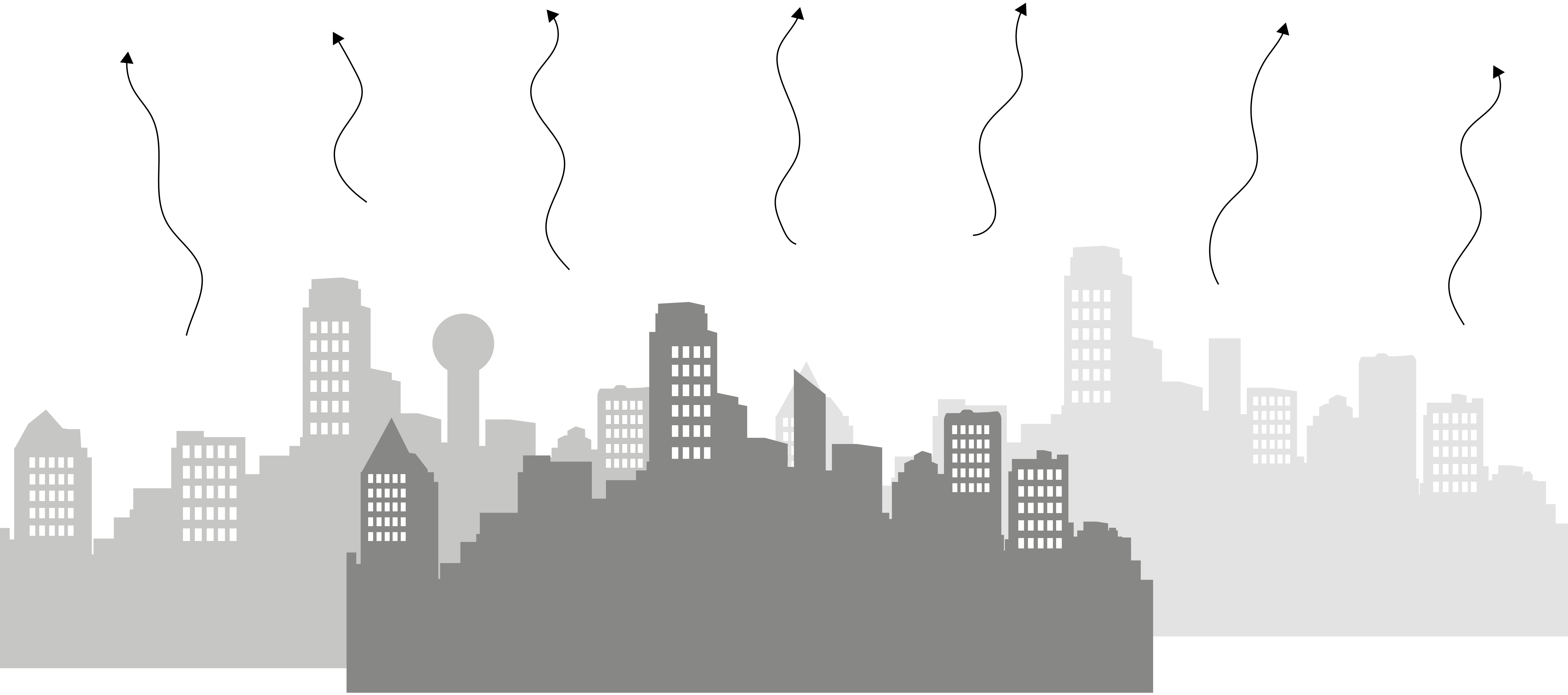
P5 PRESENTATION | NICK VAN DER KNAAP

PO-LAB: *InDetail*

"A research to contribute to the development of an innovative and sustainable product development laboratory, to provide the opportunity for further research towards a more sustainable built environment. "

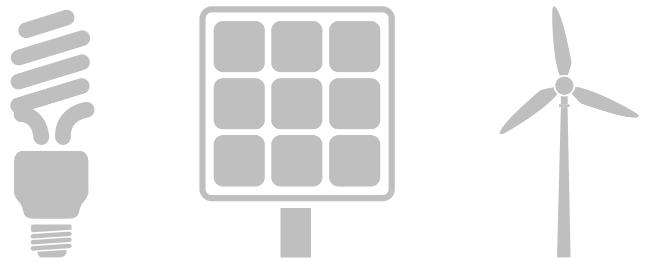
INTRODUCTION | GENERAL PROBLEM



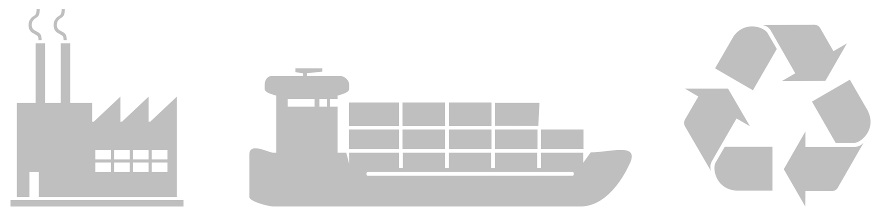
INTRODUCTION | TOWARDS SUSTAINABILITY

FUTURE GOAL:
Sustainable Buildings Industry

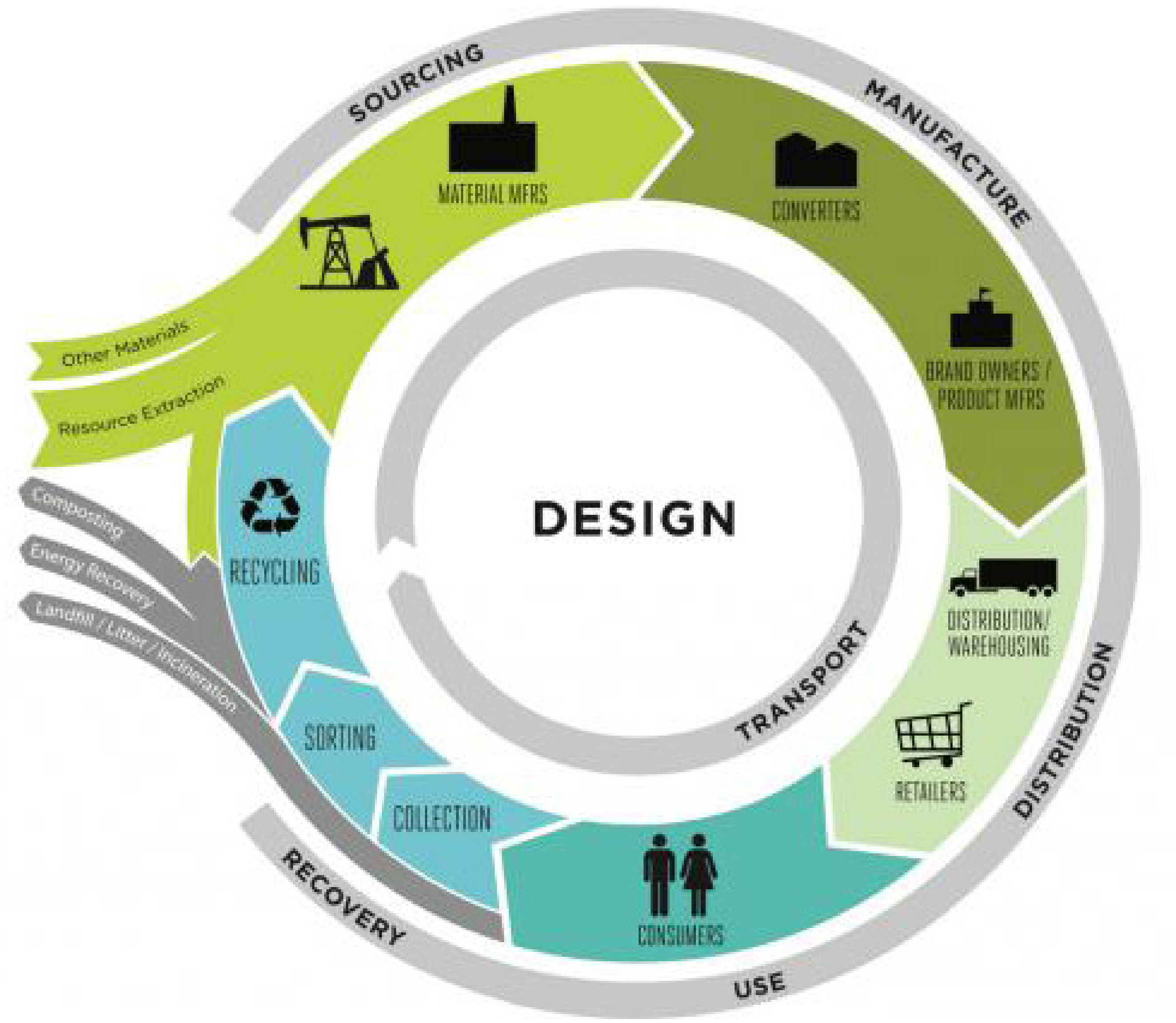
REDUCE OPERATIONAL ENERGY USE:
Efficient, insulated & natural resources



REDUCE EMBODIED ENERGY:
Reduce waste, Efficient transport & End-of-life solutions

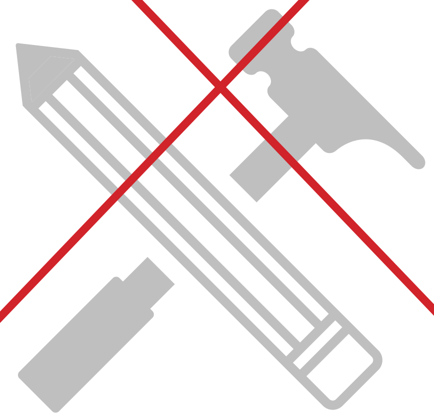


INTRODUCTION | TOWARDS SUSTAINABILITY



INTRODUCTION | RENEWED BUILDING PROCESS

TRADITIONAL BUILDING INDUSTRY



- Architect decides material and building method

- Contractor provides drawings and the actual building

- Every building is one-of-a-kind

NEXT INDUSTRIAL REVOLUTION

- Already visible in other industries like automotive and maritime.

- Building industry only 0.3% R&D

DIGITAL TECHNOLOGIES

- Integrated process

- Upfront decisions regarding customization and sustainability of the entire life-cycle

- Affordable, high quality and low-embodied energy buildings

INTRODUCTION | PO-LAB

Doel PO-Lab om onderzoek hiernaar te stimuleren!!!

Goals for the laboratory:

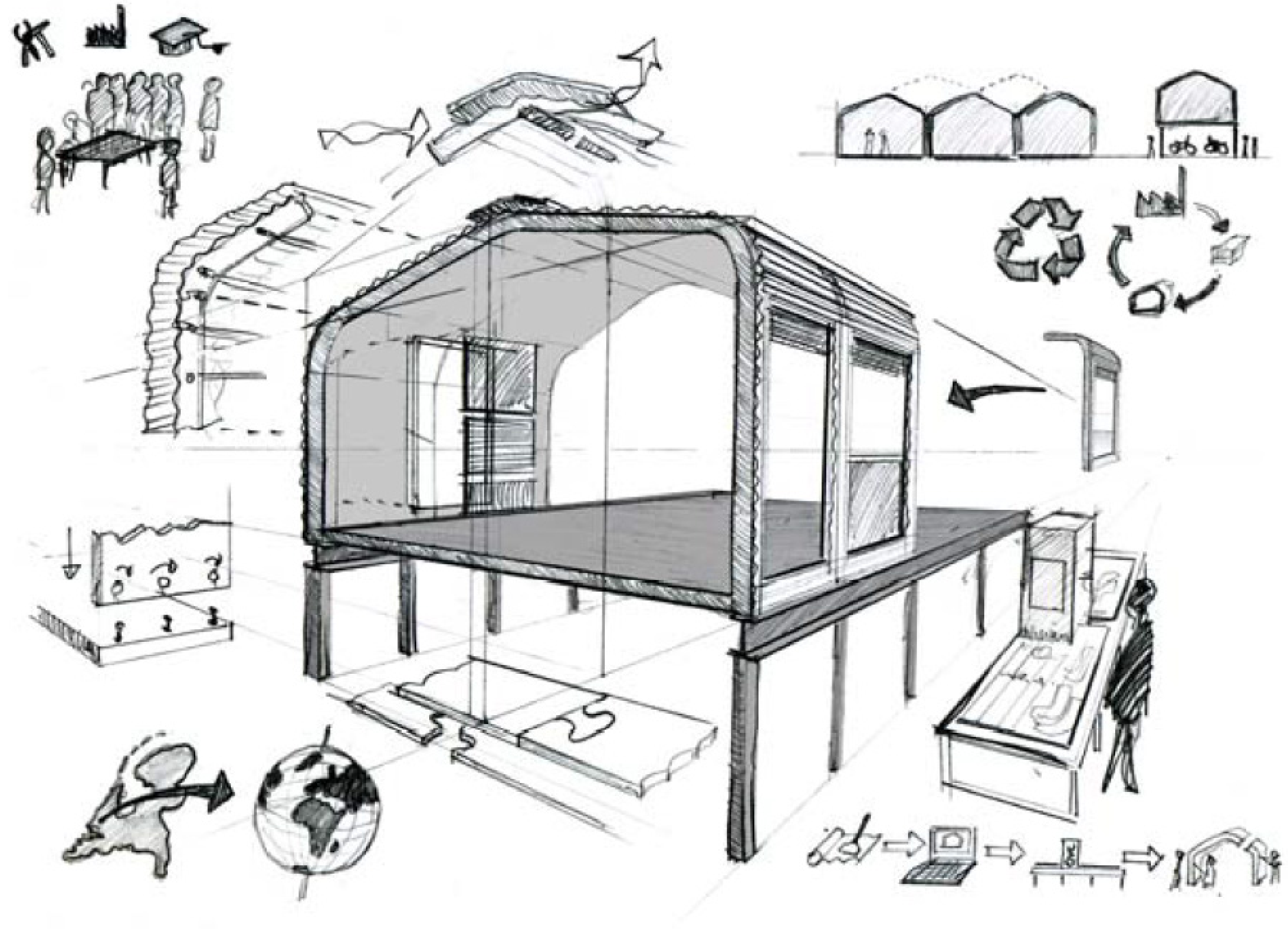
1. Sustainable material production and transport

