

Bio-based reference façade wall details

Design and analysis of moisture transport and thermal bridges for Dutch residential top-up buildings

P5 Presentation

19-06-2025

Mark de Kanter

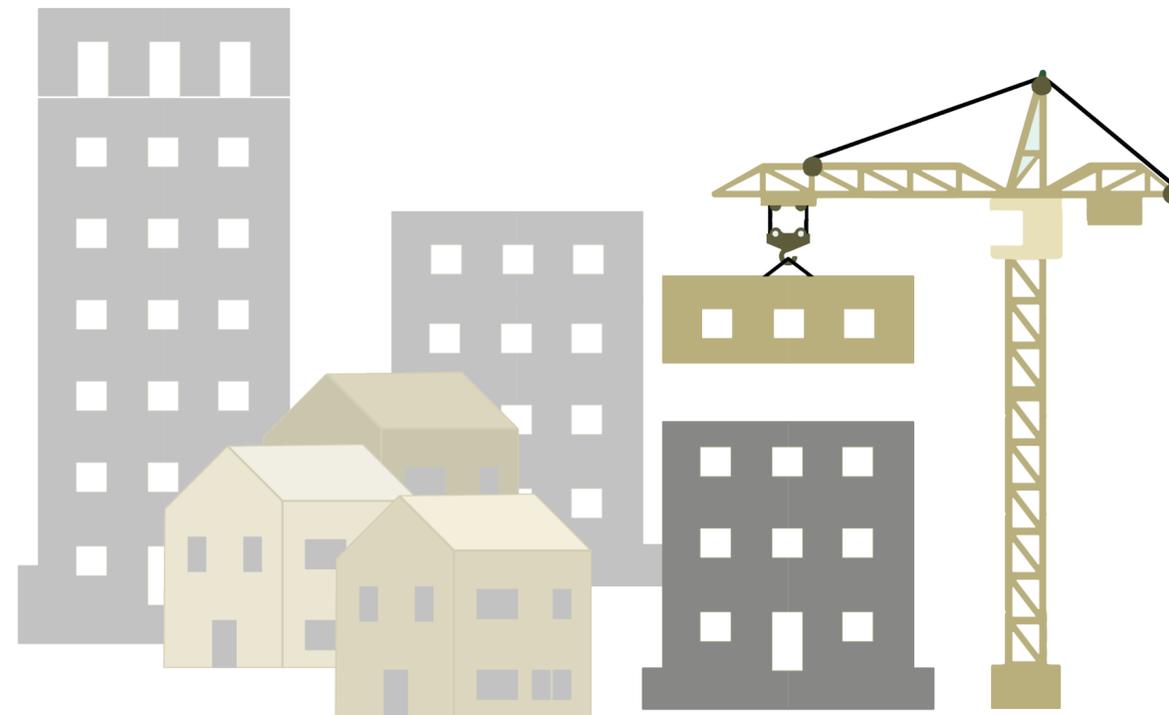


Figure 1. (NOS, 2022)

981.000 additional residences necessary



100.000 residences potential with top-ups



Definition top-up





Figure 5. (Tomlow, 2021)

Current reference details

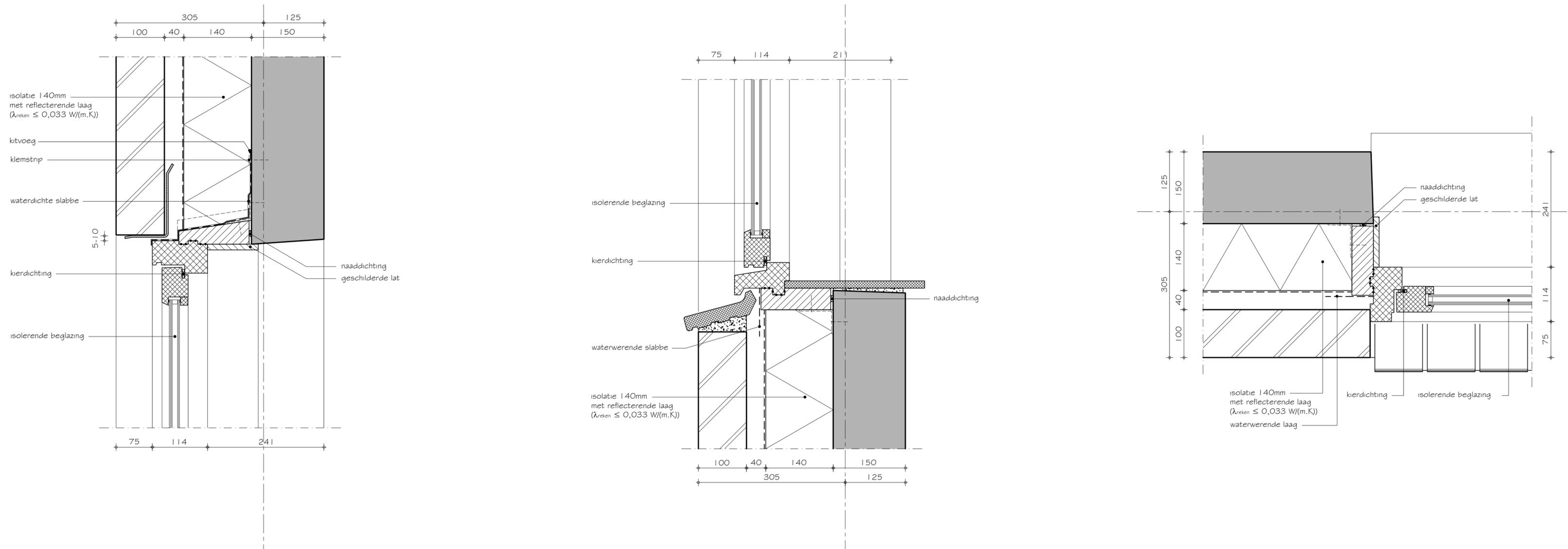
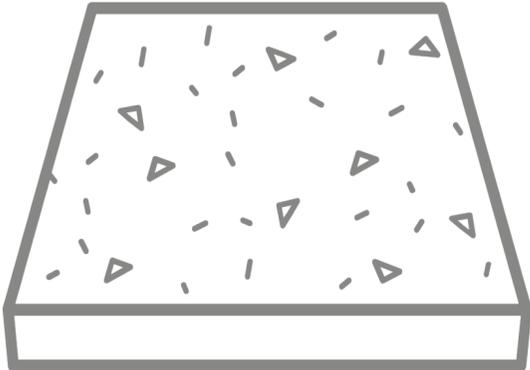
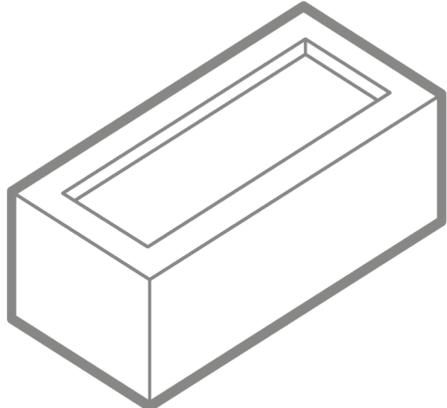


Figure 6. (Bouwzo, 2025)

Most used materials



Concrete



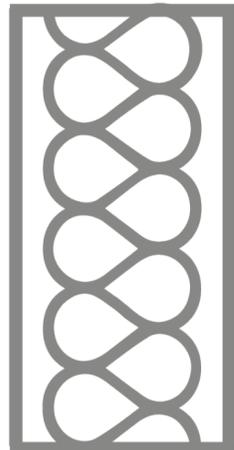
Brick



Plaster



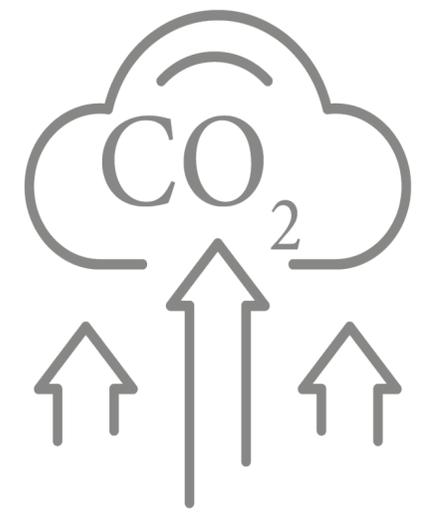
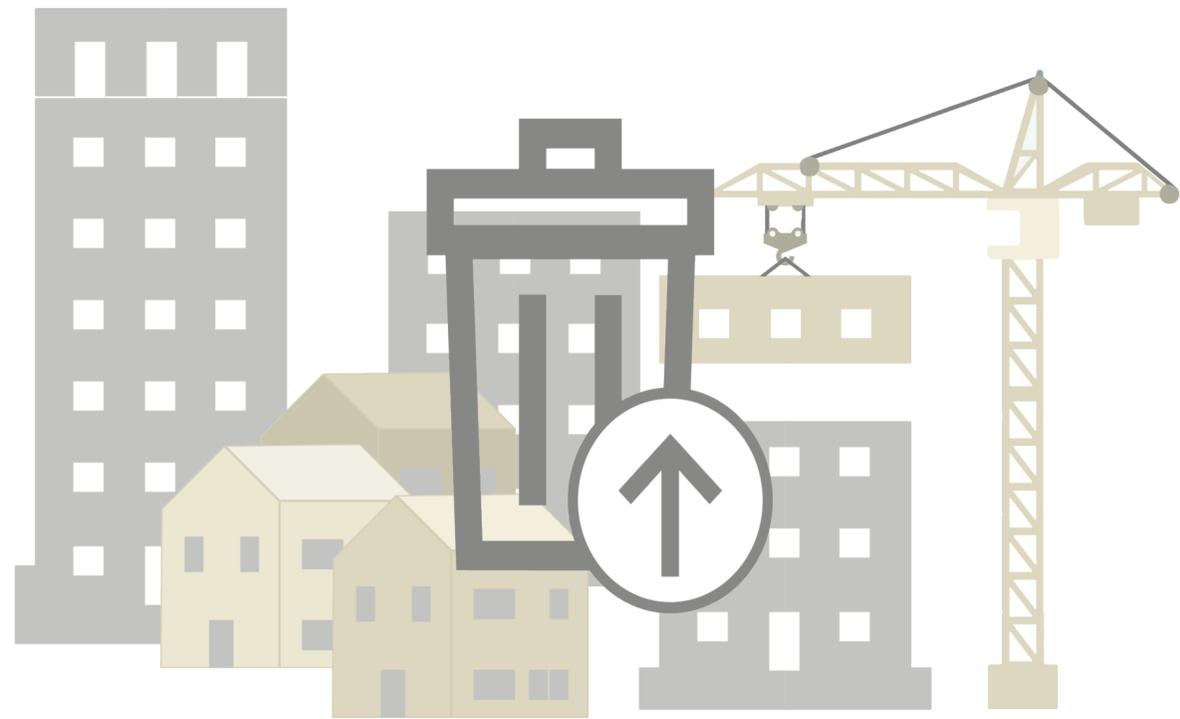
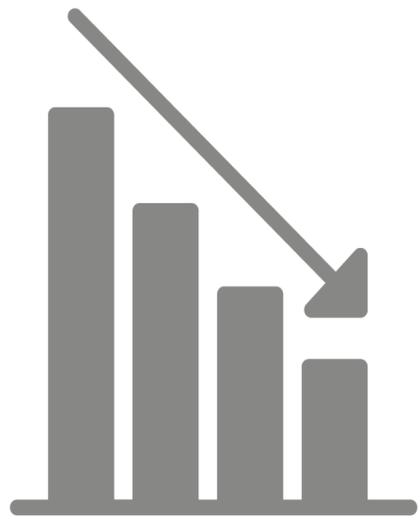
Steel



