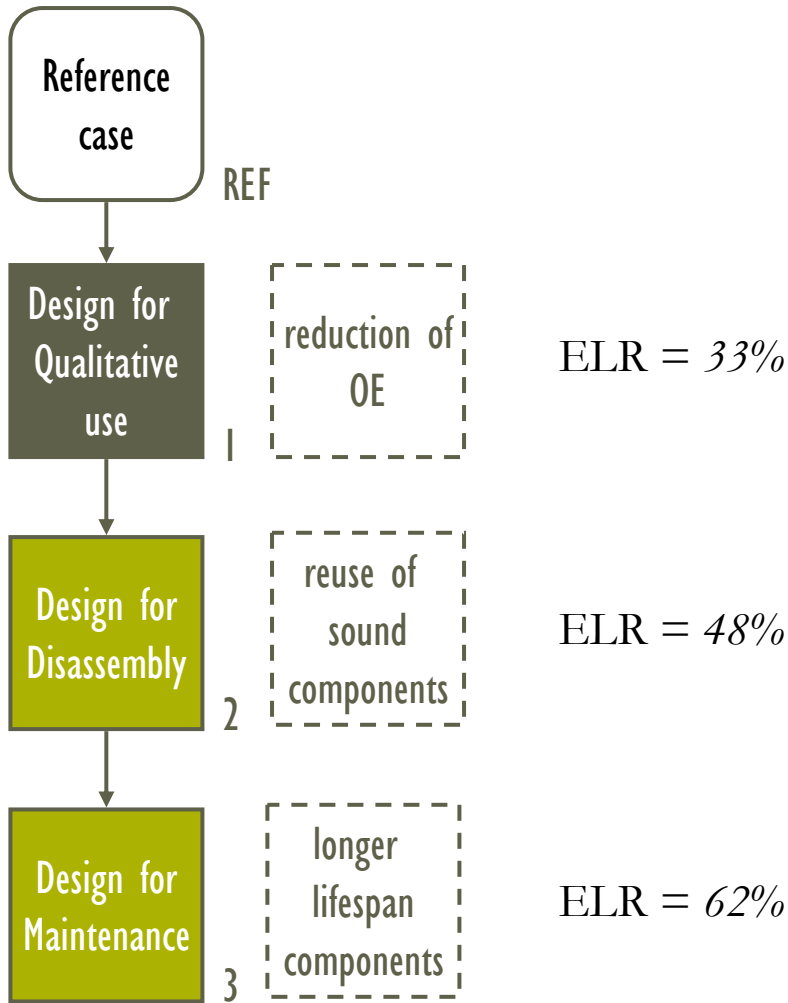


MINERALS



ENVIRONMENTAL ASSESSMENT OF PSO KIT





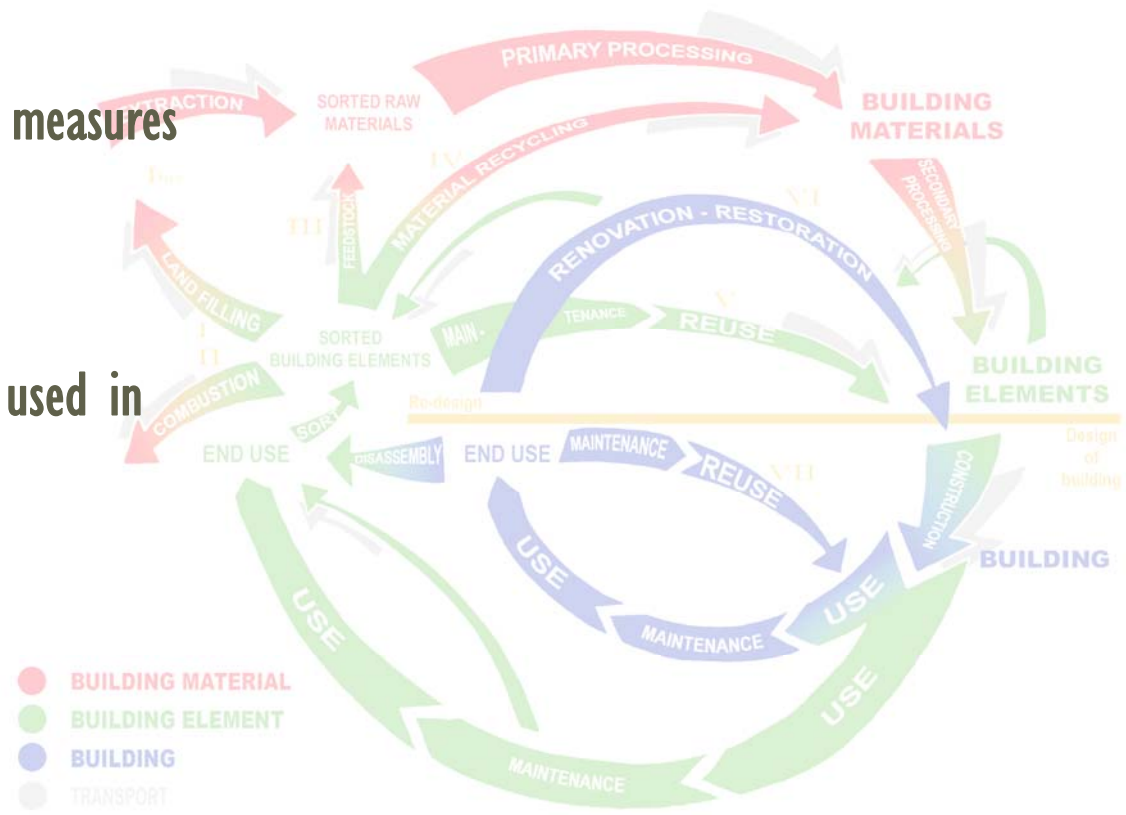
ENVIRONMENTAL ASSESSMENT OF PSO KIT





CONCLUSIONS

1. Combining life cycle design measures
2. Design of a Meccano
3. Detailing is a key element
4. Design and assessment are used in an iterative way
5. Integrative life cycle model





FURTHER RESEARCH

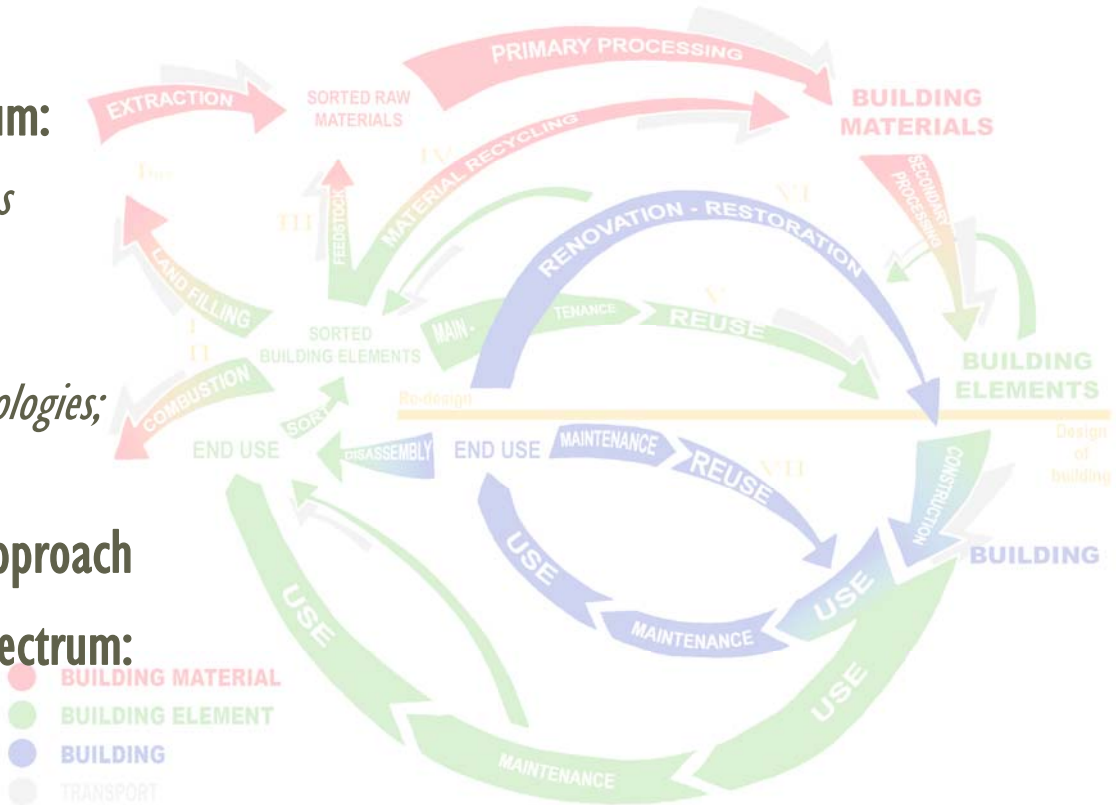
1. enlarging the design spectrum:

- vertical: *material & processes selection; suppl. accessories; prototyping & testing*
- horizontal: *other design typologies; retro-fitting and renovation*

2. generating system in H-V approach

3. enlarging the assessment spectrum:

- data acquisition
- life cycle costing



The PhD thesis of Wim Debacker is available through

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