2. Resource efficient production of building modules

3. Durable constructions with regards to functionality

4. Fast and easy to construction process

5. Strategies for disassembly, reuse and recycling



INTRODUCTION | PO-LAB

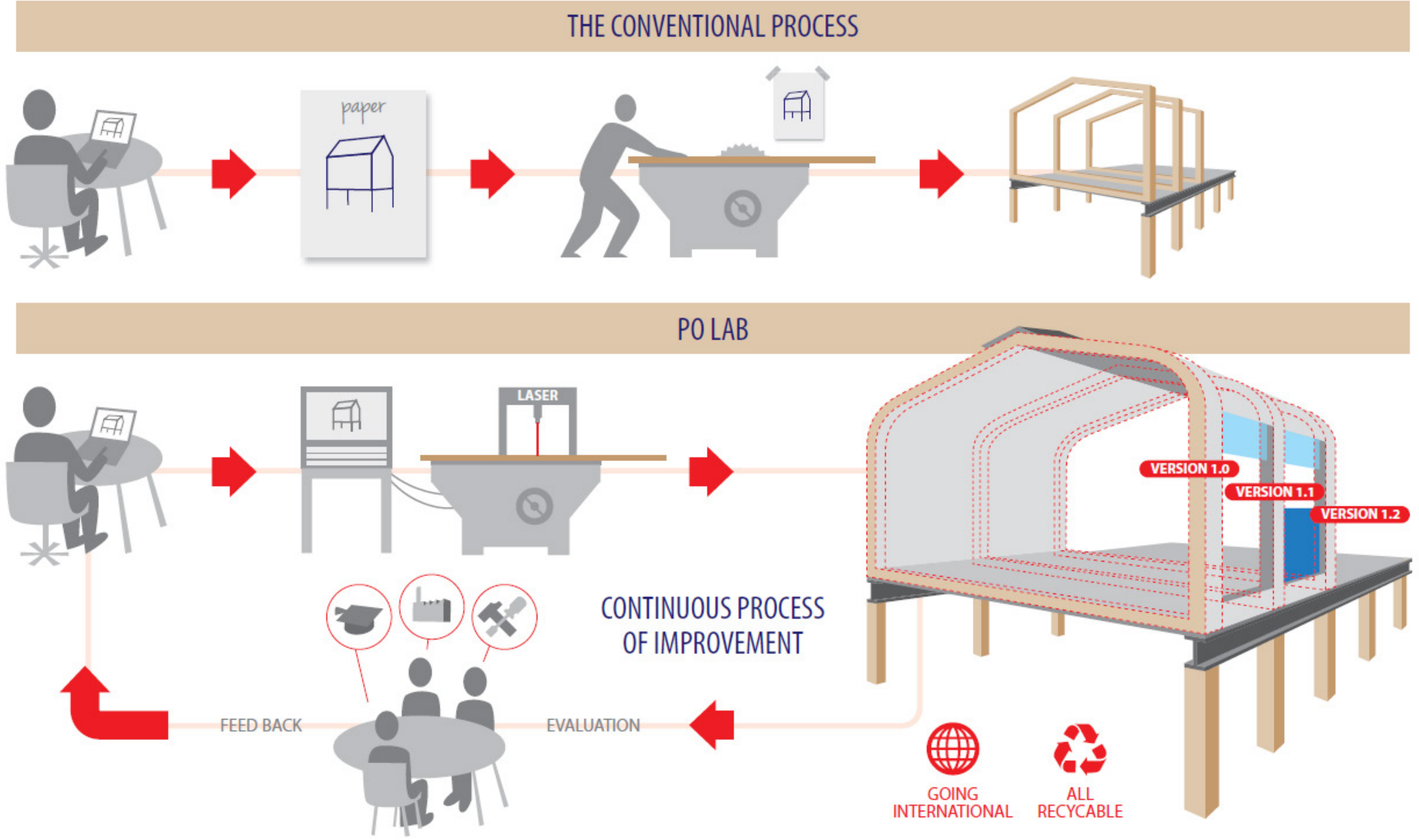
DIGITAL MANUFACTURING

1. File-to-Factory
   No more, paper drawings. Immediate digital data

2. Rapid prototype & rapid manufacturing
   Digital data into very accurate products

3. Mass produce customized product
   High customization without adjusting machines

4. From global to local production
   Fabfac's instead of large polluting factories



These aspects ask for a renewed approach in constructing
- A design that is adaptable to different context
- Customize but with the same base (like cars)

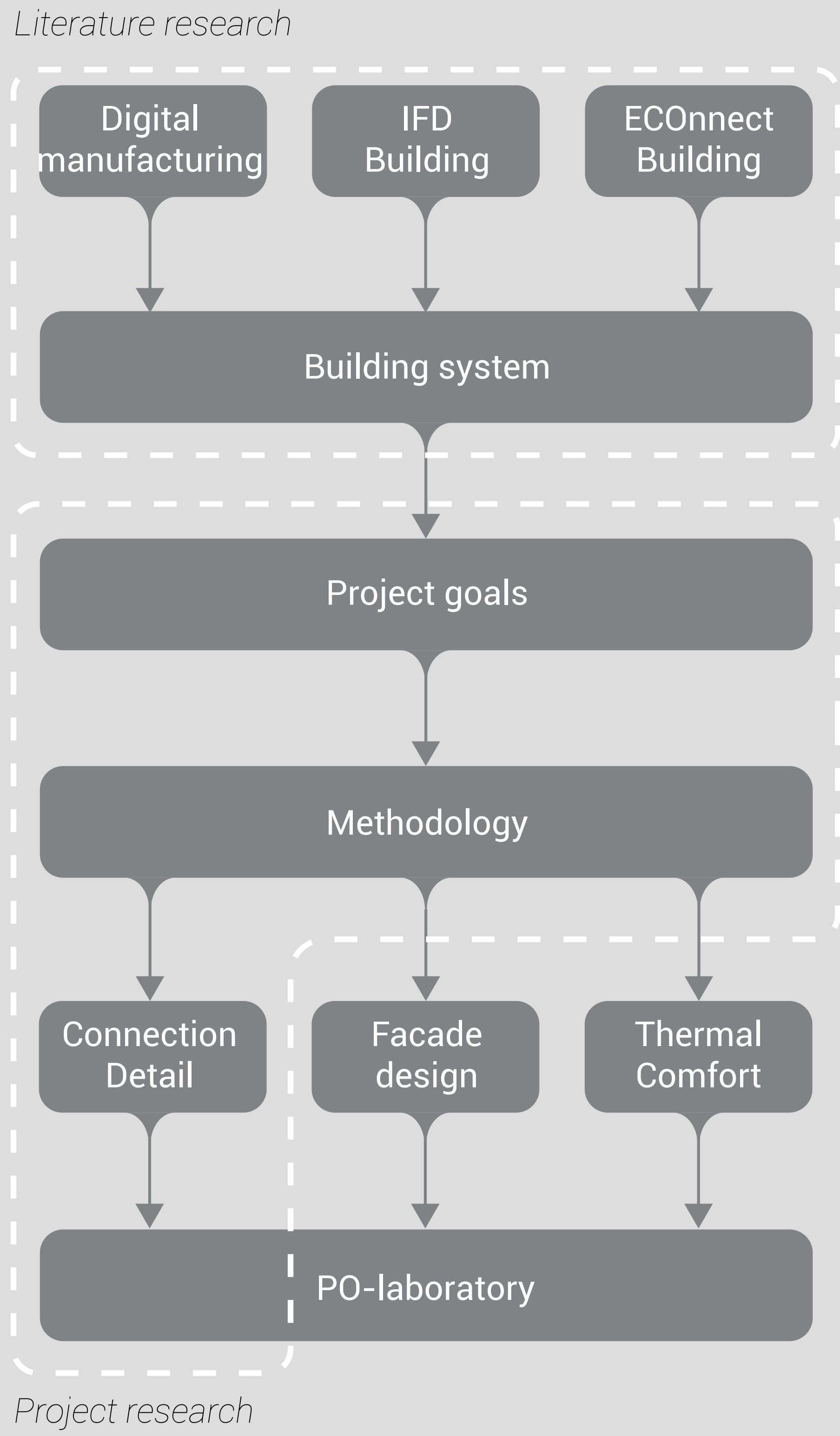
RESEARCH |

How to use CNC-milling technology to develop an innovative and sustainable product development (PO) laboratory?

- How do we solve the problems of the current building process and what can be learned from other industries?

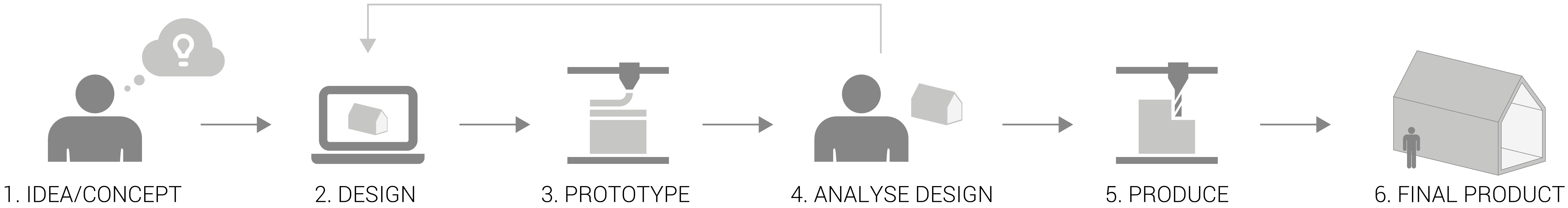
- How can methods and technologies of Product Design and the manufacturing industry be implemented in the building industry?

- How can we use the improvements of the building process, to change the way we approach design and construction?



RESEARCH | DIGITAL TECHNOLOGIES

LASER / 3D



ROBOT / FREES

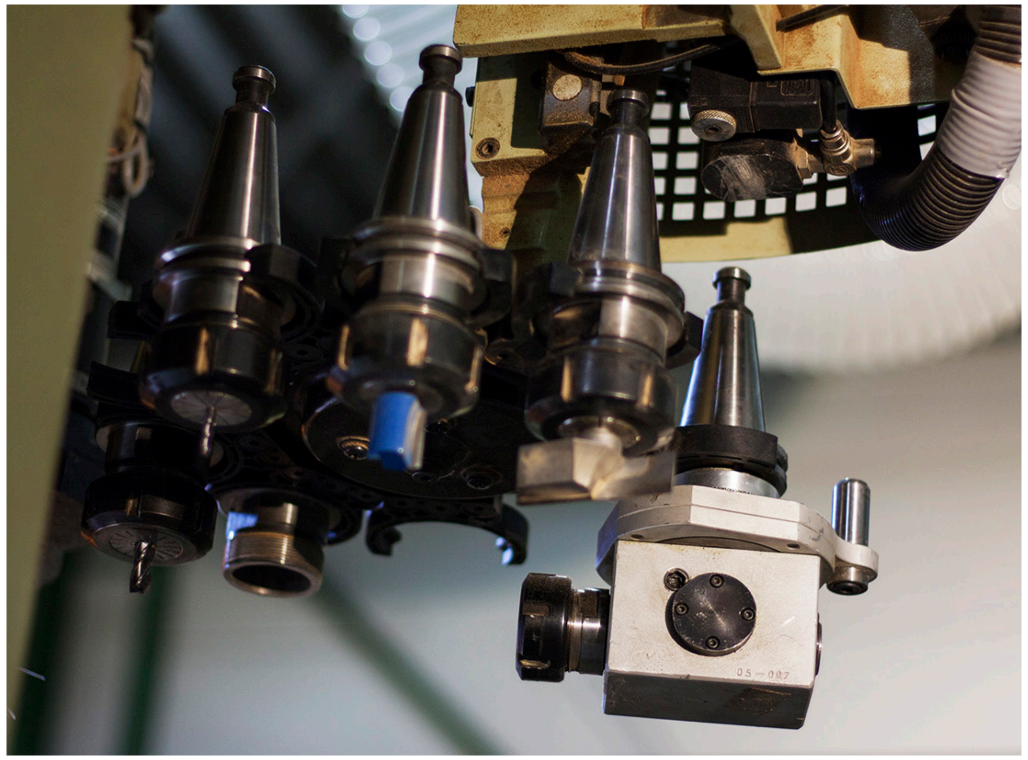
CNC-TECHNOLOGY

Advantages

- 2,5D production plane
- Very accurate, 0,1mm tolerance
- Multiple woodworking tools in 1 machine