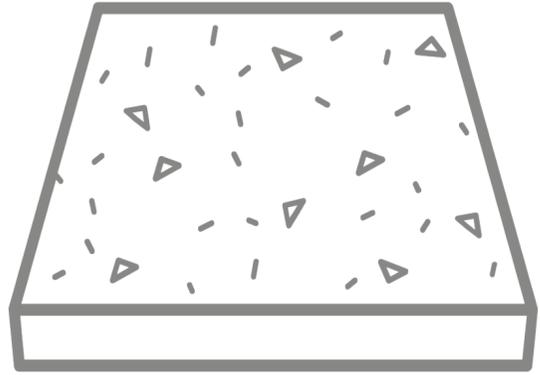
Insulation

100.000 residences potential with top-ups

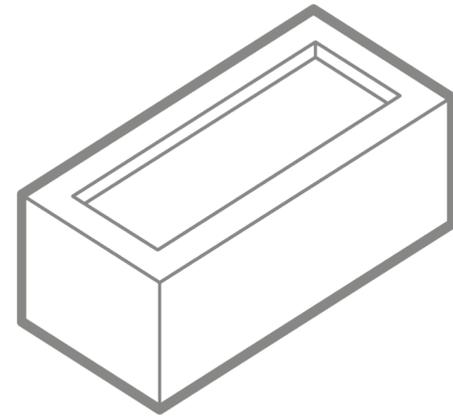




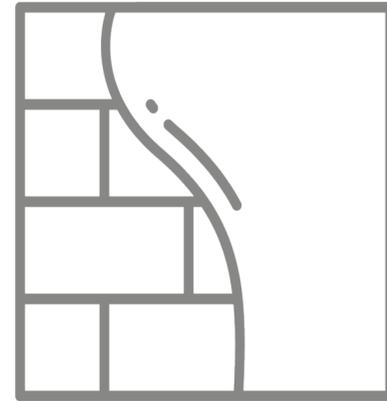
Existing building materials



Concrete



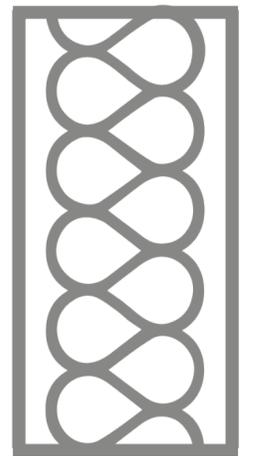
Brick



Plaster



Steel



Insulation

Bio-based building materials



Cork



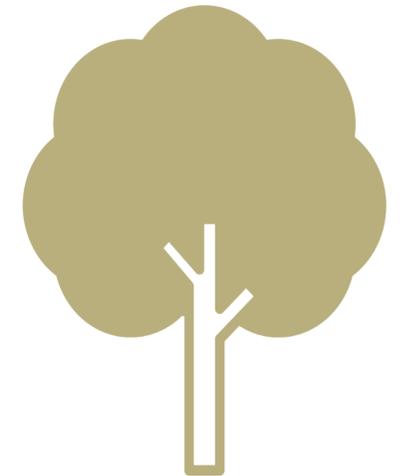
Flax



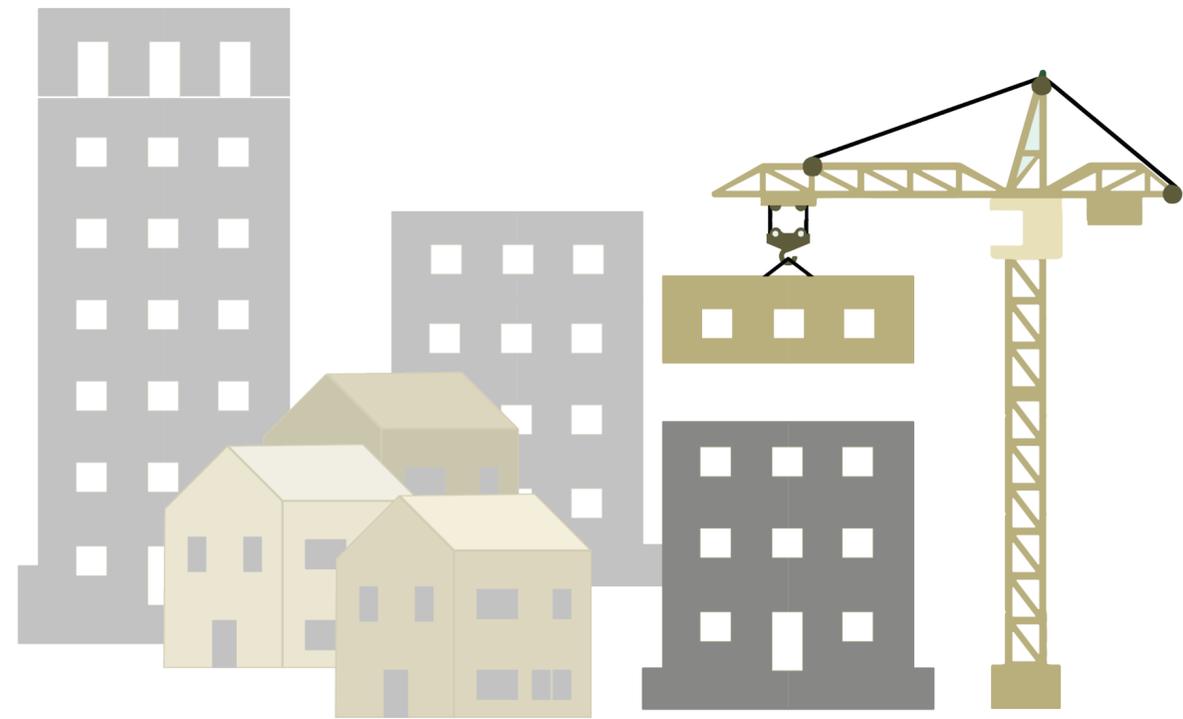
Hemp

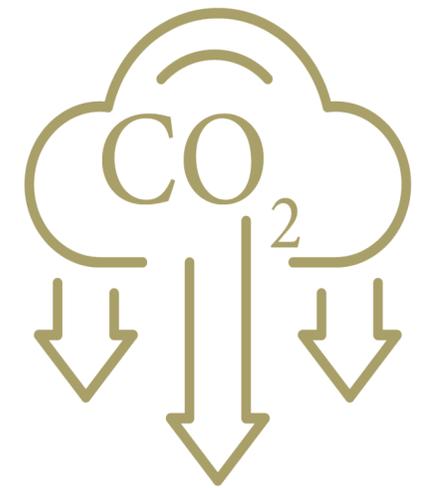
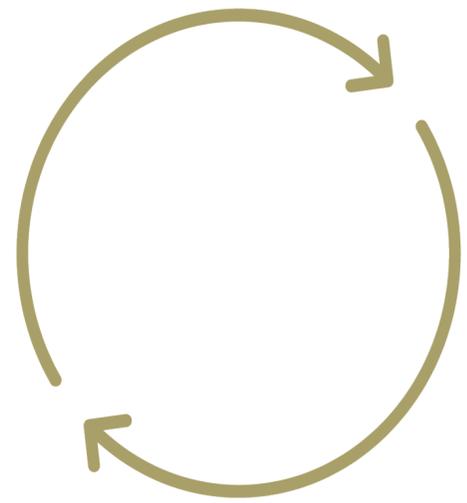