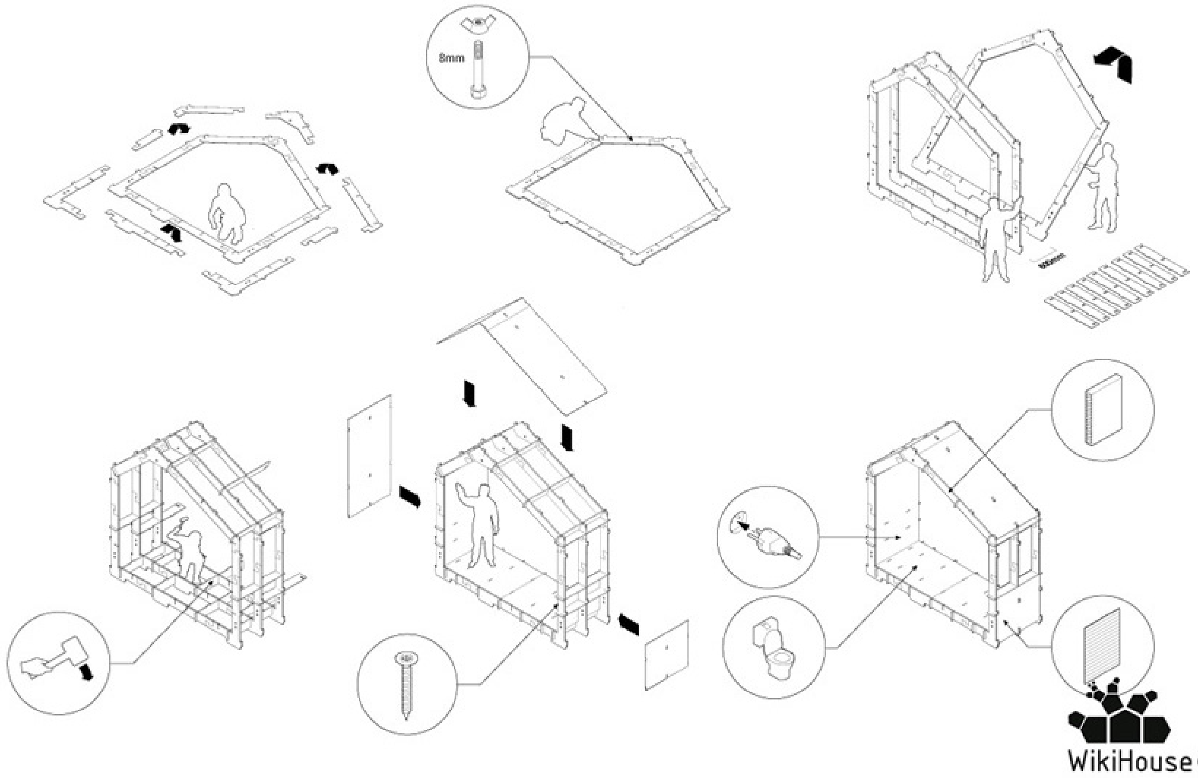
Limitations

- Design failures result in much cost and waste
- Dimension of 1220mm by 5000mm
- Only milling on 1 side
- Sharp corners result in T-bones
- Efficient nesting is required



WIKIHOUSE
Alastair Palvin

Bron: Wikihouse.cc



CNC fabricated **elements (ETO)**

Big ‘puzzle’ of parts

Very accurate

No power tools needed

Modular in 1 direction

Downside:

- open-source
- complex puzzle
- structure not building
- not standardized
- every design need new detail

EENTILEEN

Agdrup & Bjorndal

Bron: designboom.com

Prefab CNC fabricated **components (MTS)**

Build-able with only 2 persons

Insulation integrated in the components

Modular in 3 directions **(Bus modularity)**

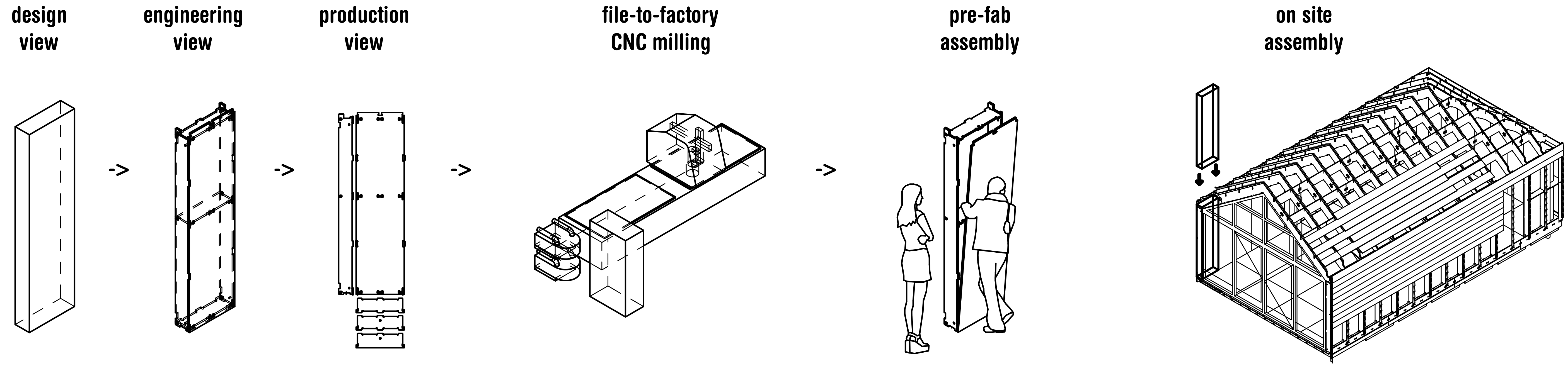
Downside:

- bus modularity needs structure
- structure not adaptable
- structure needs engineering every time
- not standardized

RESEARCH | CNC-MILLING IN ARCHITECTURE

ECONNECT
Pieter Stoutjesdijk

Bron: Pieter Stoutjesdijk



Step 1 Design the **components (ATS)**

Step 2 Engineer the components

Step 3 Make it producible

Step 4 Only a CNC miller is needed

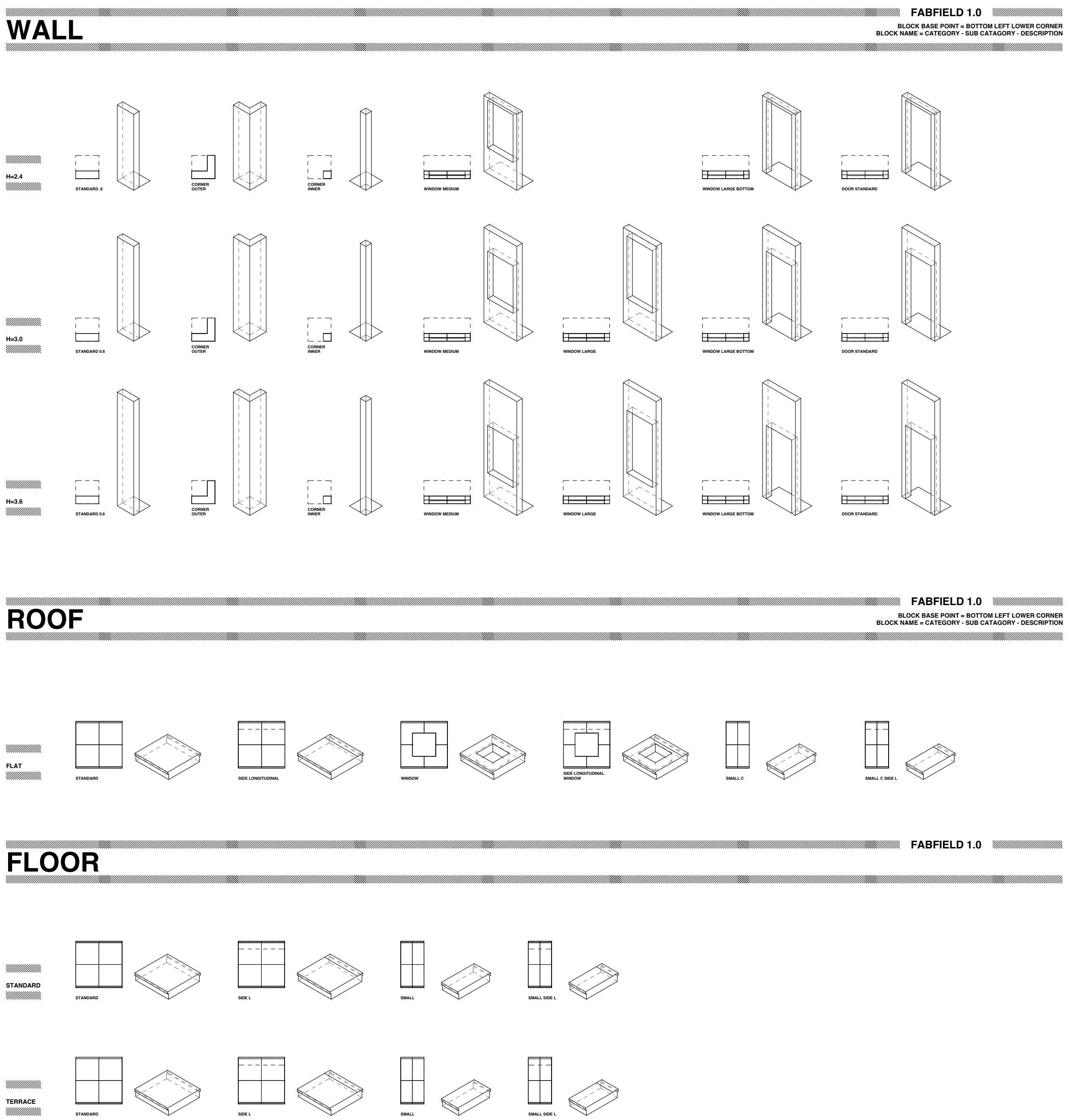
Step 5 Component assembly in factory

Step 6 Quick on site assembly process **(Bus modularity)**

RESEARCH | CNC-MILLING IN ARCHITECTURE

PRODUCT DATABASE

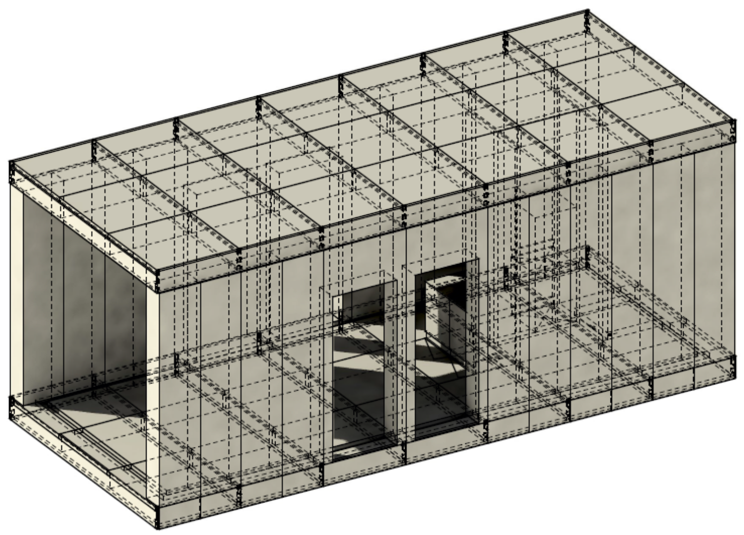
Step 1 -3 require much engineering to create the database, but when it is finished every design can be fabricated in only a few minutes.