Straw



Wood

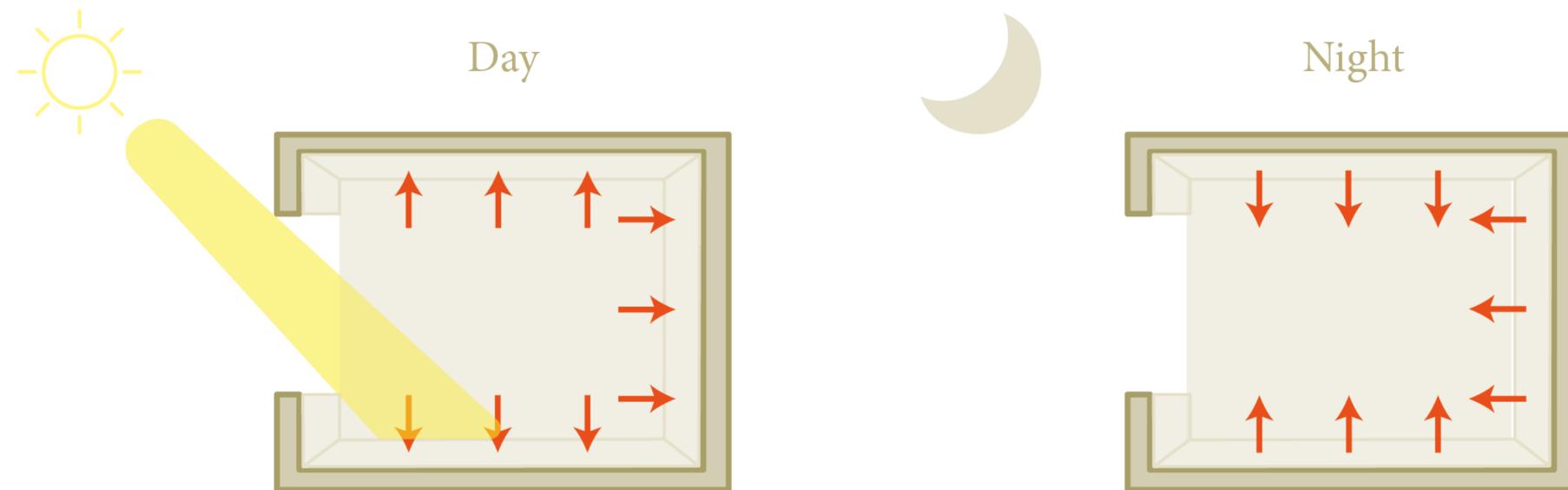




Lightweight construction

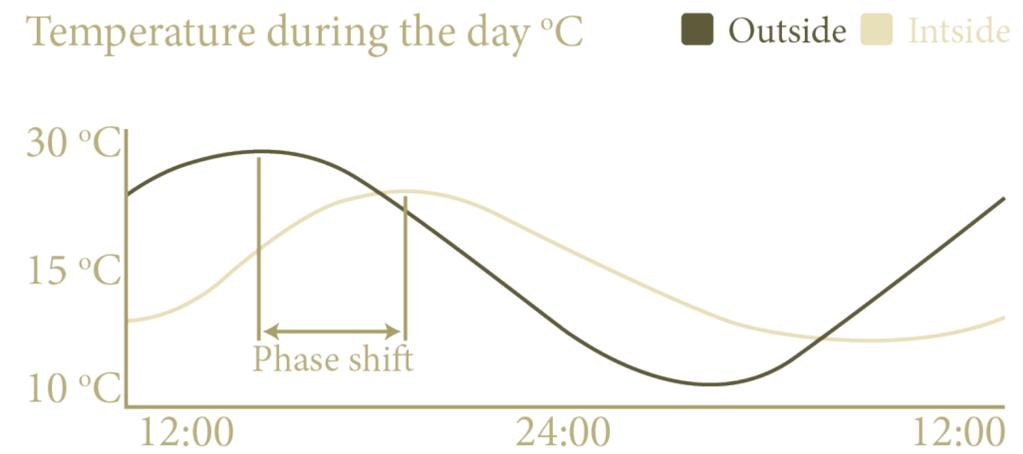


Thermal mass

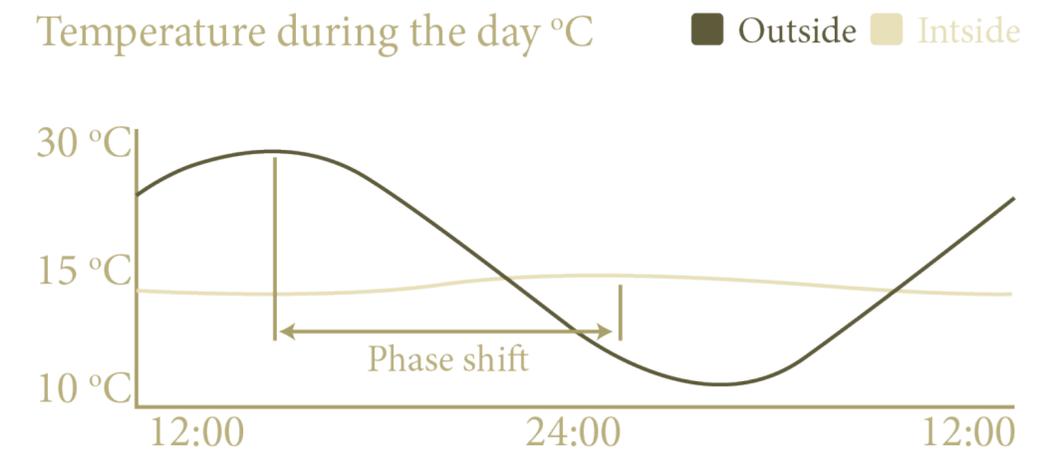


Phase shift & temperature amplitude

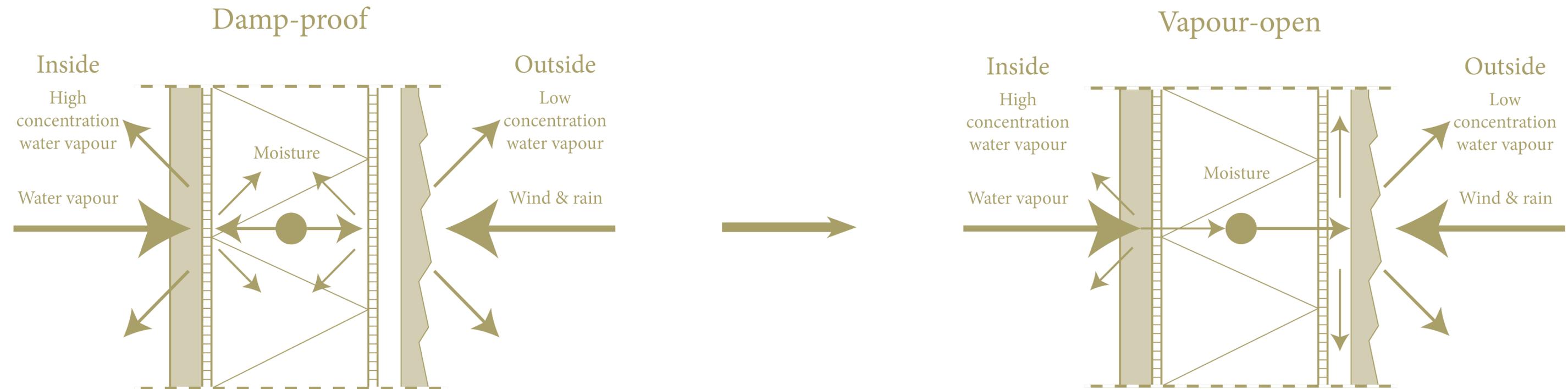
Low thermal mass constructions



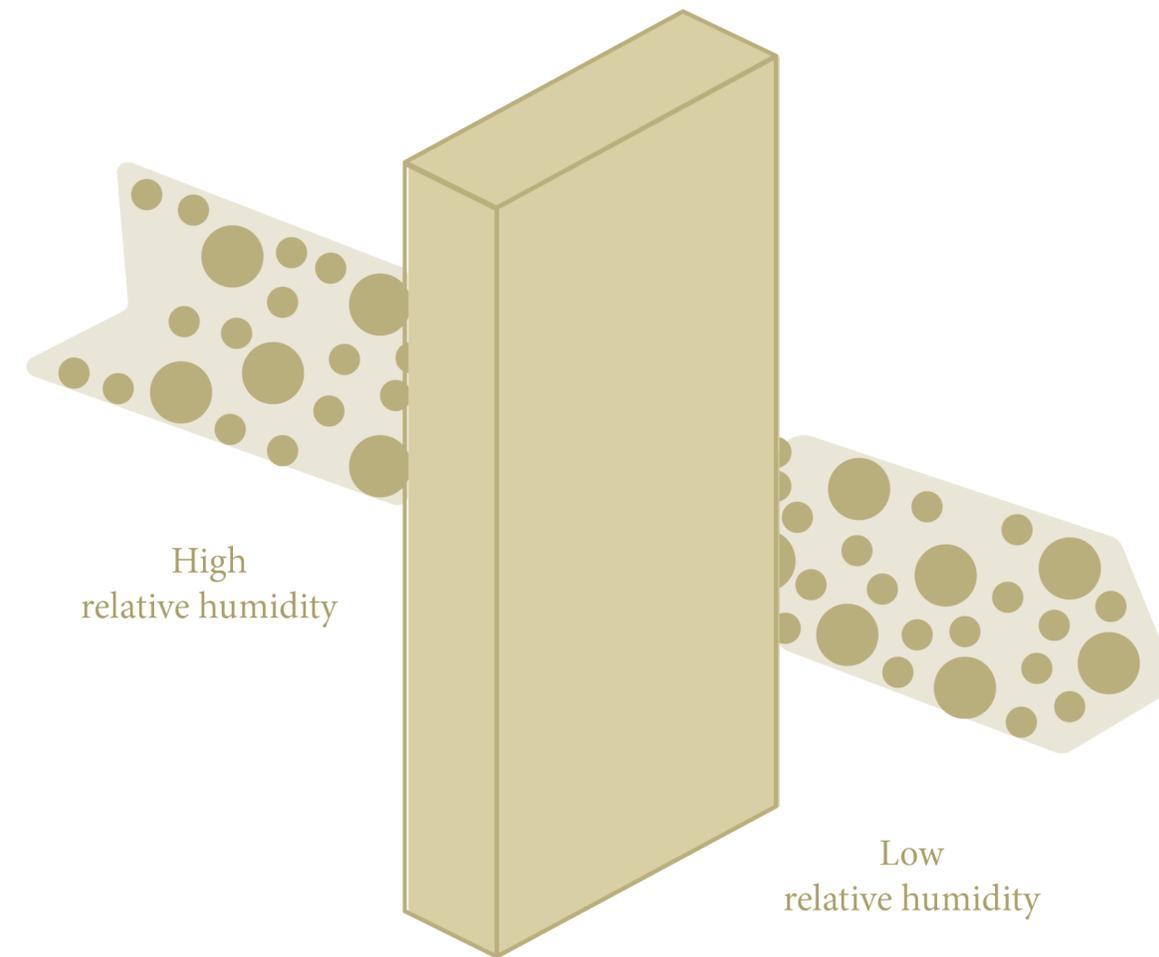
High thermal mass constructions



Vapour-open constructions



Vapour diffusion resistance factor

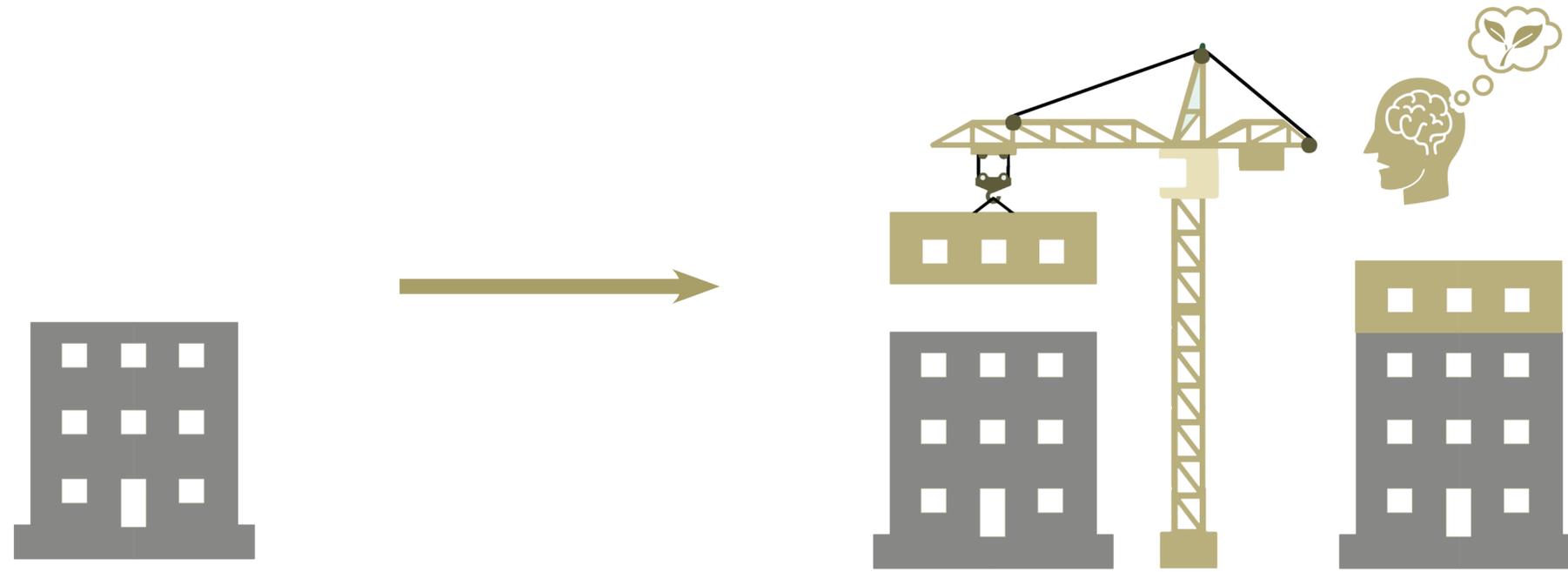


Capillary more efficient evaporation

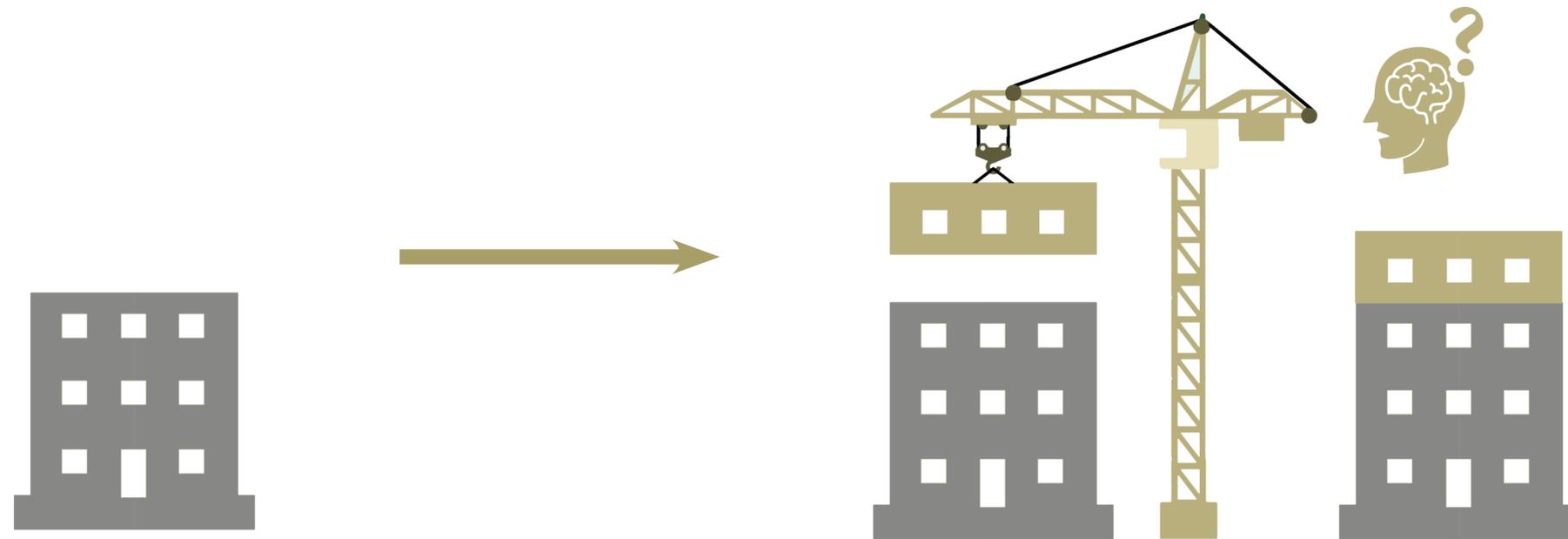


Uniform moisture distribution

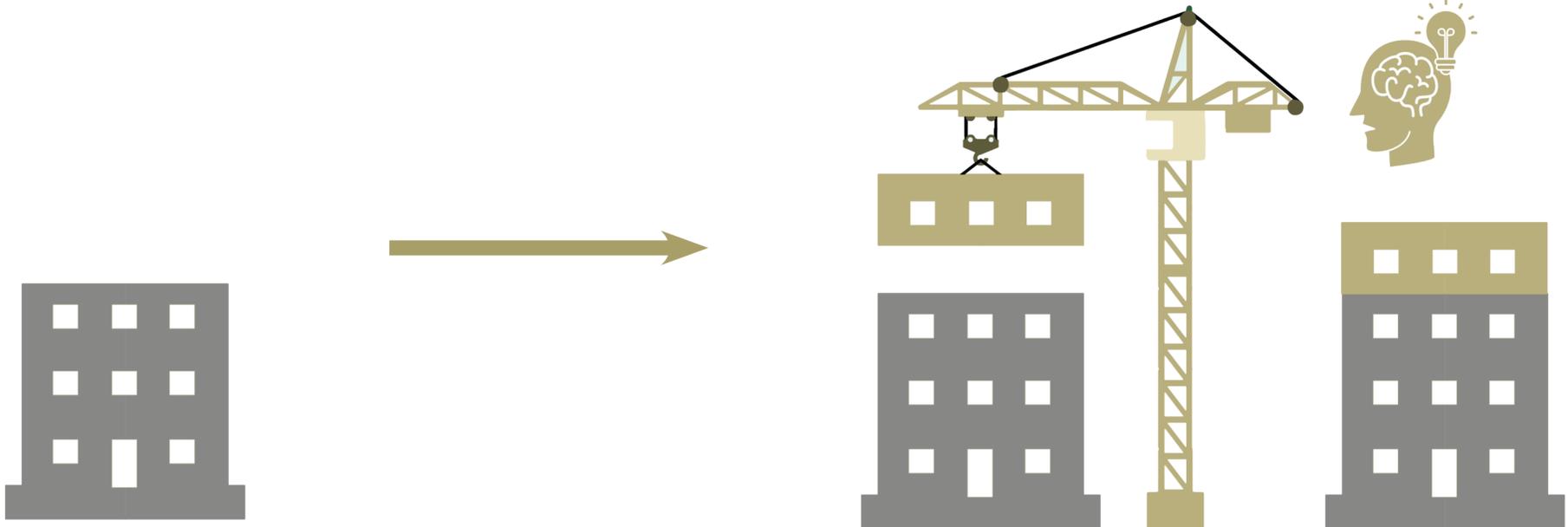
Benefits top-ups with bio-based



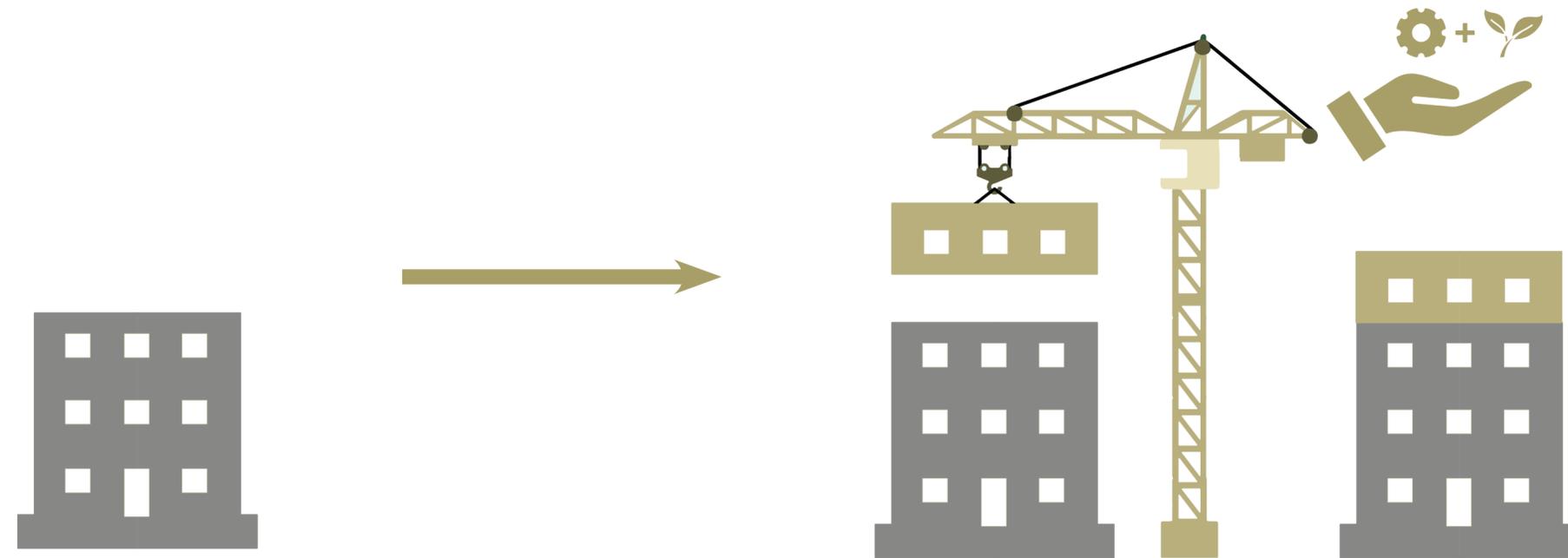
Lack of technical knowledge



What if?

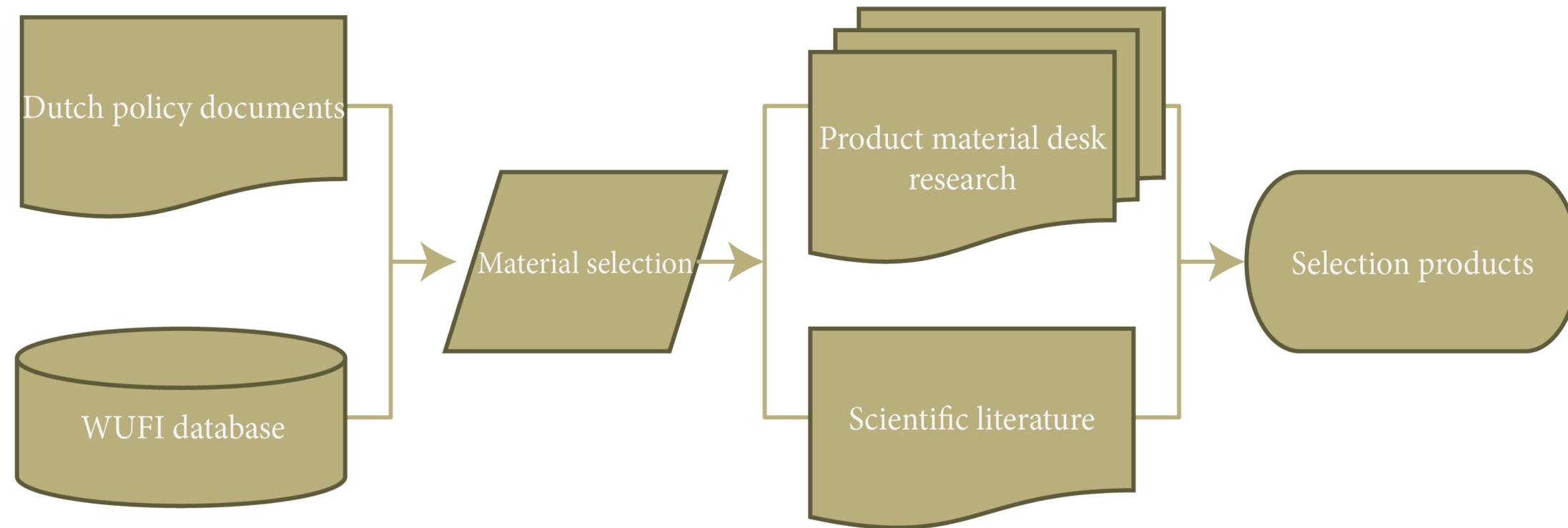


Hypothesis

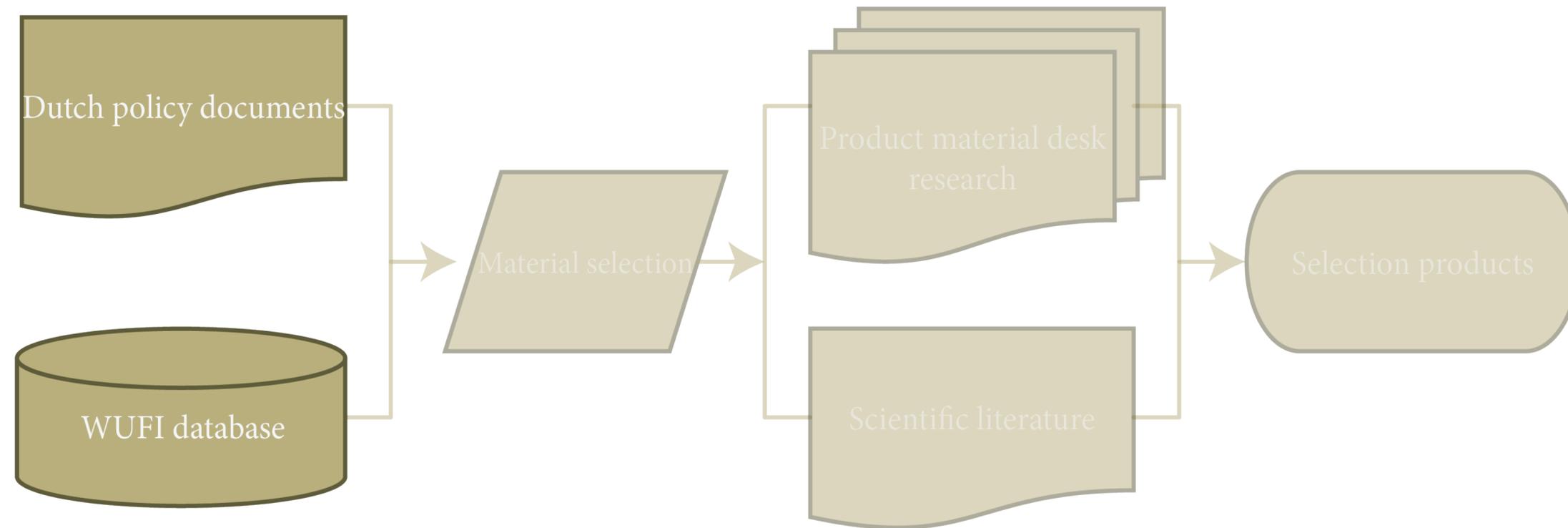


How can bio-based façade wall reference details for residential top-up buildings be developed according to thermal and moisture regulation within the construction?