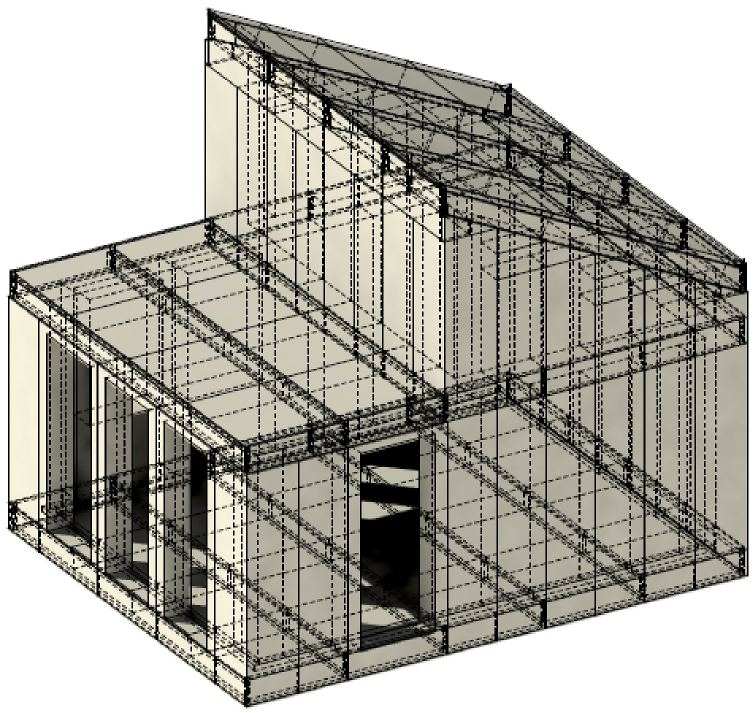
EXAMPLES

Bron: Pieter Stoutjesdijk

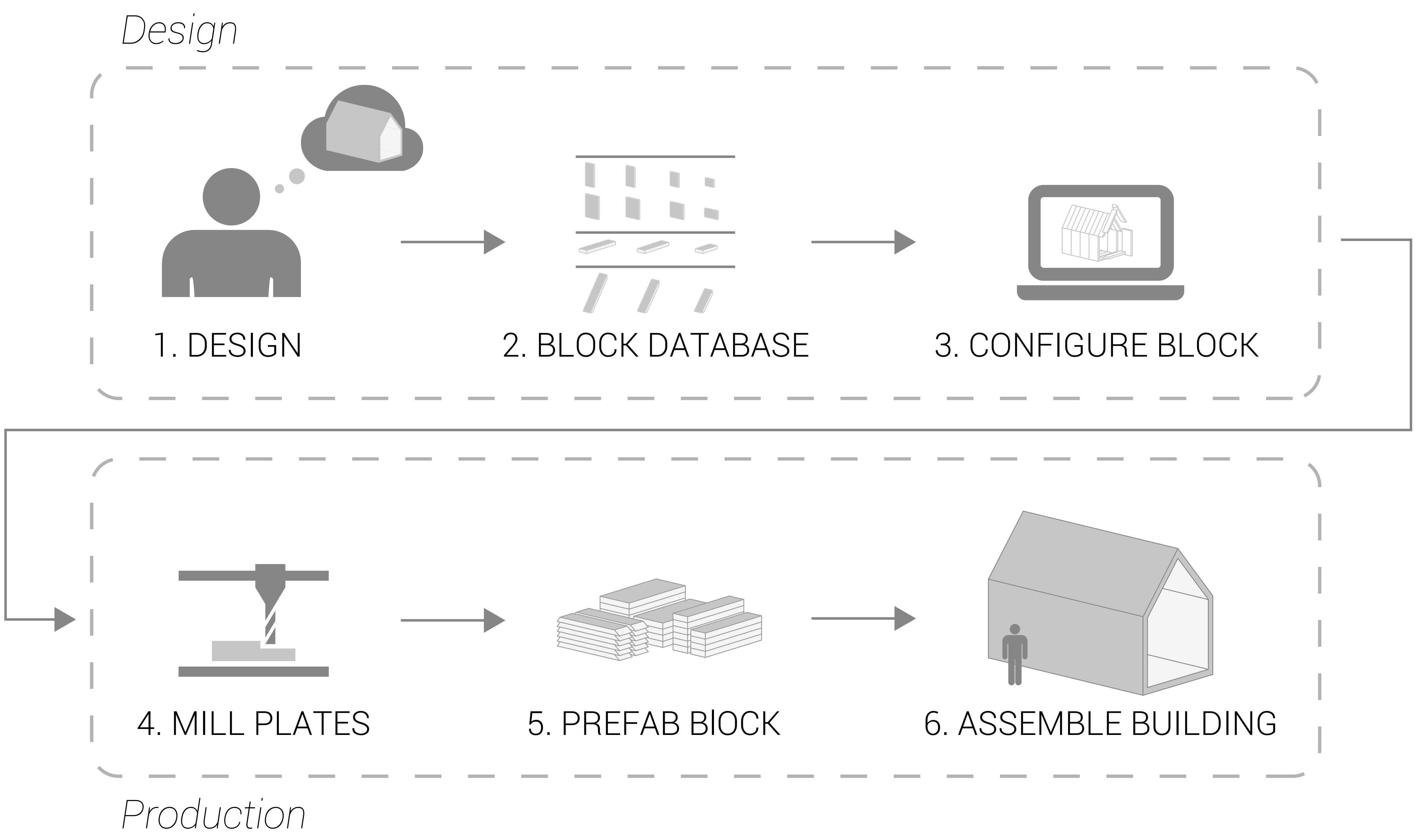
MAPA Architects
25.000 Euro
Milling time: 20h
Prefab assembly: 47h
On site assembly: 47h



Woody15
30.000 Euro
Milling time: 25h
Prefab assembly: 45h
On site assembly: 55h



RESEARCH | PO-LAB SYSTEM



DESIGN TASKS:

- ***Connection detail***
- Facade
- Installations /thermal comfort
- Interior

Connection detail:

Behave like every ordinary detail, but:

- CNC producible

- Modular components

- Vapour open

- Optimized to building ease and speed

RESEARCH BY DESIGN |

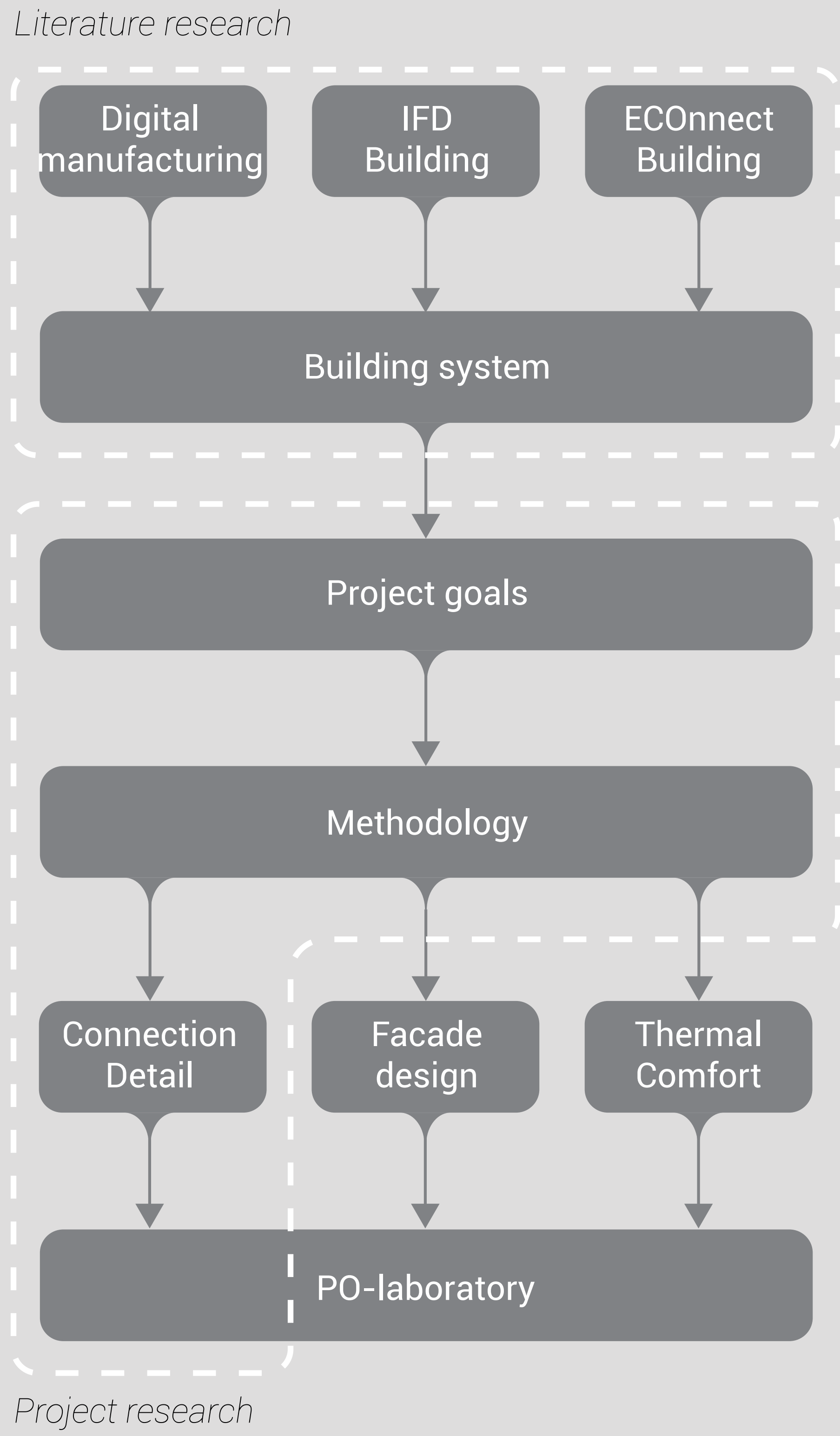
How to connect digital (pre)fabricated building components, to create a modular building system, with takes in consideration its entire life cycle? (PO-Lab)

How can a methodology, to develop a sustainable digital-prefabricated building product, be generated that has (user) requirements as leading aspect?

- *What methodologies are used in product development?*
- *How can user requirements be integrated?*
- *How can sustainable aspect of modularity be integrated in (building) product development?*
- *How is the methodology used to generate a concept?*

What are the criteria for a connection detail in a modular building system (PO-Lab)?

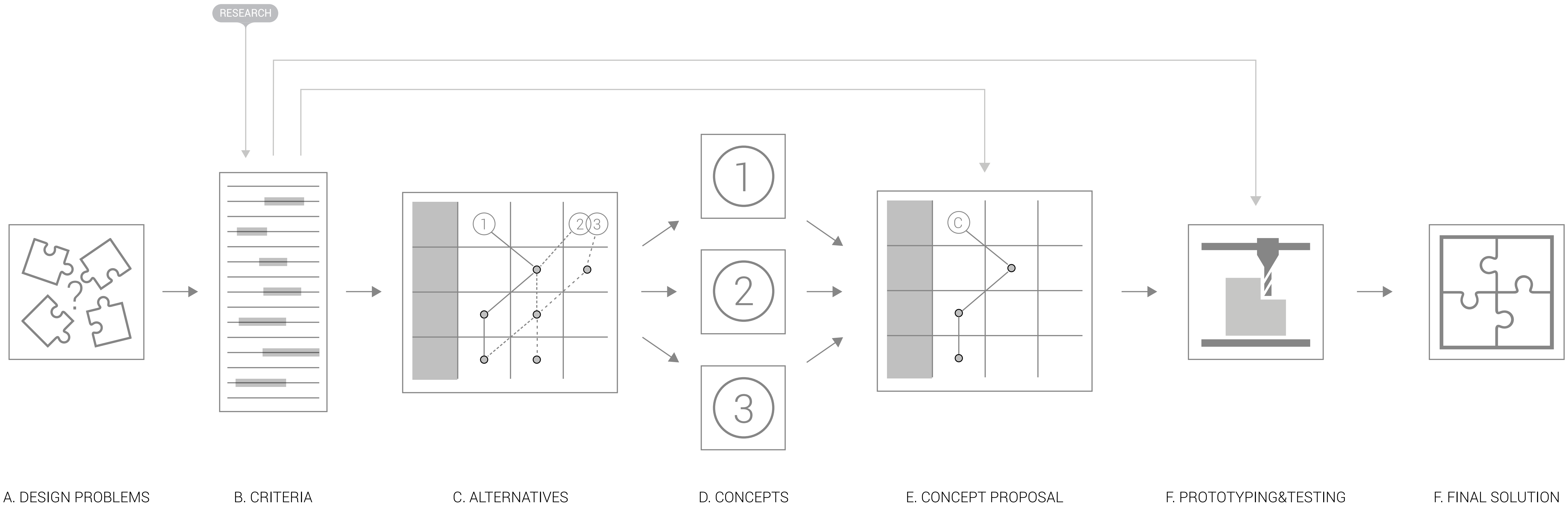
- *What are the exact project goals, that can be derived from the sustainable strategies?*
- *How can the project goals be used in the development of a (concept) design?*



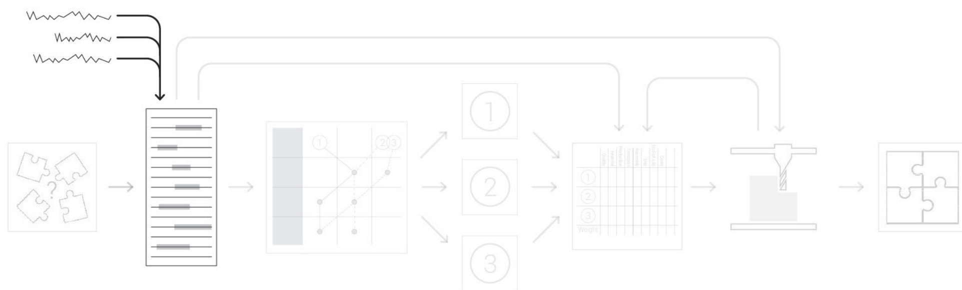
RESEARCH BY DESIGN | METHODOLOGY

METHODOLOGY

- Renewed approach requires renewed methodology
- Who makes the decision and when do we have to make them?
- Architect involved during the entire process
- Decisions on entire life cycle need to be made upfront.
- Methods of product development are introduced

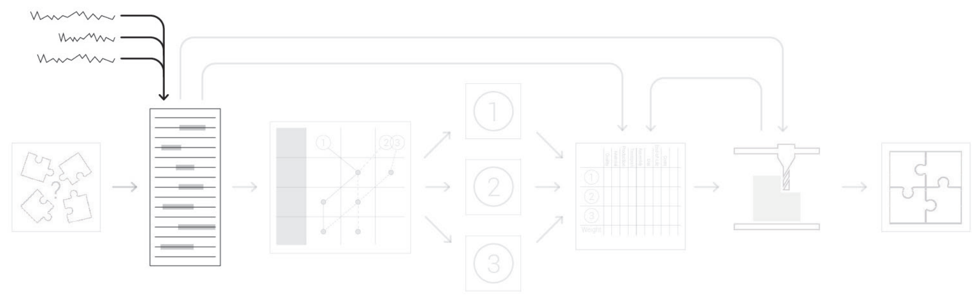


RESEARCH BY DESIGN | DESIGN PROBLEMS



	Combine components	Structural behaviour	Placement	Connection type	thermal comfort	Water resistance	Airtightness
Function	How do the components meets? The concept modular of the components need to be integrated in combining the components. Is it still adaptable?	What kind of laod can the connection bear? With taking in consideration the modular behaviour in combination to the oversizing.	How are the components placed? What method is the easiest to install them, are they stable when building? Can the be in the wrong place?	How to join all the different components? Taking in consideration the goals of (dis)-assembly easy and speed, but strong enough to bear the loads	How to insulate the component during production to save time in the onsite assembly? The vapour open system requires special insulators	The vapour open building system requires vapour open water protection ECOnnect had problems integrating this in the concept.	The building is vapour op, however it is important to keep the building airtight. This prevents heat loss, and improves thermal comfort