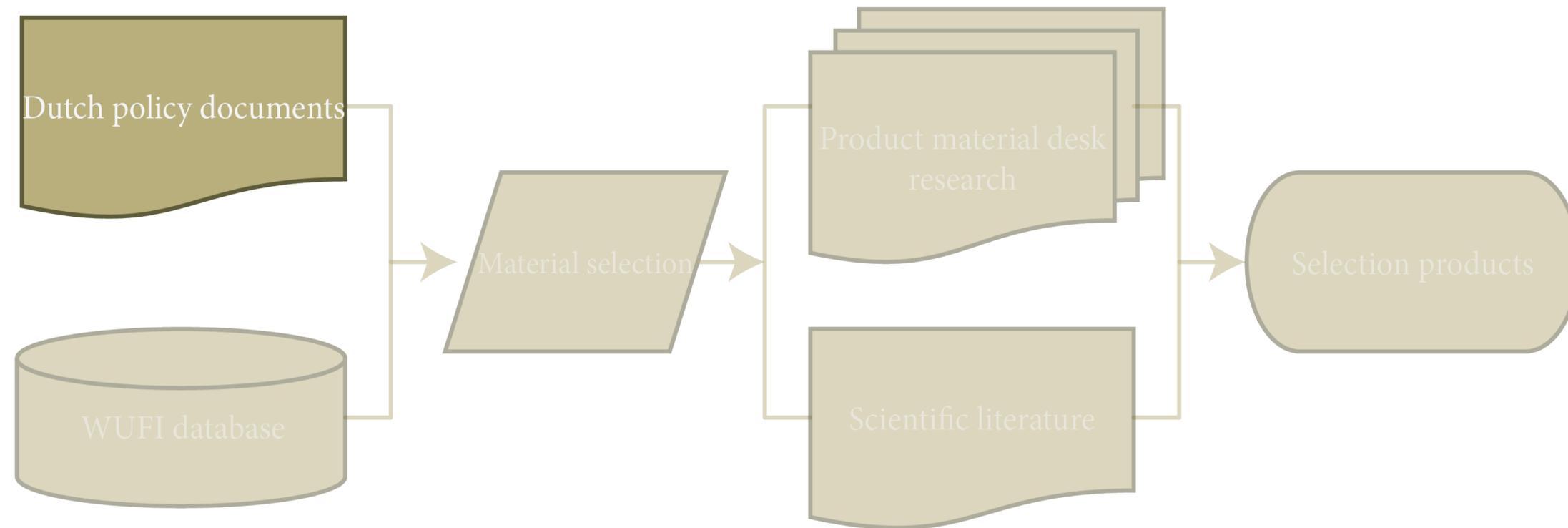
First methodology



First methodology

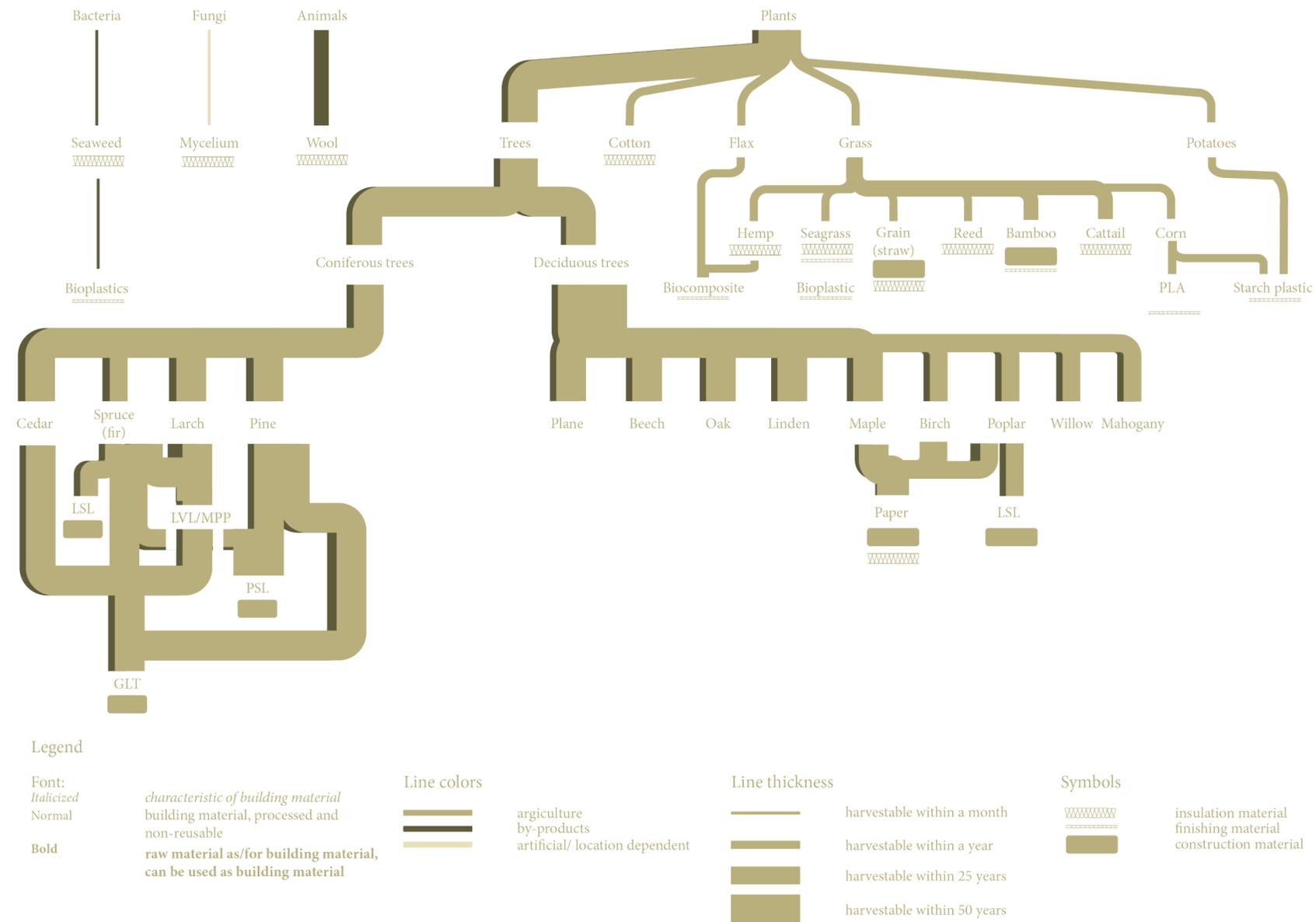


Dutch policy documents

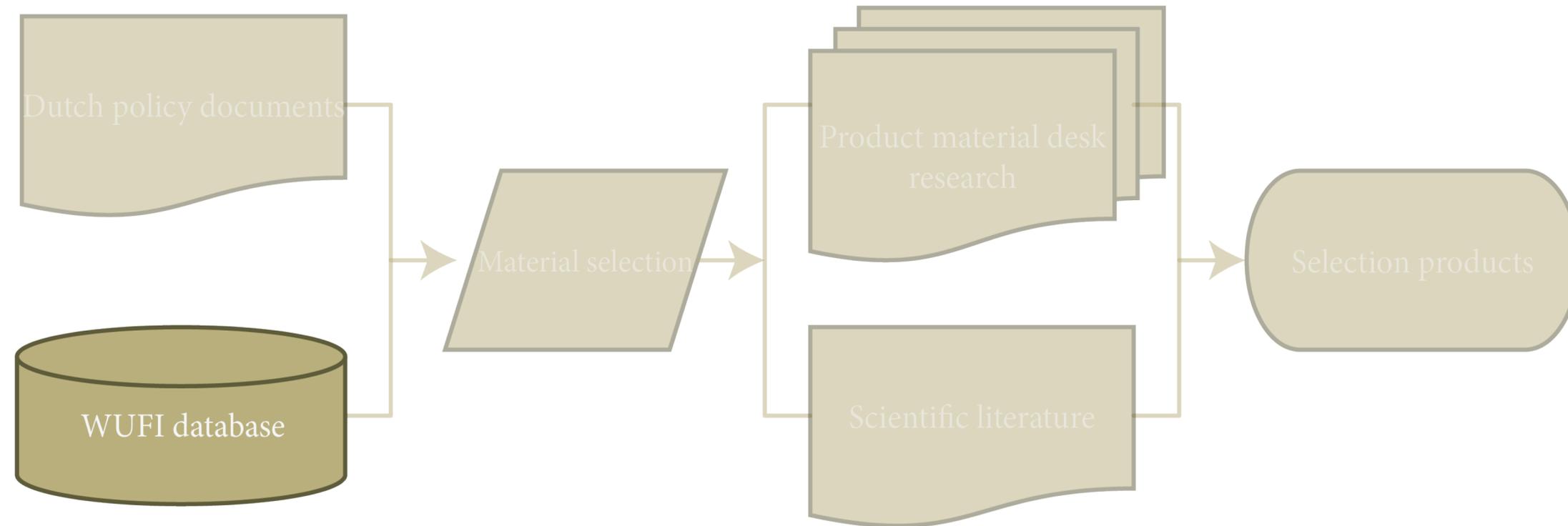


Most promising bio-based materials

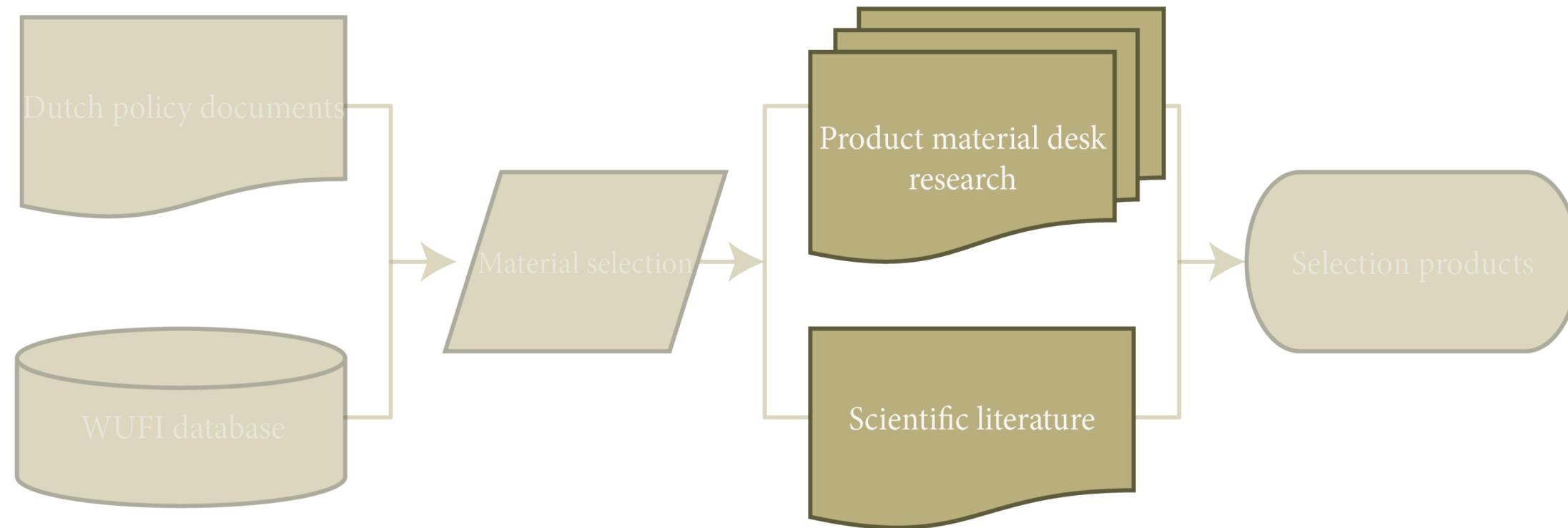
Diagram of bio-based building materials



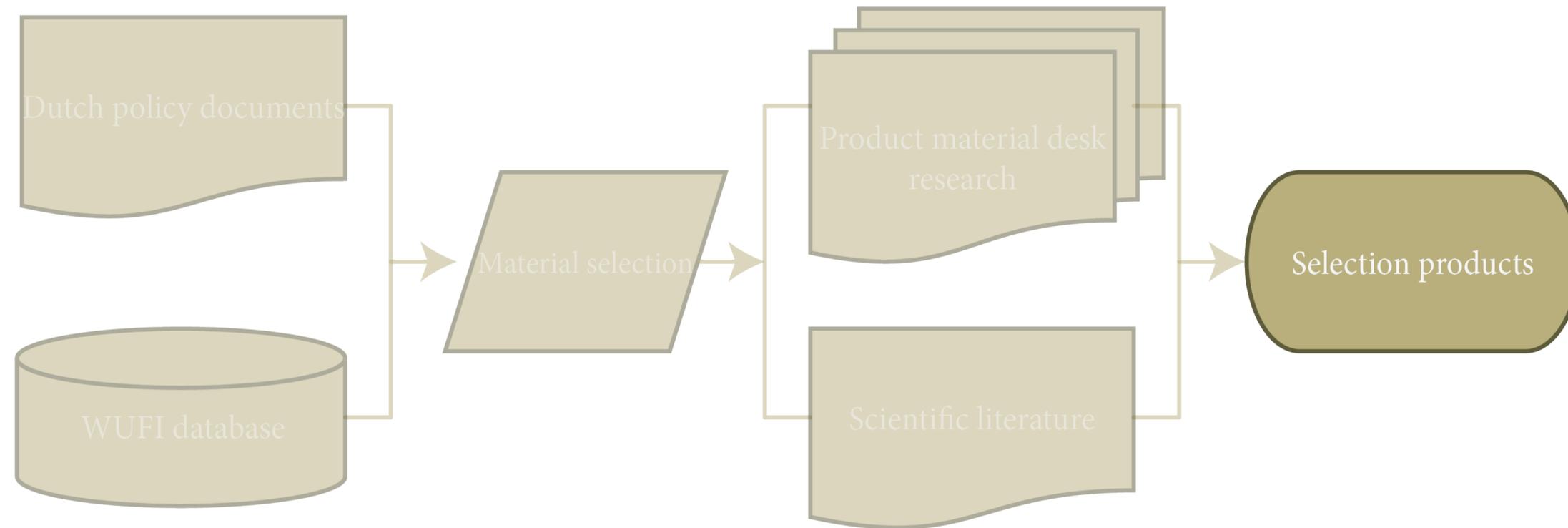
WUFI database



First methodology



Selection bio-based materials



Selection bio-based materials



Cork



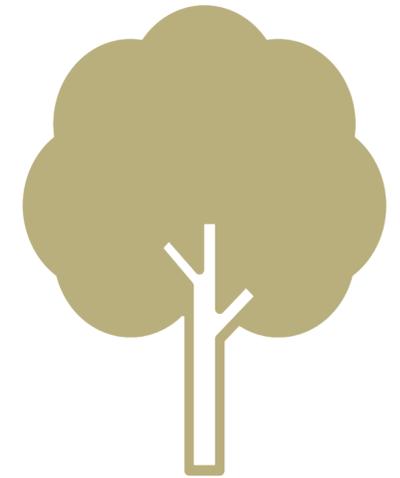
Flax



Hemp



Straw



Wood



Cork



Expanded cork
agglomerates
façade plate



Expanded cork
agglomerates
insulation plate



Granulated
cork



Flax



Flexible flax
insulation



Hemp



Hempcrete
insulation



Flexible hemp
insulation



Straw



Straw bale
insulation



Blow-in straw
insulation



Wood



Timber
façade finish



Treated
wood



Untreated
wood



Glulam

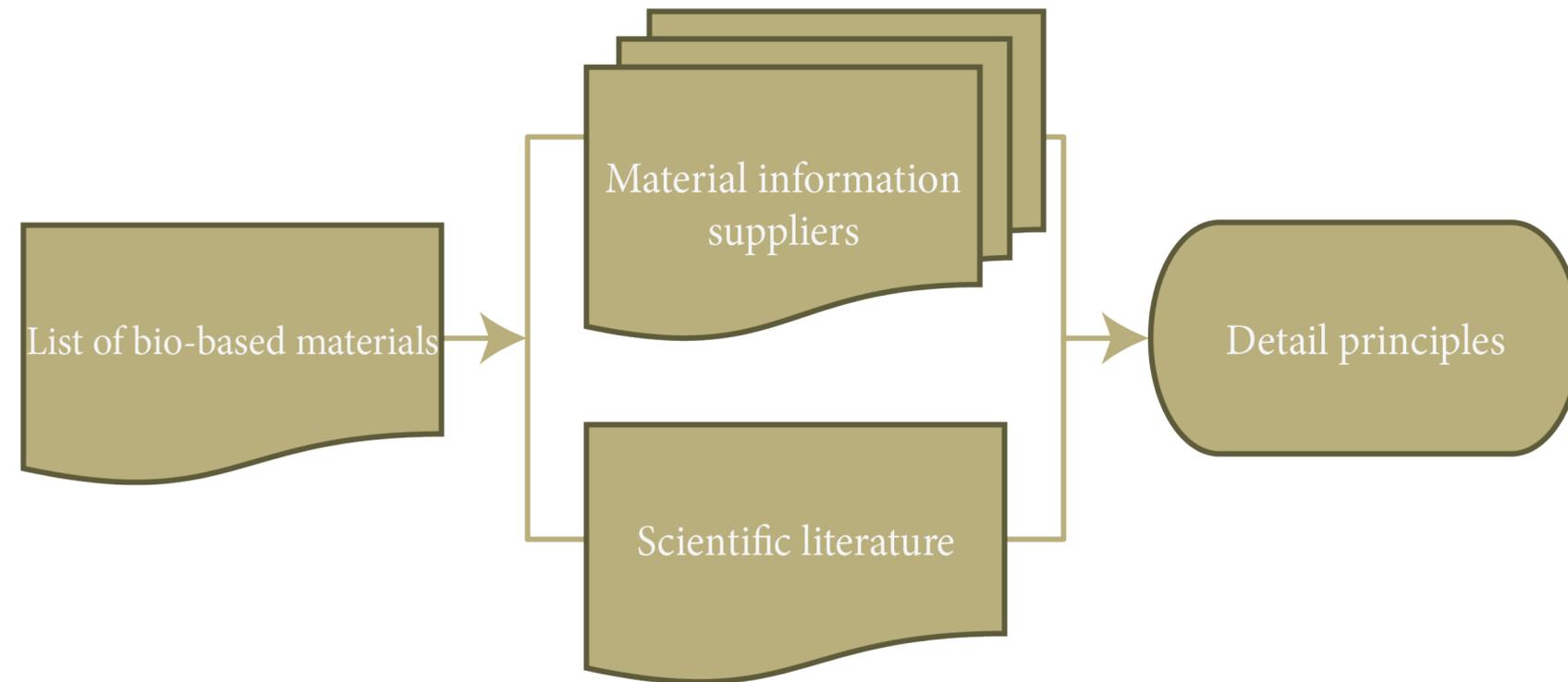


ESB board

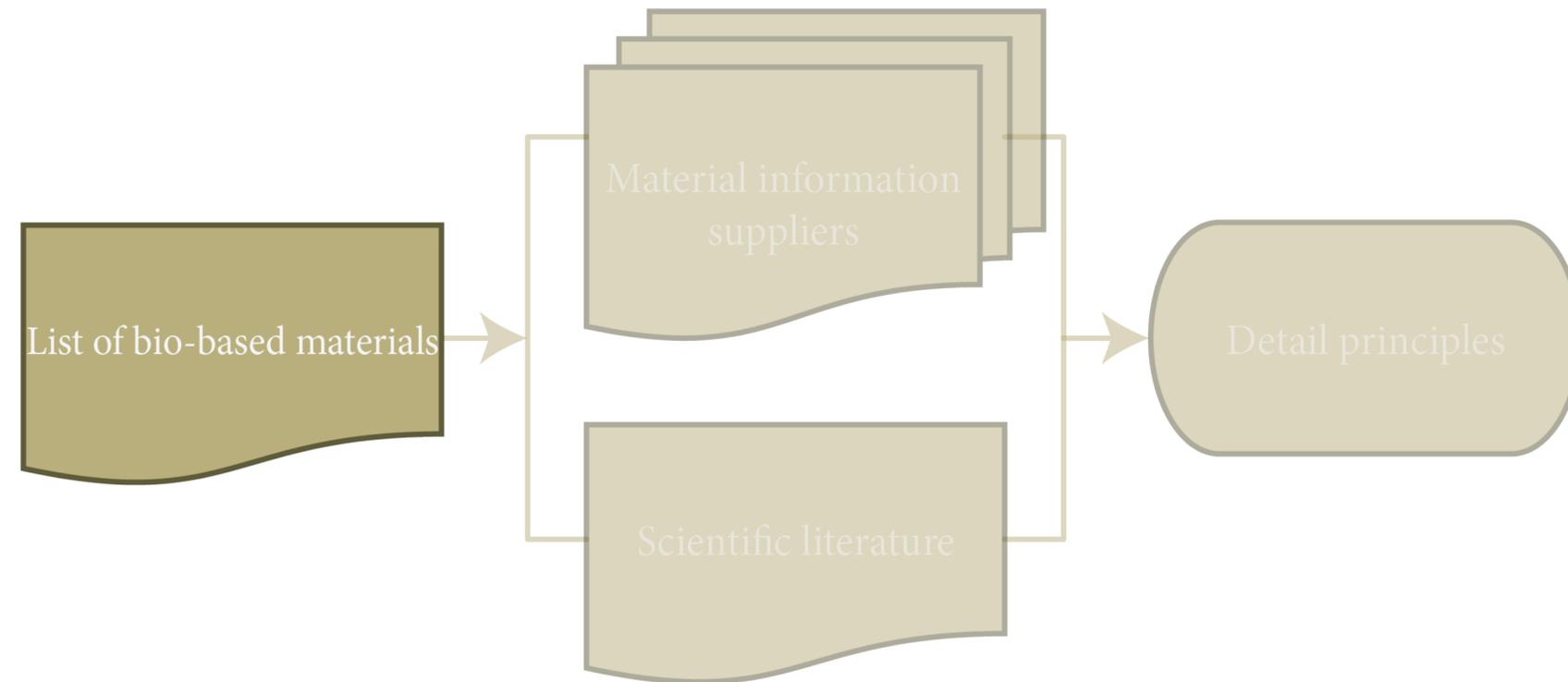


Wood fibre
board/
insulation

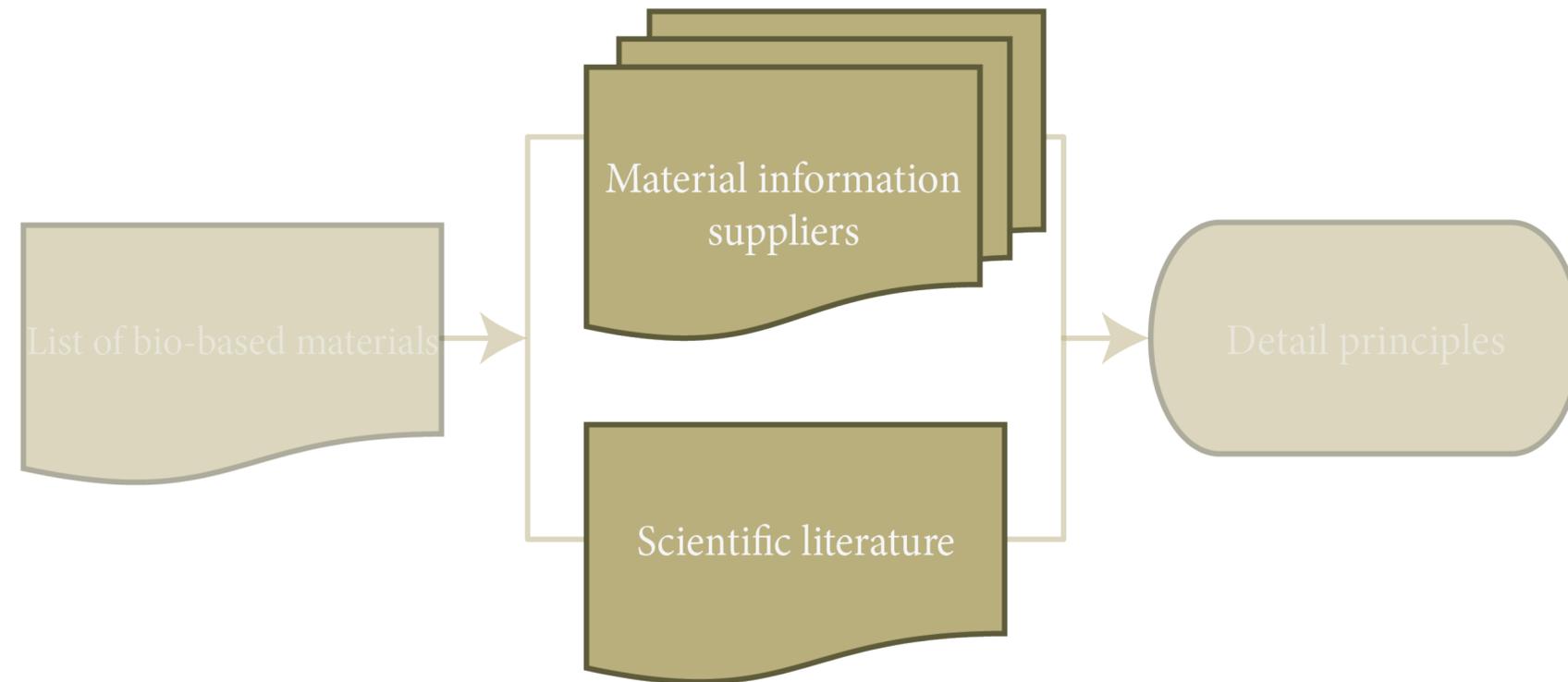
Second methodology



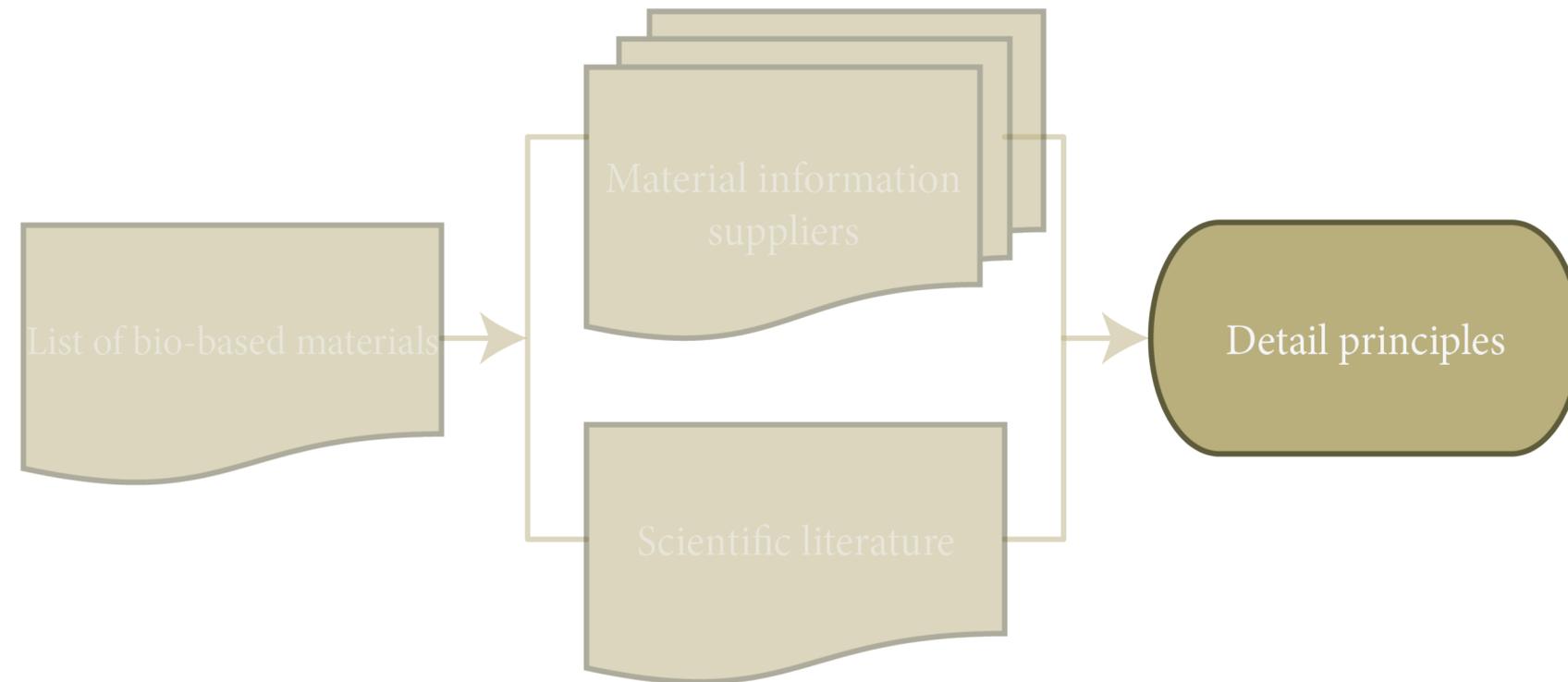
List of bio-based products



Second methodology

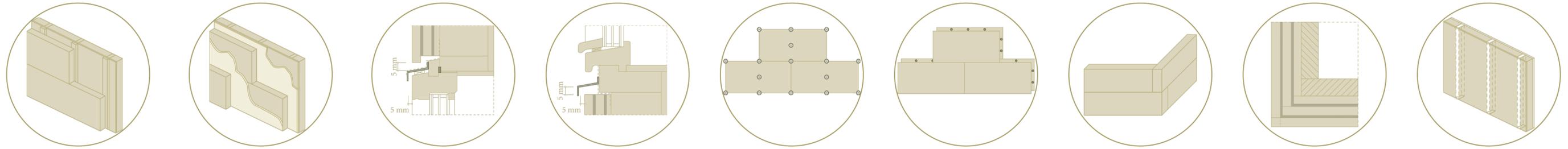


Design principles

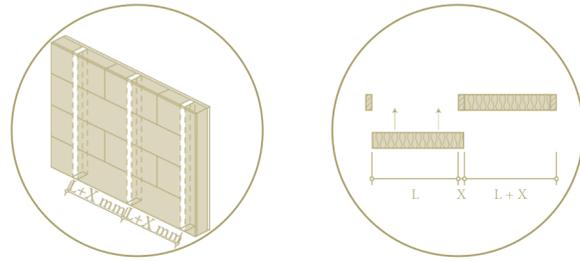