RESEARCH BY DESIGN | CRITERIA



Strategies		*Ambitions*
DESIGN	- Development of scenarios for building use - Integrate building process - Developing effort in relation to standarization	- Freedom of design - Level of Finishing
MATERIAL	- Use of recyclable or reusable material - Avoid harmful substances - Use of low weight materials - Consider energy to obtain material in in relation to material lifespan	- Environmental impact
PRODUCTION	- Minimize residual waste in production - Digital technologies to improve quality and minimize production tolerances - Minimize human labour, thus assembly errors - Decrease energy use in production	- Batch size - Nesting efficiency - Milling time - Amount of elements - Assembly complexity
TRANSPORT	- Minimize product bounding box - Avoid vulnerable parts	- Vulnerability - Loading efficiency
ASSEMBLY	- Dry assembly - Parallel assembly - Minimize on-site building activities - Minmize use of heavy equipement - Provide easy handling methods - Provide feedback for correct assembly	- Ergonimics - Weigth - Amount of components - Amount of joints
USE	- Provide possibilities to adapt lifespan to changing demands - Easy to maintain - Minimize energy use	- Adaptability - Maintenance - Accessibilty
END OF LIFE	- Design for disassembly in all levels - Aim for highest EoL-activity - Consider durable materials in relation to lifetime and reuse	- EoL-activity - Lifespan - Disassembly ease
COSTS	- Consider all decisions in relation to economic feasibility	- Costs, in combination to lifespan and reuse

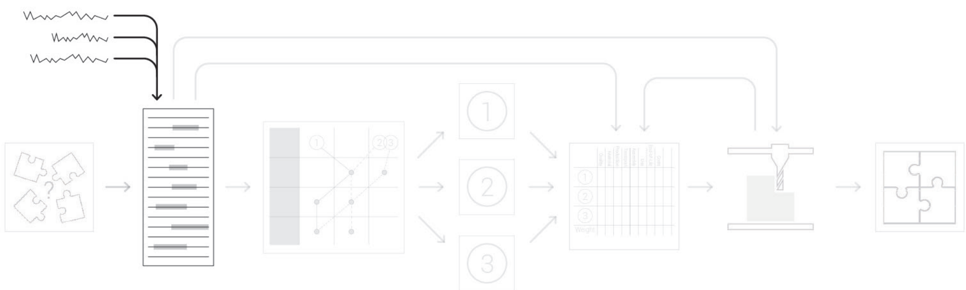
Requirements:

- Ordinary detail
- CNC limitations
- Design requirements

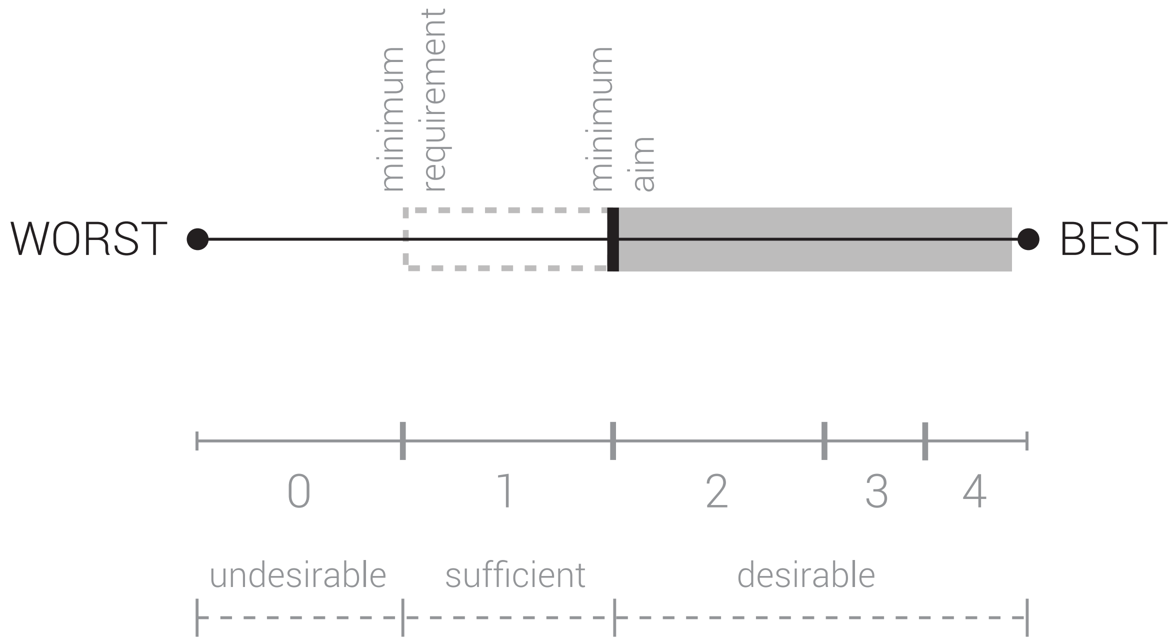
Ambitions:

- User requirements > PO-lab goals
- Design for environment > Life-cycle phases
- Design for manufacturing > optimize production

RESEARCH BY DESIGN | CRITERIA



	Freedom of design	Aesthetic	Environmental imp.	Batch Size	Process time	Component assemb.	Am. of elements	Nesting	Weight	Vulnerabilty	Loading efficiency	Adaptability	Accessability	Building speed	Building ease	Am. of components	EoL activity	Lifespan	Disassembly	Costs	SCORE	WEIGHT
Freedom of design	■	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	0	1	0	1	14	3
Aesthetic	0	■	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Environmental imp.	1	1	■	1	0	1	1	0	1	1	1	0	1	0	0	1	0	1	0	0	11	2
Batch Size	0	1	0	■	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
Milling time	0	1	1	1	■	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	8	2
Assembly complex.	0	1	0	1	0	■	1	0	1	0	0	0	0	0	0	0	0	0	0	0	4	1
Am. of elements	0	1	0	0	0	0	■	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1
Nesting efficiency	1	1	1	1	1	1	1	■	1	1	1	0	1	1	1	1	0	0	0	0	14	3
Weight	0	1	0	1	0	0	0	0	■	0	0	0	0	0	0	0	0	0	0	0	2	1
Vulnerabilty	0	1	0	1	0	1	1	0	1	■	0	0	1	0	0	0	0	1	0	0	7	1
Loading efficiency	0	1	0	1	1	1	1	0	1	1	■	0	1	0	1	0	0	0	0	0	9	2
Adaptability	1	1	1	1	1	1	1	1	1	1	1	■	1	1	1	1	0	1	1	1	18	3
Accessability	0	1	0	1	0	1	1	0	1	0	0	0	■	0	0	0	0	0	0	0	5	1
Am. of joints	0	1	1	1	1	1	1	0	1	1	1	0	1	■	0	1	0	0	0	0	11	2
Ergonomics	0	1	1	1	1	1	1	0	1	1	0	0	1	1	■	1	0	0	0	0	11	2
Am. of components	0	1	0	1	1	1	1	0	1	1	1	0	1	0	0	■	0	1	0	0	10	2
EoL activity	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	■	1	0	1	18	3
Lifespan	0	1	0	1	1	1	1	1	1	0	1	0	1	1	1	0	0	■	0	0	11	2
Disassembly	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	■	0	17	3
Costs	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	■	16	3



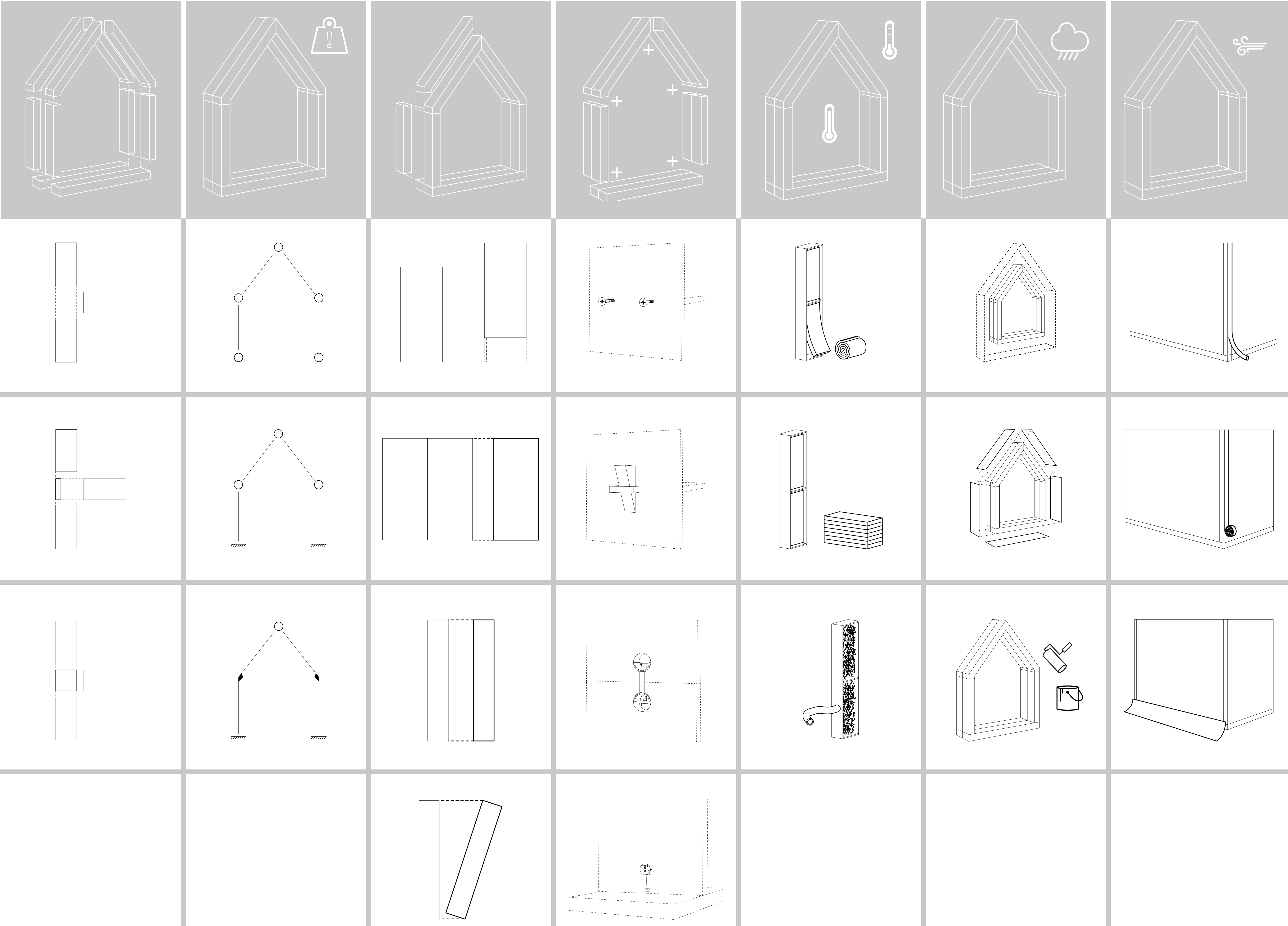
Weight ambitions:

- Compare all ambitions to each other
- ***not so important = 1***
- ***important = 2***
- ***very important = 3***

Aim:

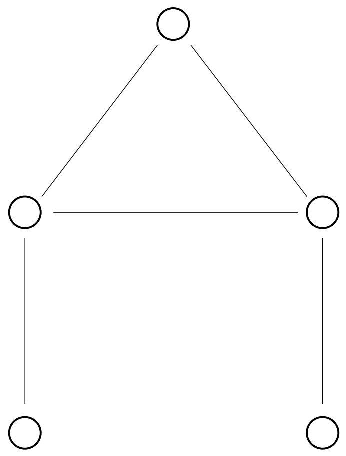
- Set a minimal aim
- ***not sufficient = 0***
- ***sufficient = > 1***
- Better score means, more desirable

RESEARCH BY DESIGN | ALTERNATIVES

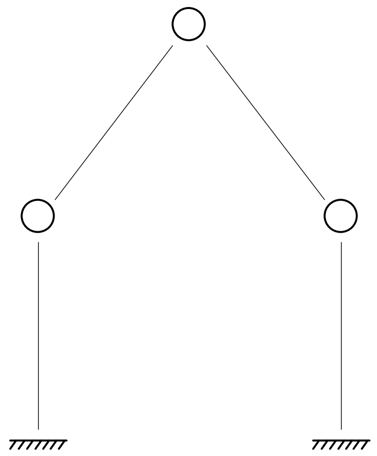


RESEARCH BY DESIGN | ALTERNATIVES

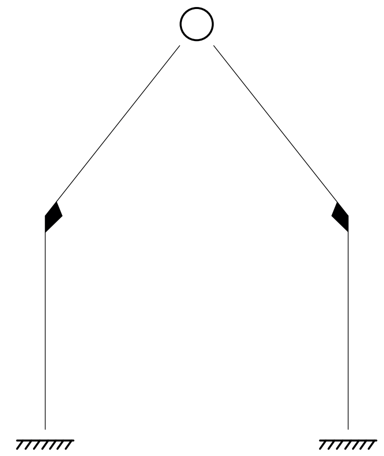
Structural behaviour of connection



ONLY HINGED

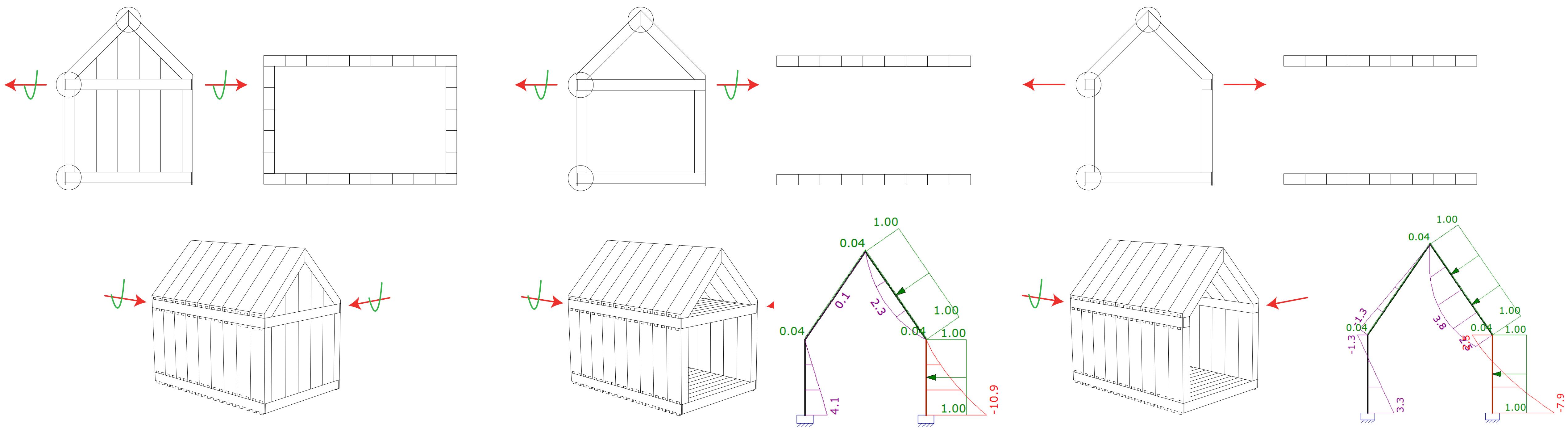


BOTTOM FIXED



ALL FIXED

- freedom of design
- component assembly
- process time
- transport
- modularity
- building speed
- building ease