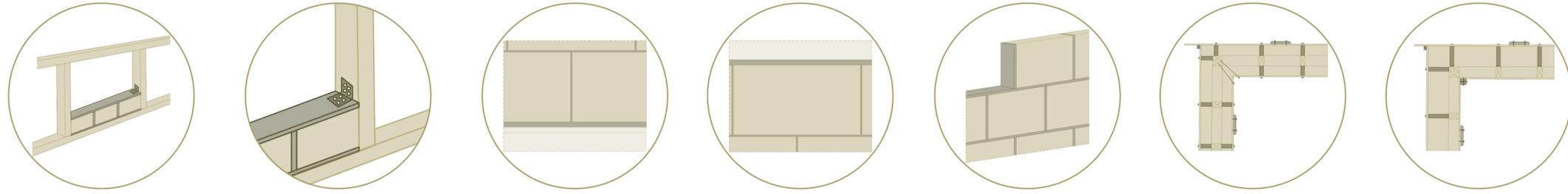
Cork



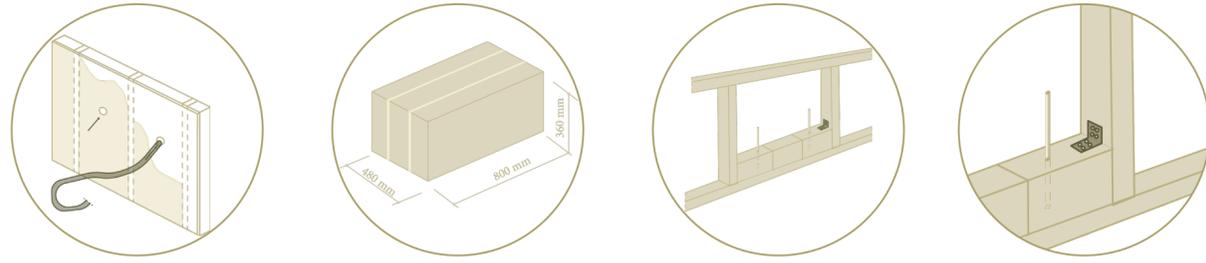
Flax



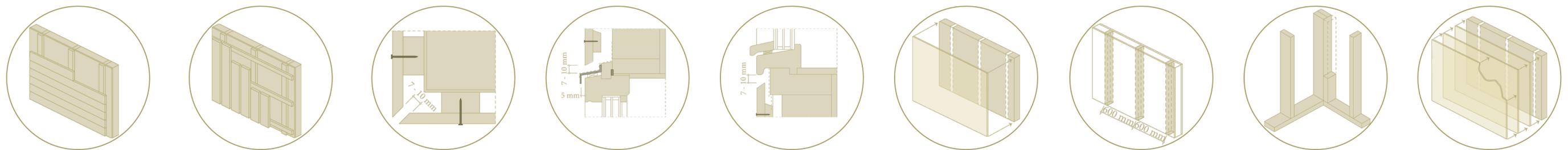
Hemp



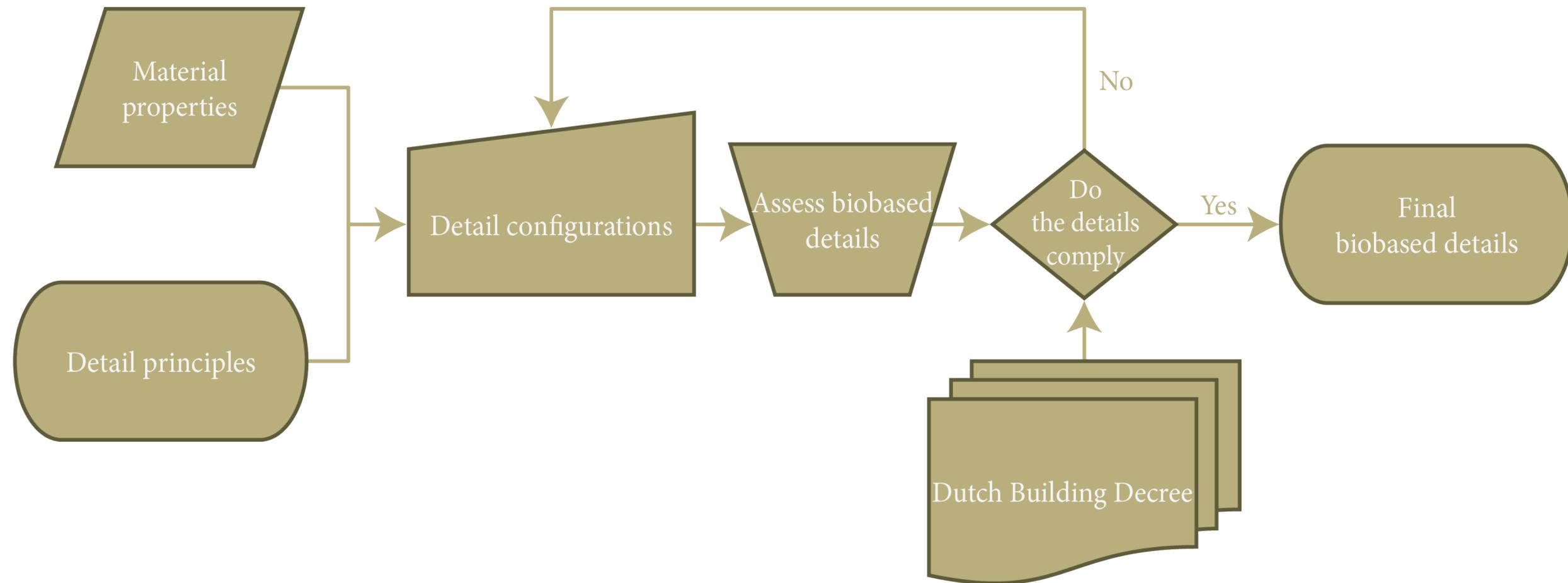
Straw



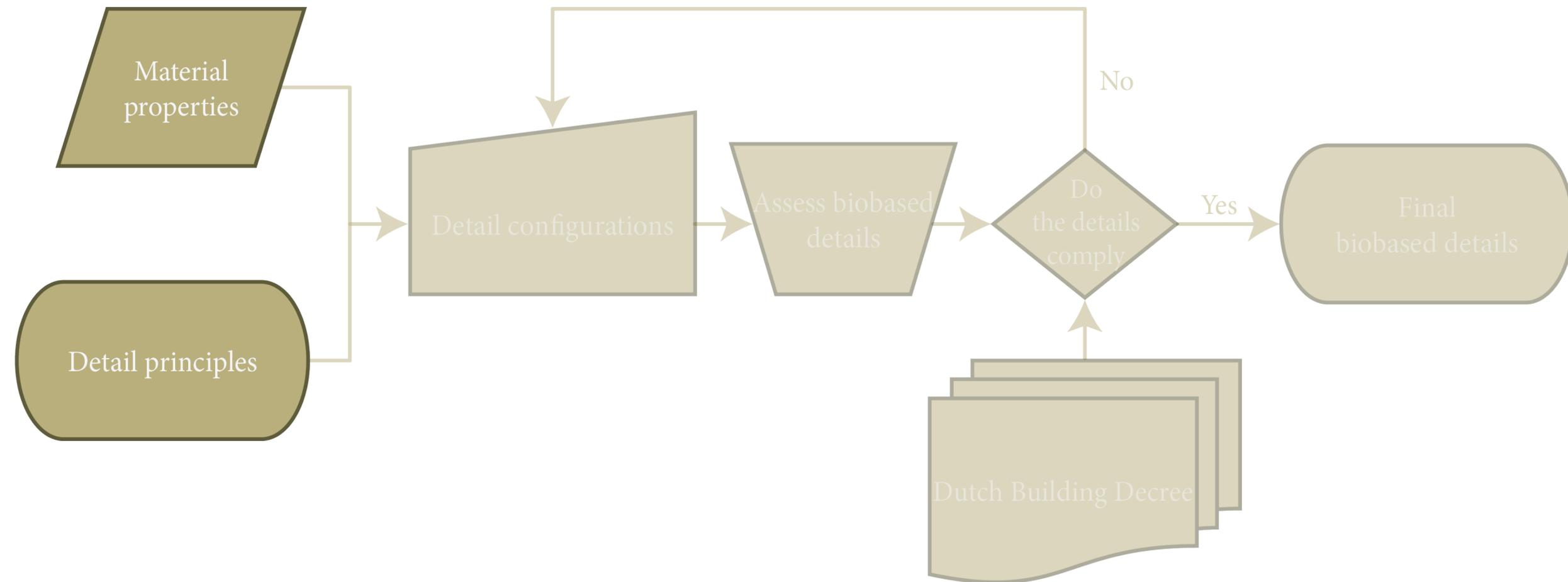
Wood



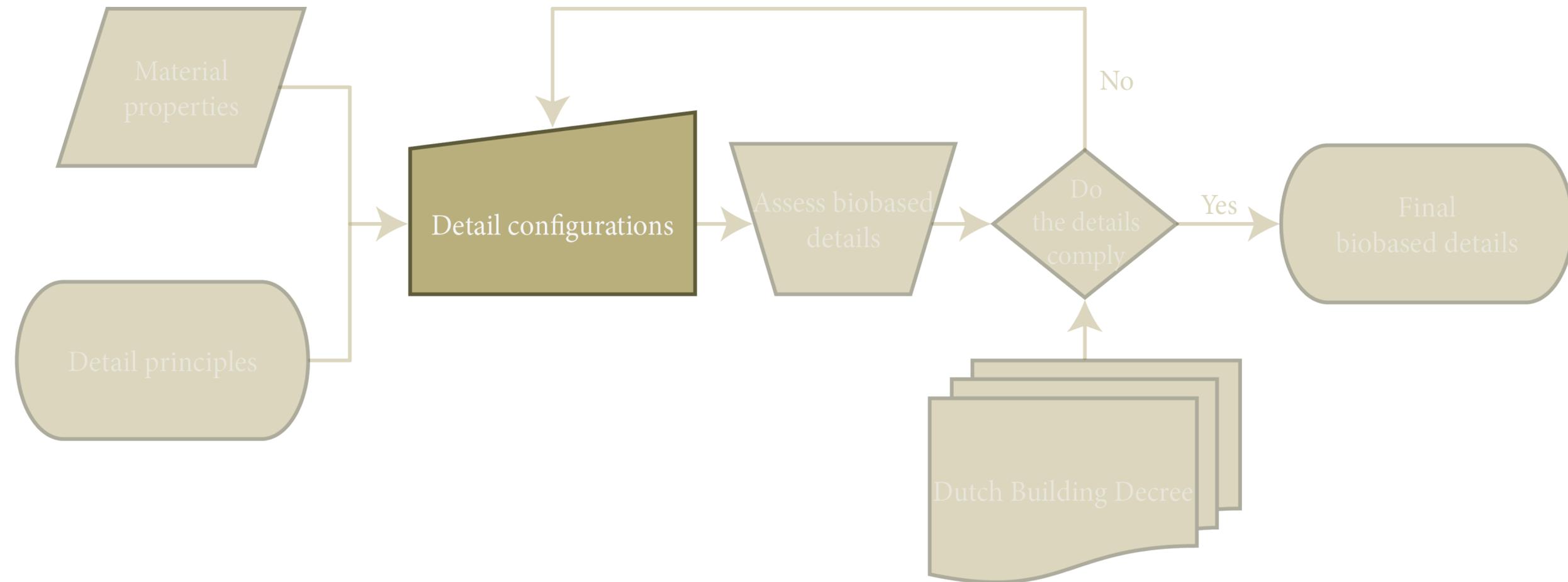
Third methodology



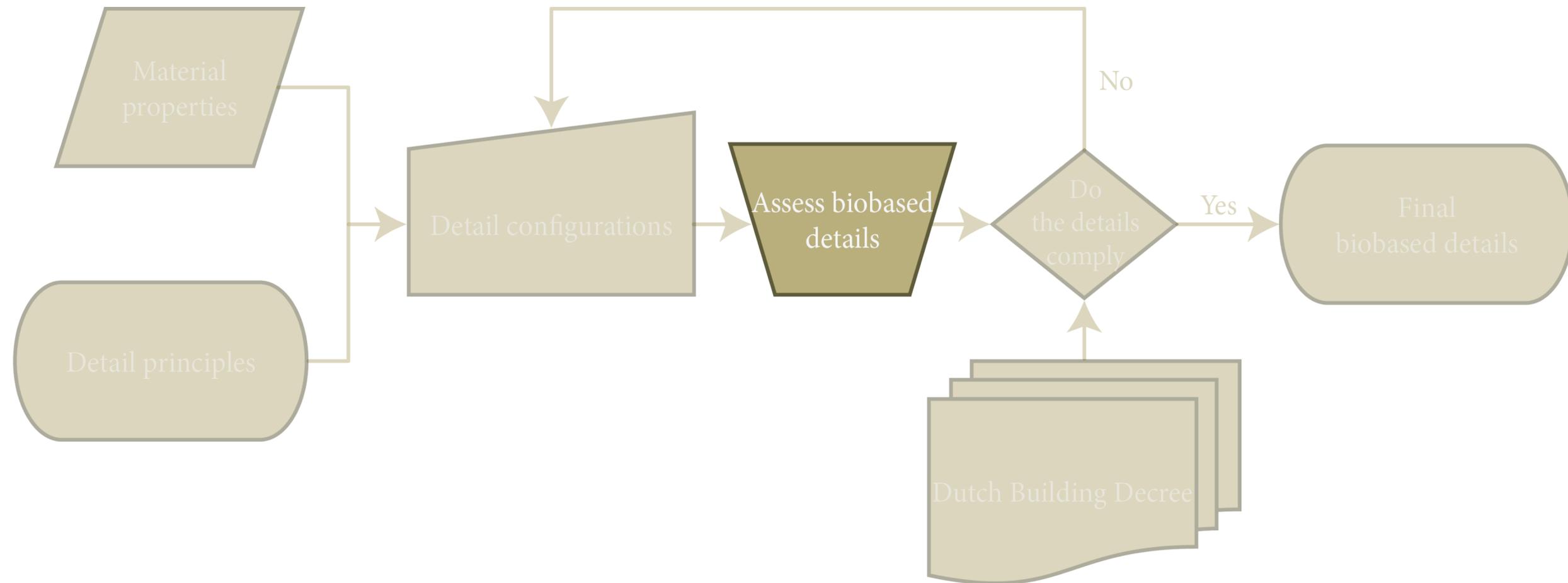
Third methodology



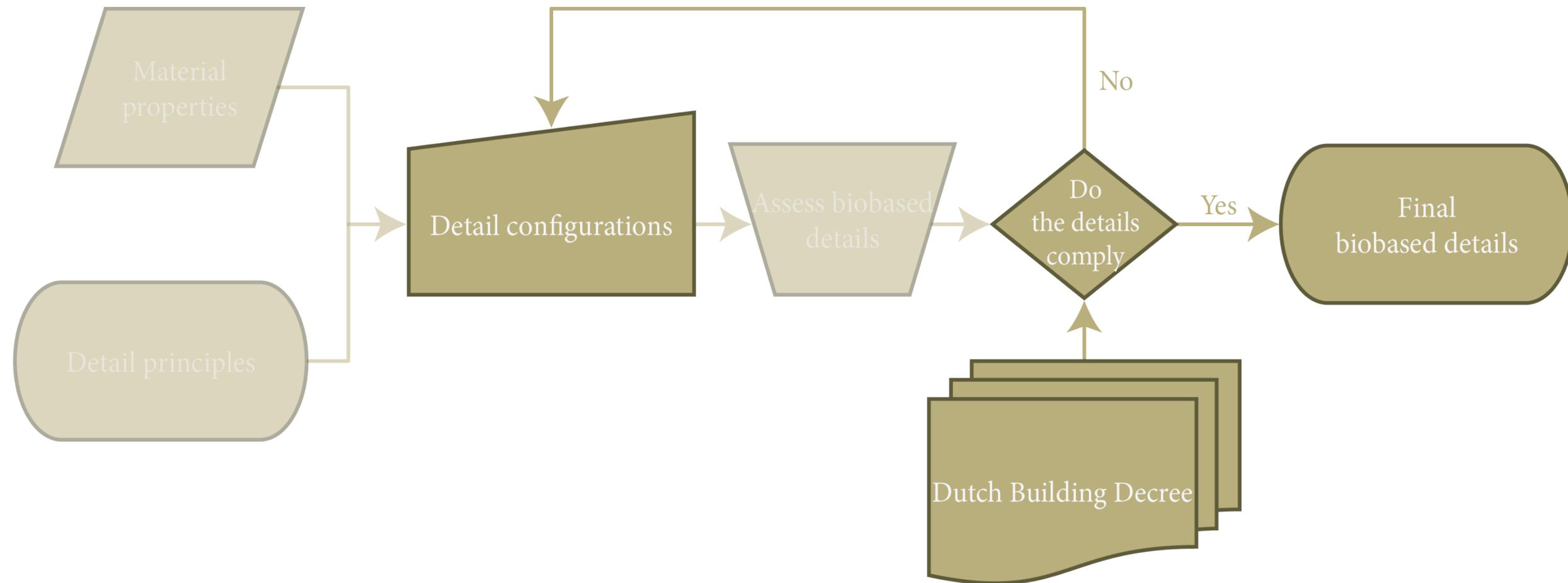
Development details



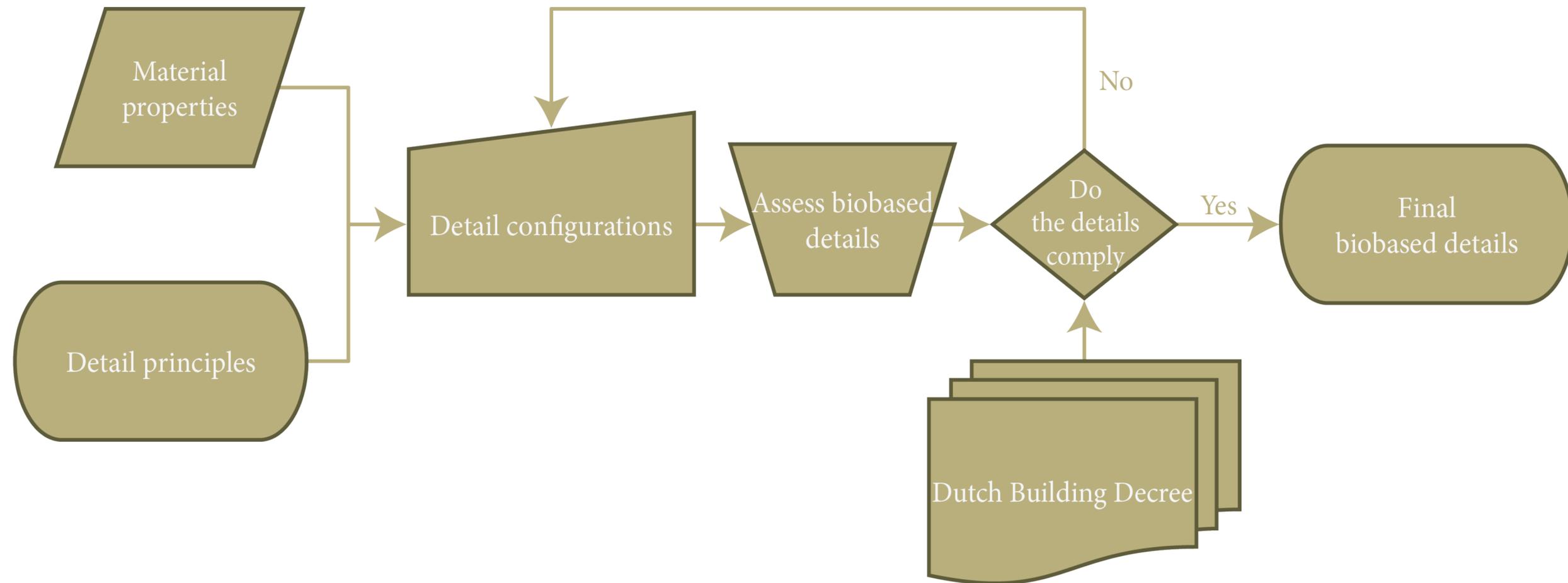
Assessment details



Third methodology



Third methodology



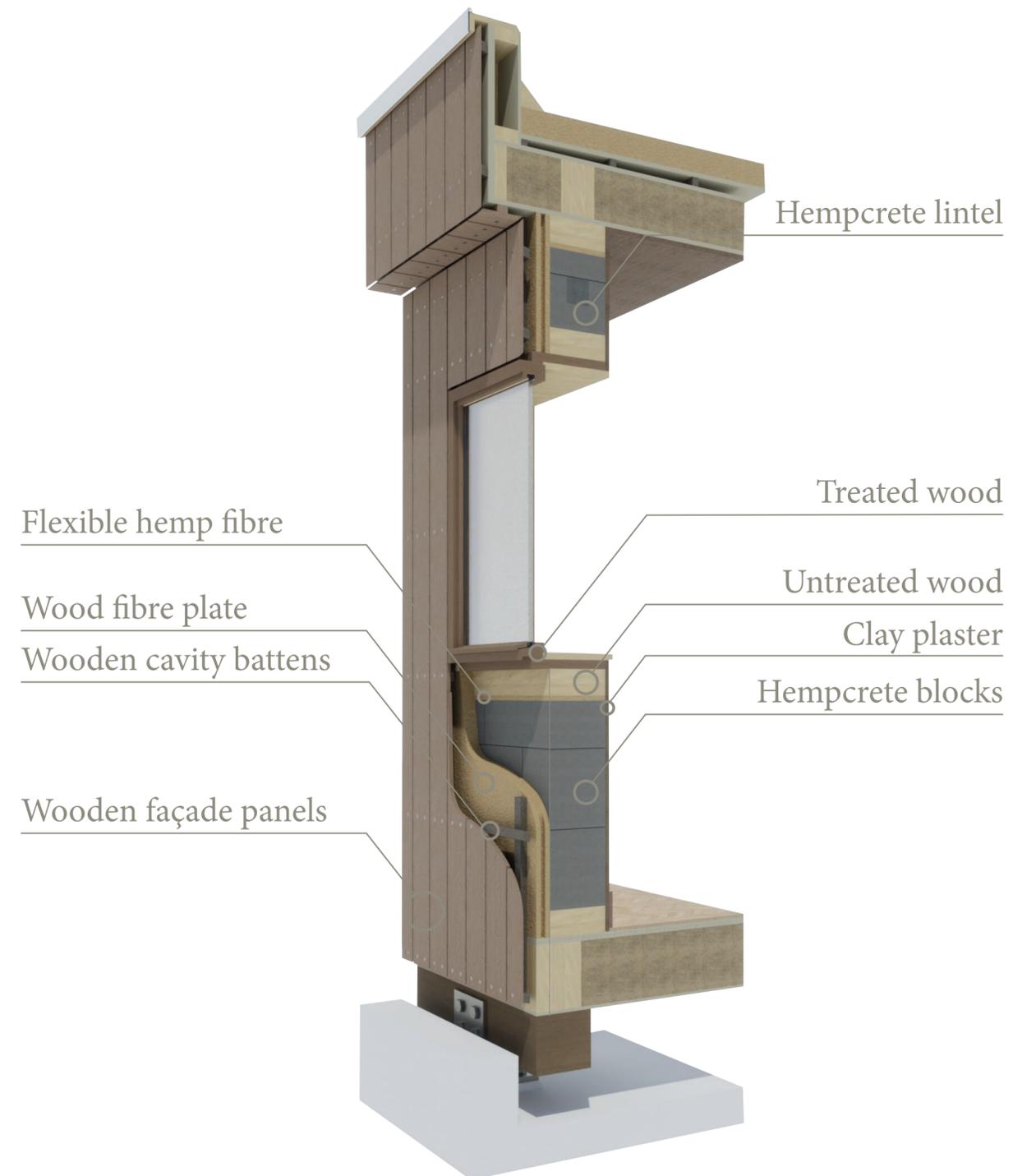
The bio-based reference detail configurations