More connections and more complex details, to reach more freedom of design

+ Completely Stable
+ No complex details

- Very little freedom in design
- Hard to disassemble

+ Freedom in Facade design
+ Freedom in Building design

- More complex detail
- A lot of forces on bottom detail
- Different detail top and bottom

+ Freedom in Facade design
+ Freedom in Building design
+ Easier install
+ Forces more distributed

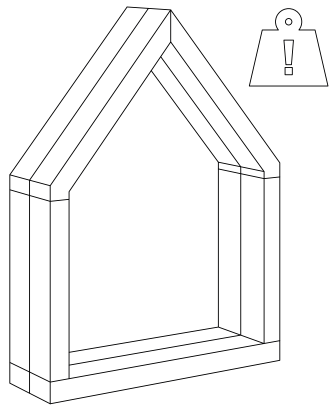
- More complex details

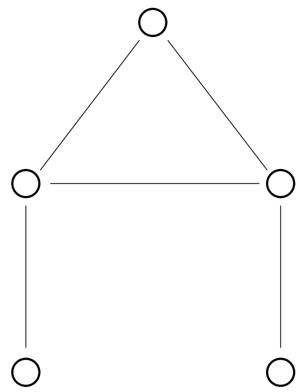
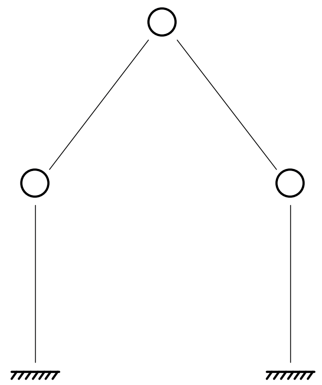
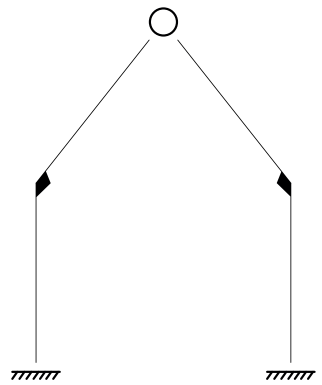
RESEARCH BY DESIGN | ALTERNATIVES

Structural behaviour of connection

- freedom of design
- component assembly
- process time
- transport
- modularity
- building speed
- building ease

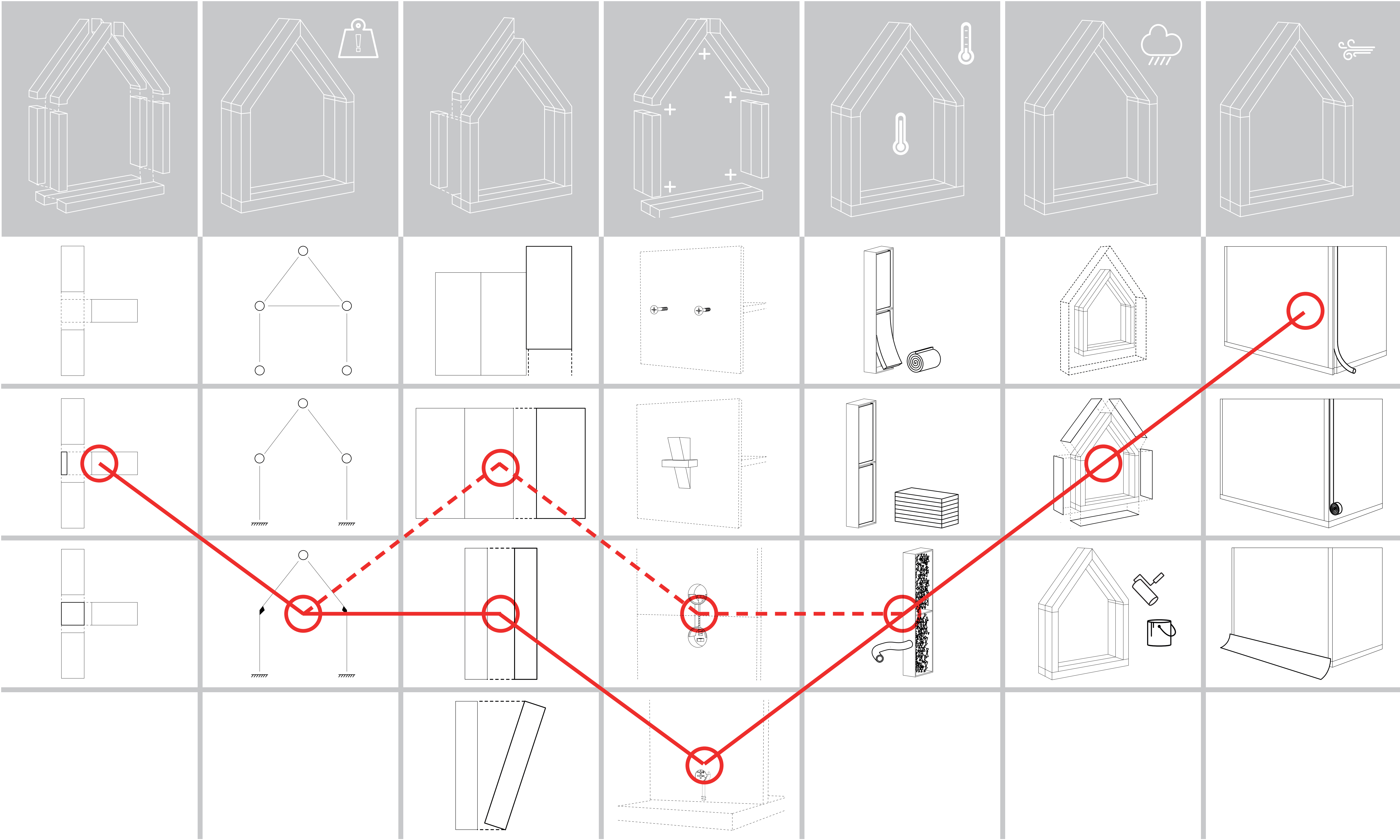
More connections and more complex details, to reach more freedom of design



Criteria	weight			
- freedom of design	3	3	12	12
- milling time	2	6	4	4
- assembly complexity	1	3	3	2
- loading efficiency	2	4	2	2
- adaptabilty	3	3	6	9
- amount of joints	2	6	2	4
Score		31	31	37

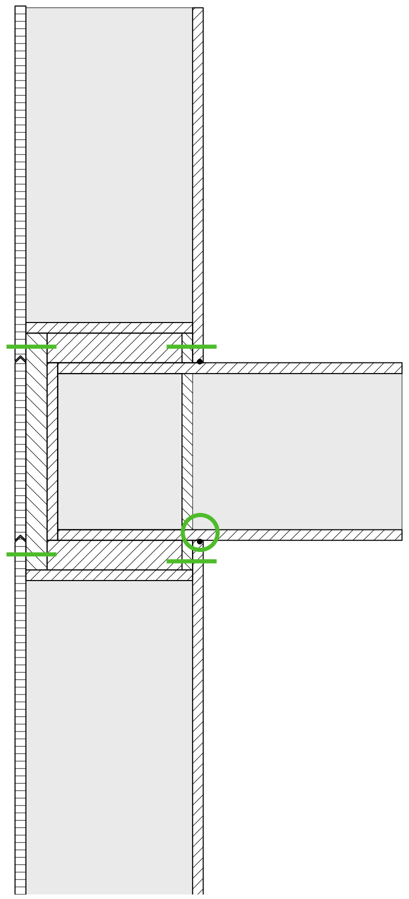
RESEARCH BY DESIGN | ALTERNATIVES

ALTERNATIVE SOLUTIONS



PLACING COMPONENT

Option 1

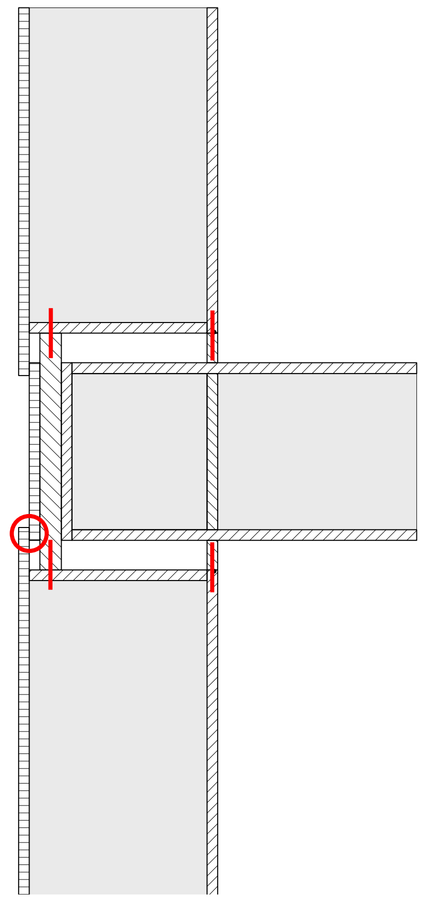


+ connection
+ water-protection
+ airtightness

- single module is stuck

(BEST OPTION)

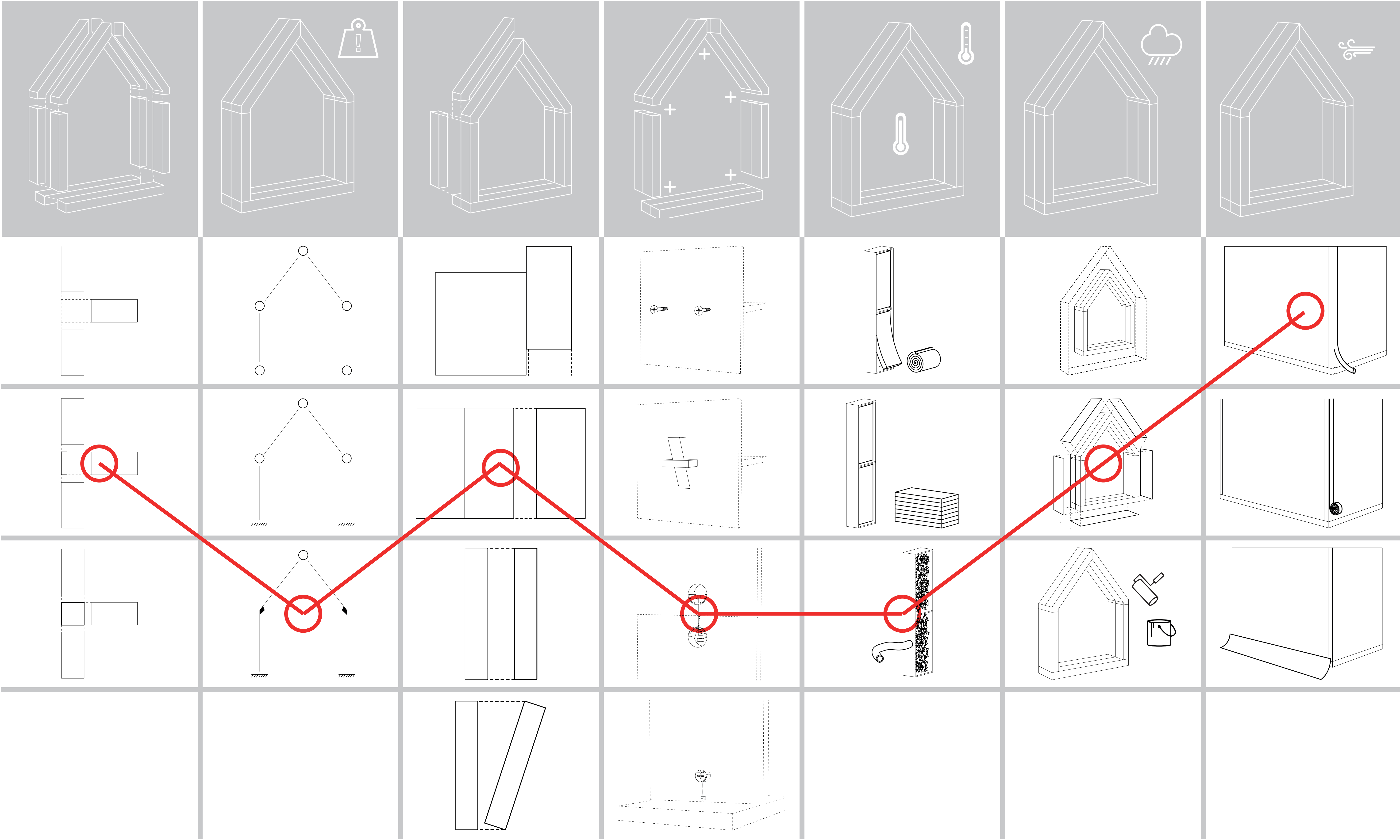
Option2

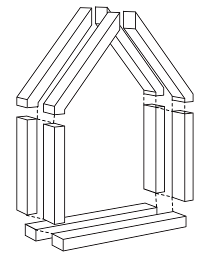


+ remove single element

- water-protection
- air gap
- weak connection

RESEARCH BY DESIGN | E. CONCEPT PROPOSAL





COMBINE COMPONENTS:

To transfer loads and connect

A. Bevelled Layer, to carry the floor

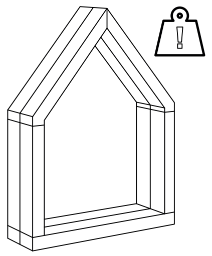
B. Combining floor and wall

C. Combining floor and wall, and close the openings

D. Waterproof material

RESEARCH BY DESIGN | E. CONCEPT PROPOSAL

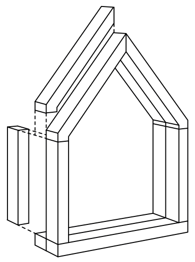
STRUCTURAL:



A. 300mm couple

B. 2 notches to transfer loads

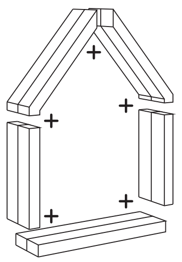
PLACEMENT:



C. Place walls from above

D. Floor lifted in beam

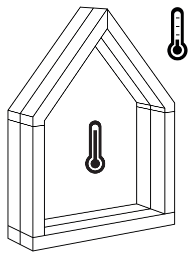
CONNECTION:



E. Inserted nut

F. Beam penetrating and
connecting all components

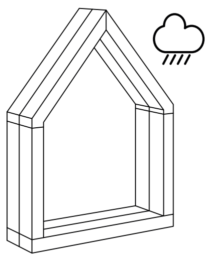
THERMAL:



A. Injected insulation

B. No thermal bridges

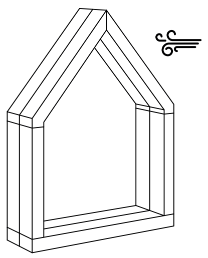
WATER:



C. Water protective plates

D. Watertight edges

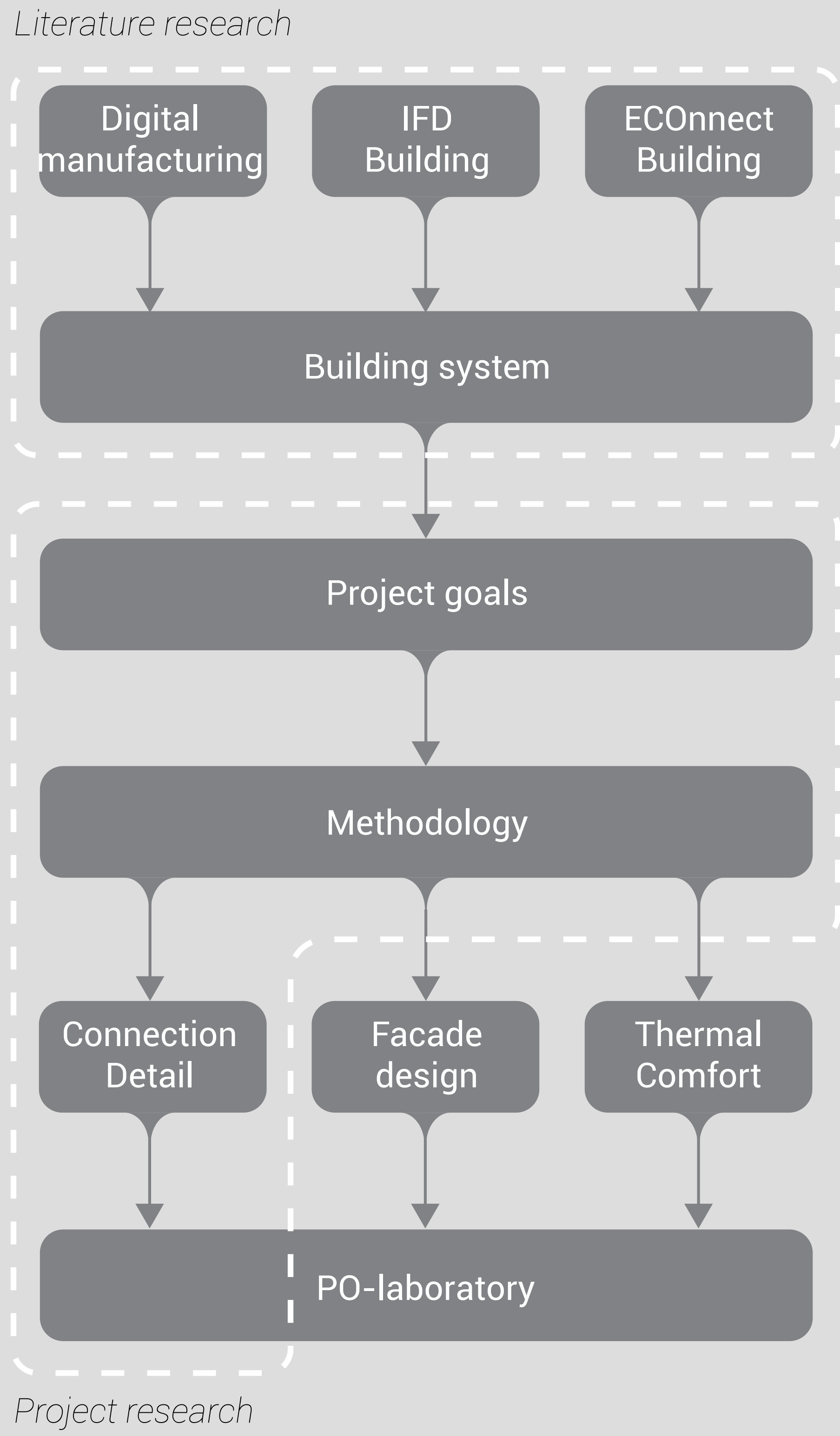
AIR:



E. Integrated rubber

F. Both in the sides and bottom

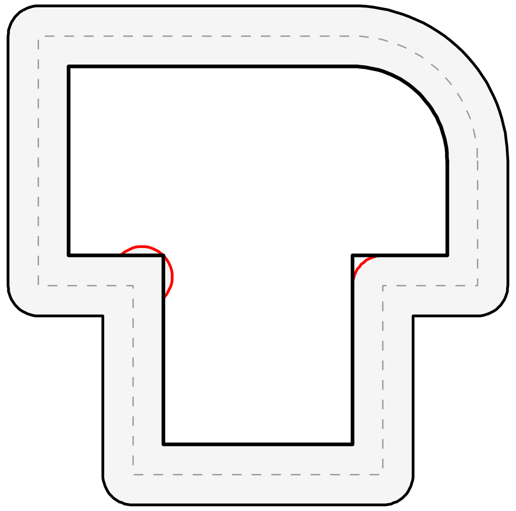
REALISATION |

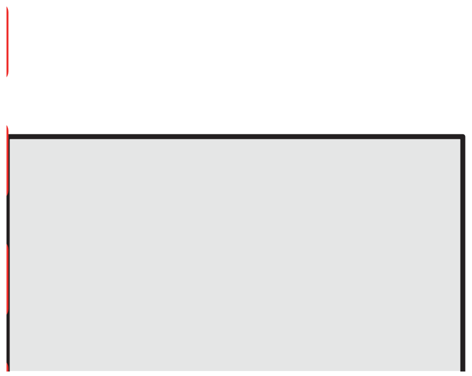


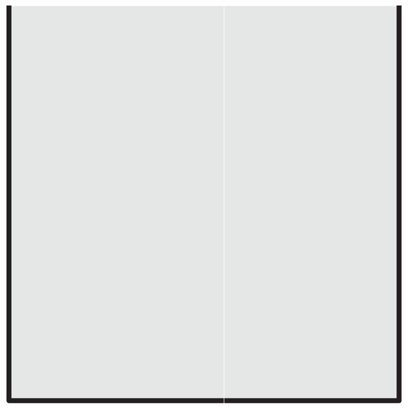
REALISATION | PROTOTYPE 1

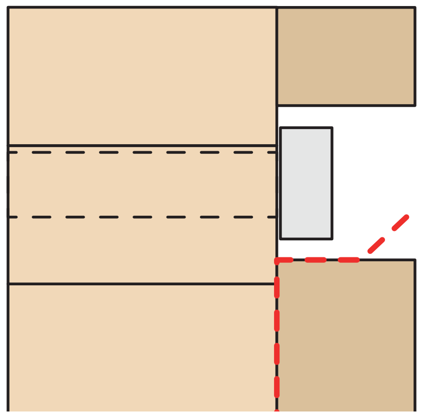
PROTOTYPE 1:

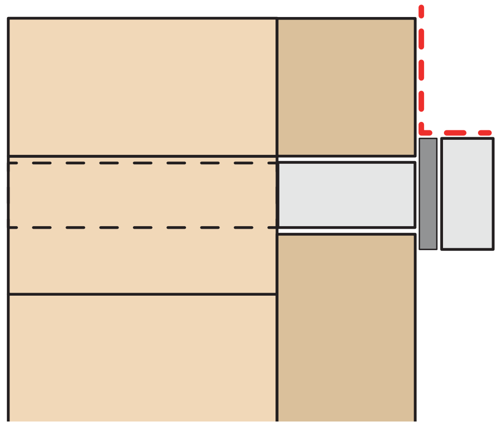
- Assembly component problems
- Connecting component problems
- Building physics problems

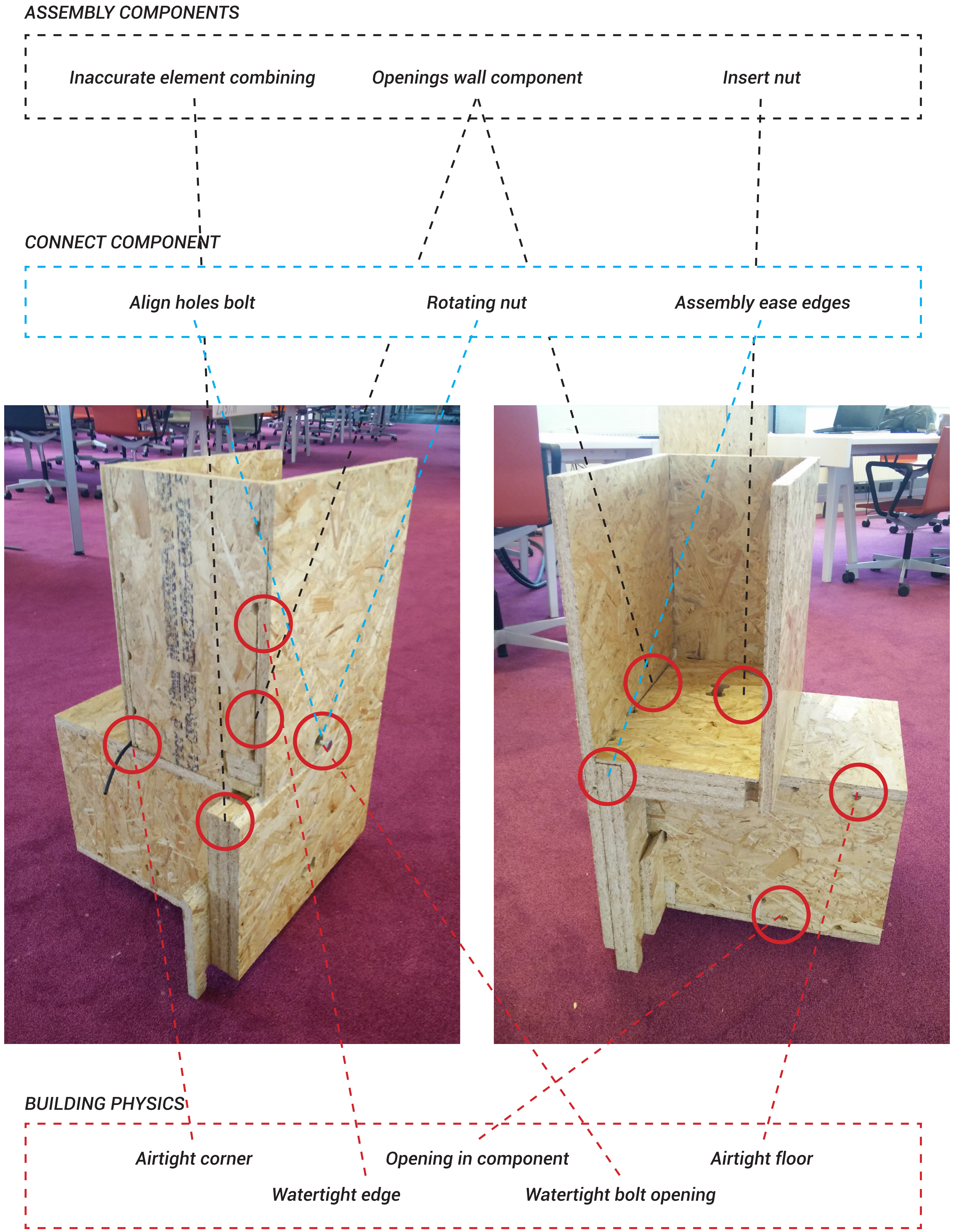








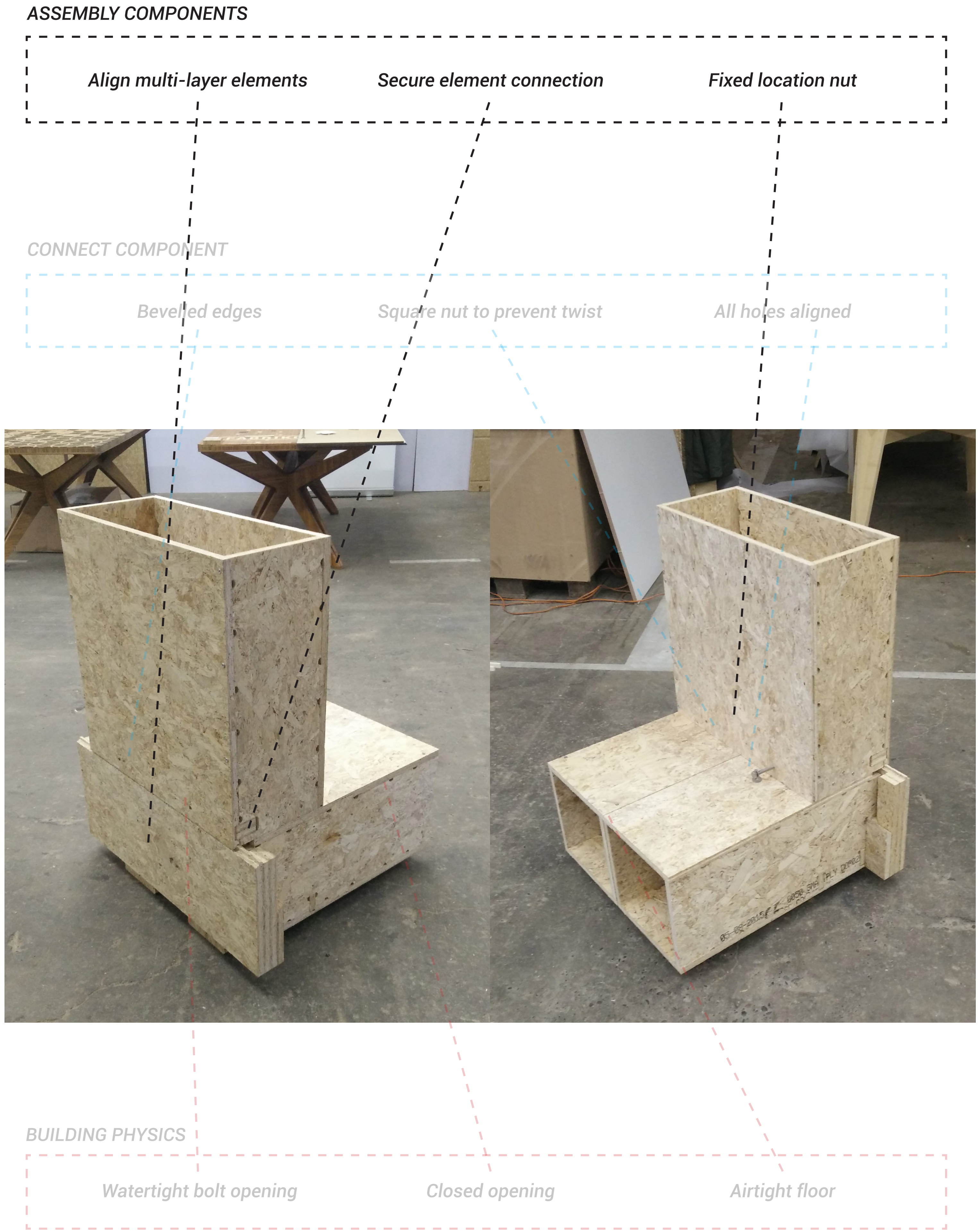




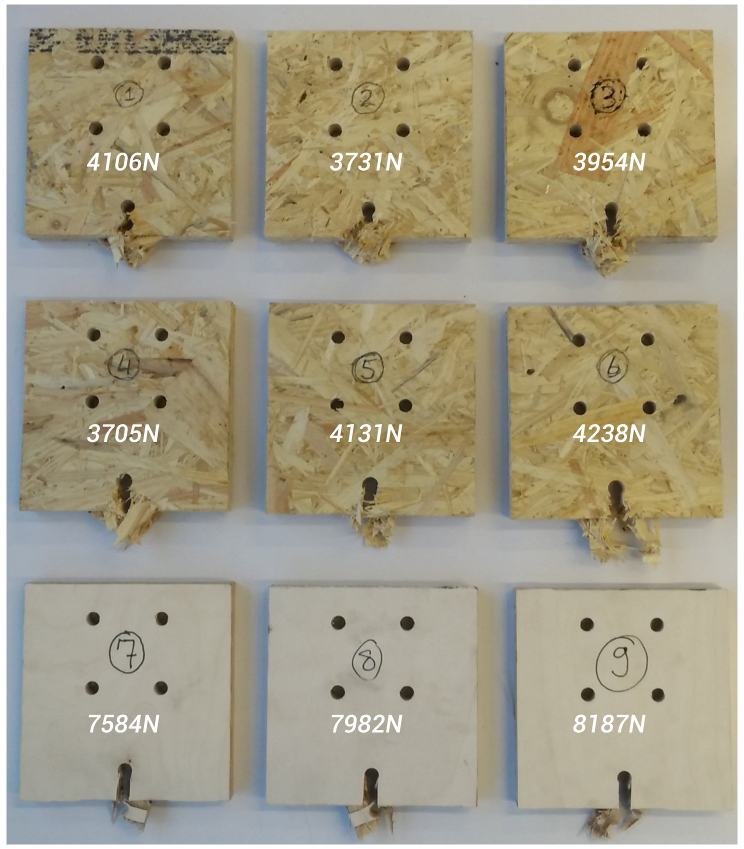
REALISATION | PROTOTYPE 2

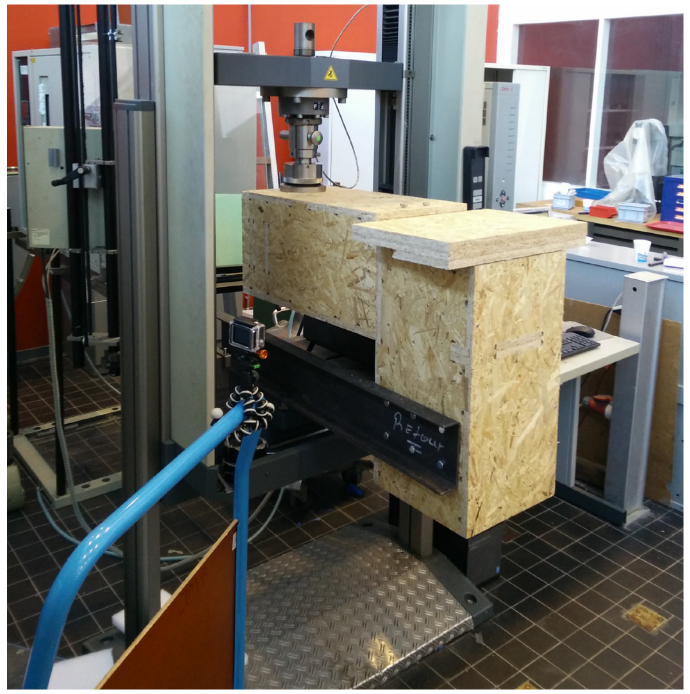
PROTOTYPE 2:

• Problems solved



REALISATION | STRUCTURAL TEST





REALISATION | FINAL DESIGN

4 COMPONENTS

Component:	Beam
Plates required:	2440 x 1220
Milling time:	10 minutes
Assembly time:	5 minutes
Weight:	5 kg

Component:	Floor
Plates required:	5000 x 1220
Milling time:	20 minutes
Assembly time:	20 minutes
Weight:	45 kg

Component:	Wall
Plates required:	5000 x 1220
Milling time:	25 minutes
Assembly time:	20 minutes
Weight:	49 kg

Component:	Roof
Plates required:	5000 x 1250
Milling time:	25 minutes
Assembly time:	25 minutes
Weight:	47kg

REALISATION | FINAL DESIGN

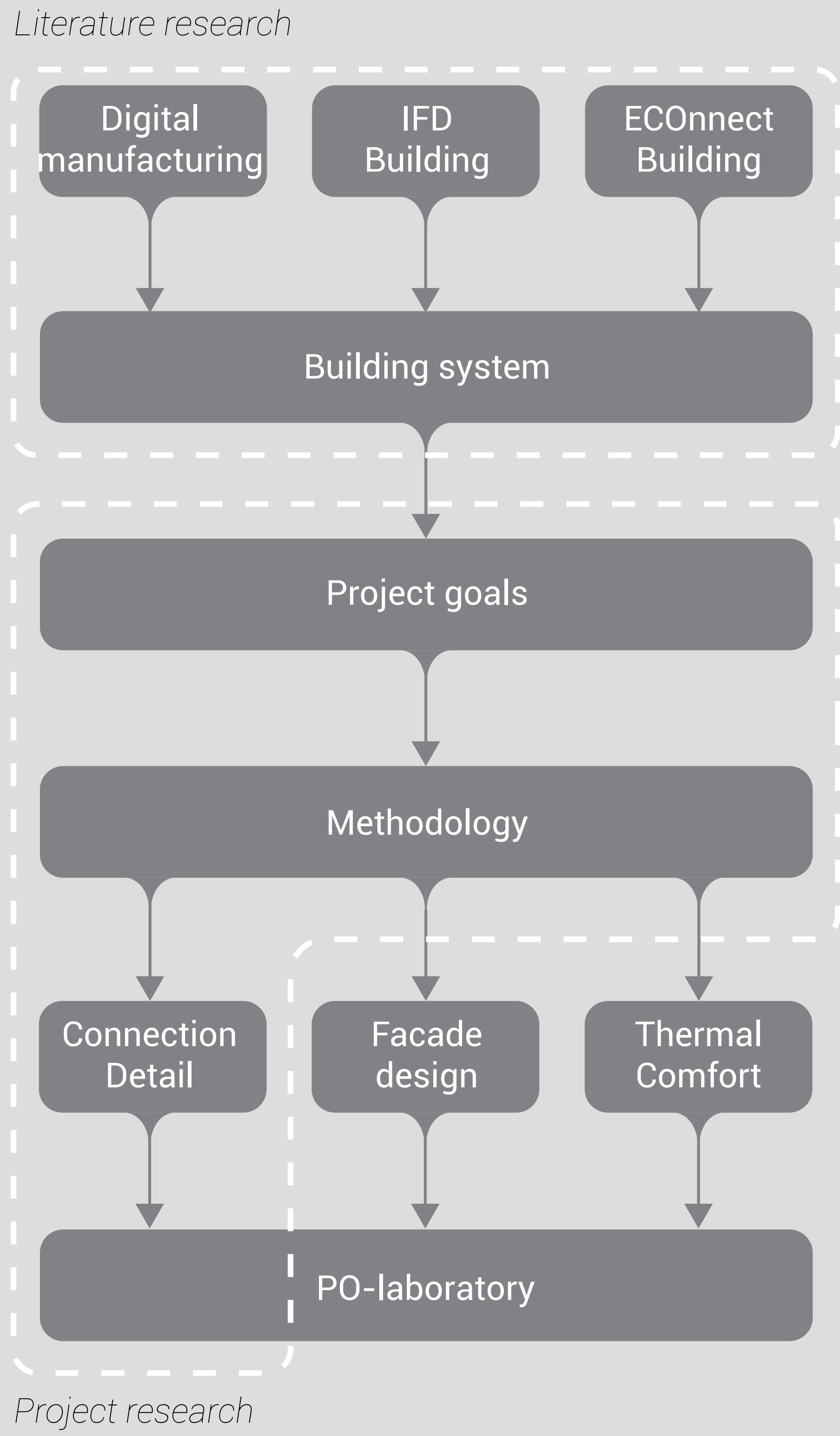
4 COMPONENTS

REALISATION | FINAL DESIGN

GEVEL2016

REALISATION | FINAL DESIGN

REVIEW |



Literature research
Digital manufacturing
IFD Building
ECOnnect Building
Building system
Project goals
Methodology
Connection Detail
Facade design
Thermal Comfort
PO-laboratory
Project research

REALISATION | CONCLUSION

Design: PO-Lab
Plates required: 138
Milling time: 51,5 hours
Assembly time: 41 hours

PO-LAB:

• *Sustainable material production and transport*
- Sharing digital data to locally manufacture building components
- Reduced transport distances of both materials and prefabricated building products

• *Resource efficient production*
- CNC fabrication to make optimize production
- Pre-assembling elements into components in proper work conditions

• *Durable construction with regards to functionality*
- Possible to adapt the building
- Prevents buildings from premature demolition

• *Fast and easy constructible system*
- Prefab components result in a uniform assembly process
- Everything can be done with two men

• *Strategies for disassembly, reuse and recycling*
- Components be replaced to maintain or update a building
- Components can be disassembled and reused in other projects.