Detail configuration hempcrete insulation blocks and a wooden façade



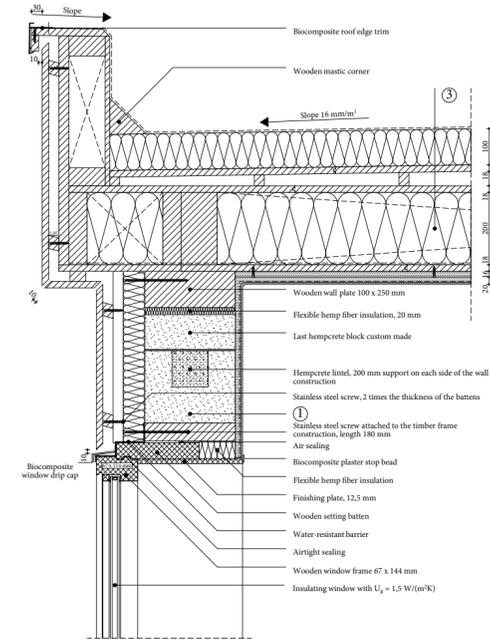
Detail configuration

hemcrete insulation blocks and a wooden façade

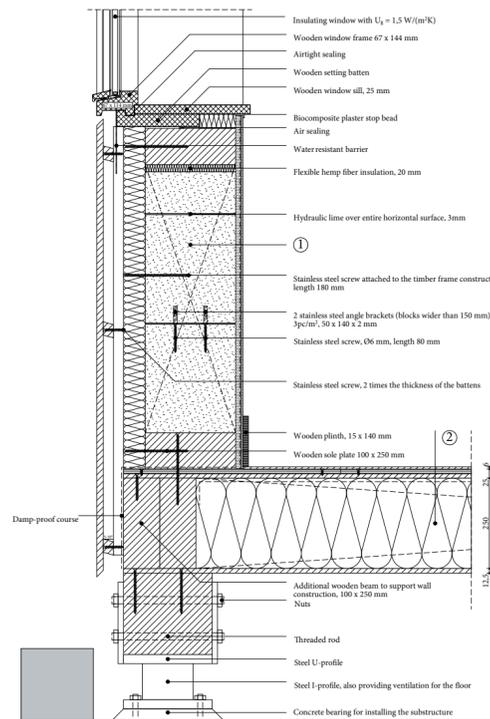


Corresponding details

Detail V2



Detail V1



Detail H1

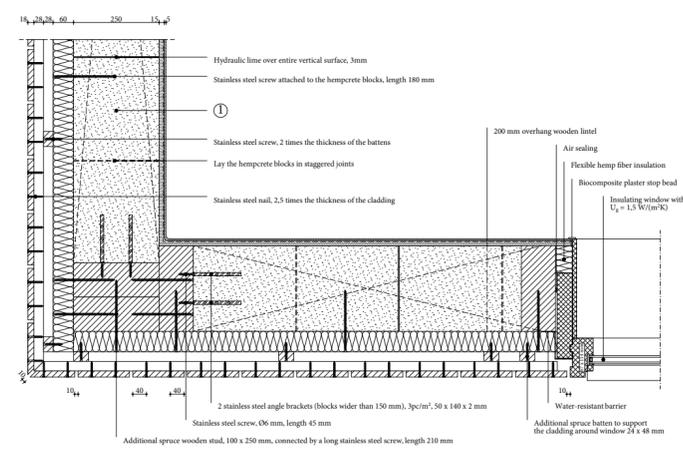


Figure 24. (Own illustration, 2025)

Figure 25. (Own illustration, 2025)

Methodology detail development



Methodology detail

hempcrete insulation blocks and a wooden façade

Products selection



Timber
façade panel
finish



Treated
construction
wood



Wood fibre
insulation
plate



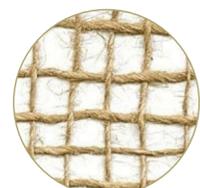
Hempcrete
insulation
blocks



Glulam
structural
frame



Flexible
hemp
insulation

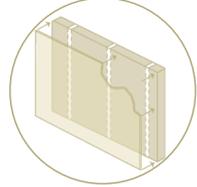
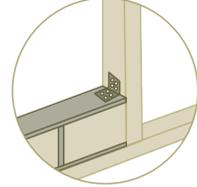
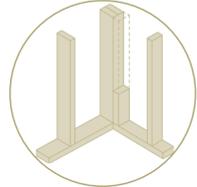
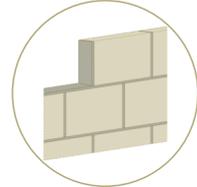
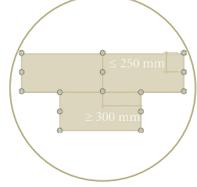
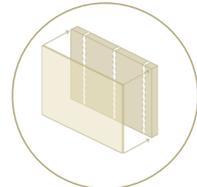
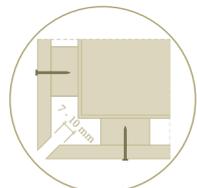
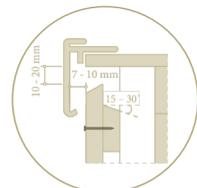
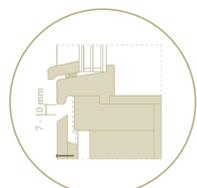
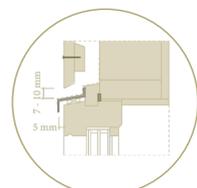
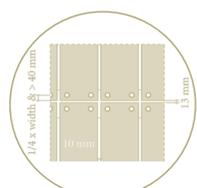


Jute
reinforcement
mesh

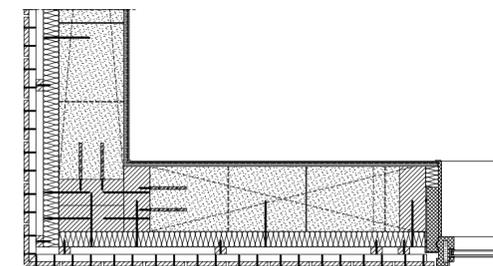
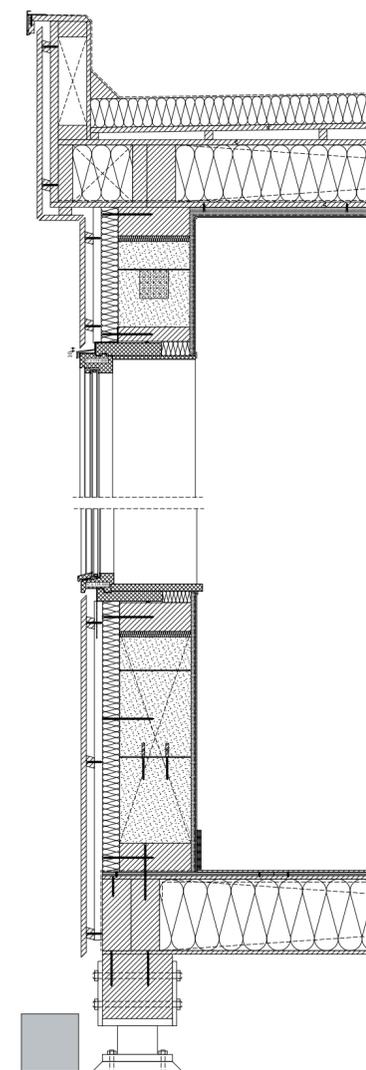


Clay plaster
interior
finish

Design principles



Detail development



Detail configurations

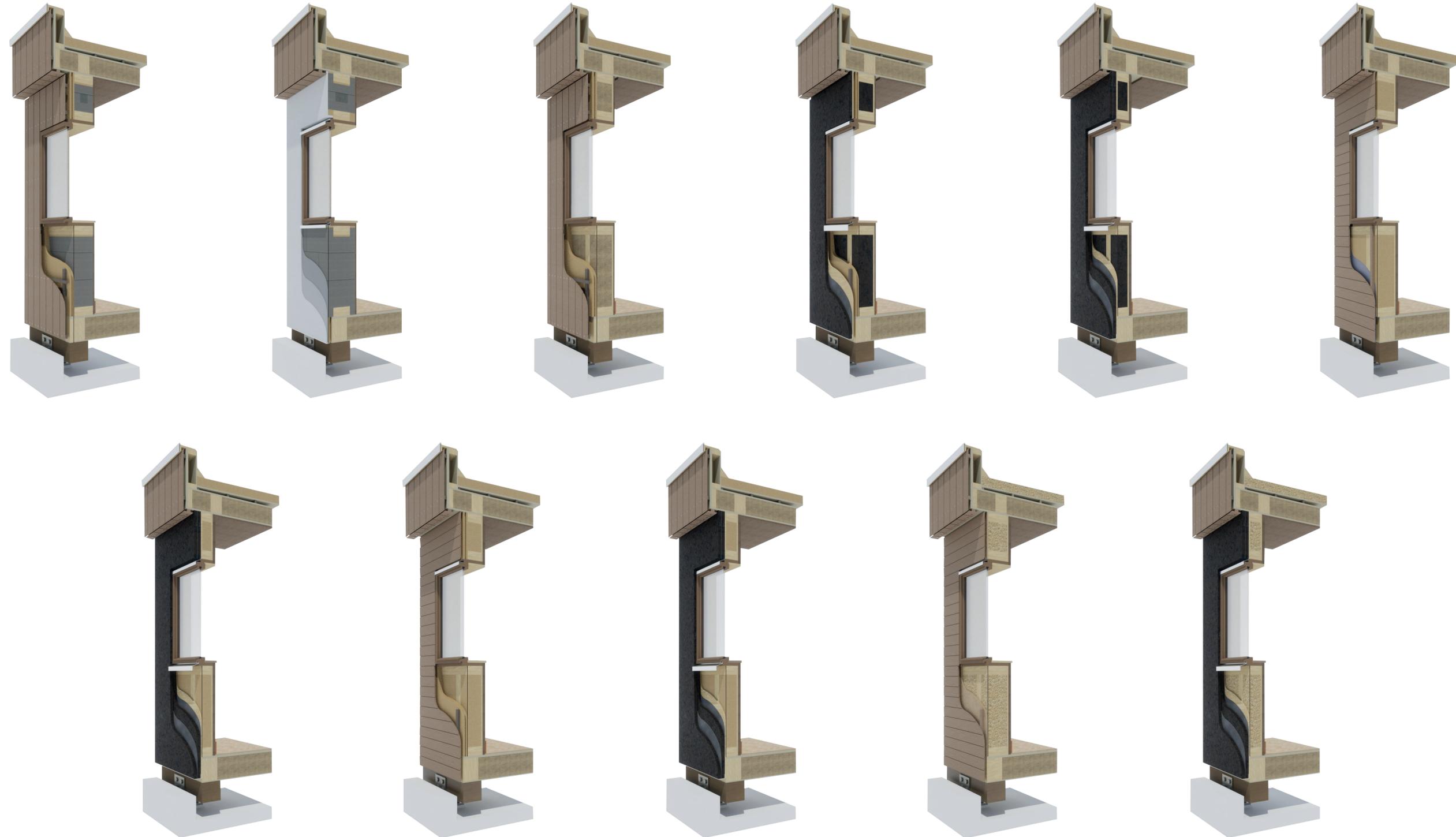
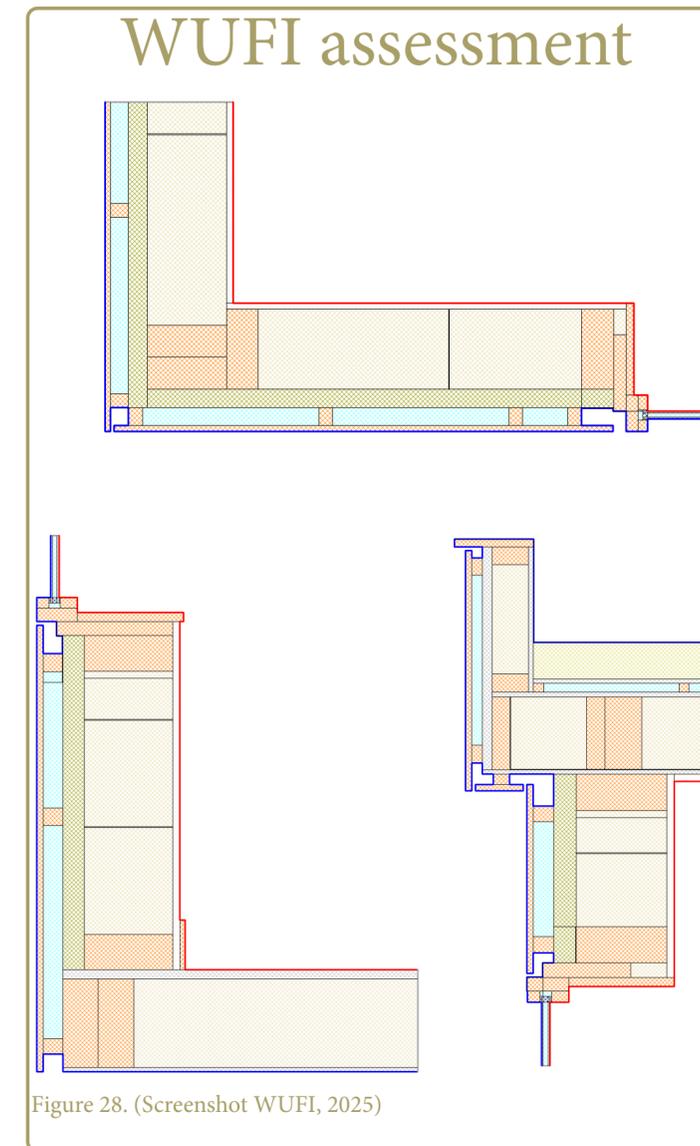
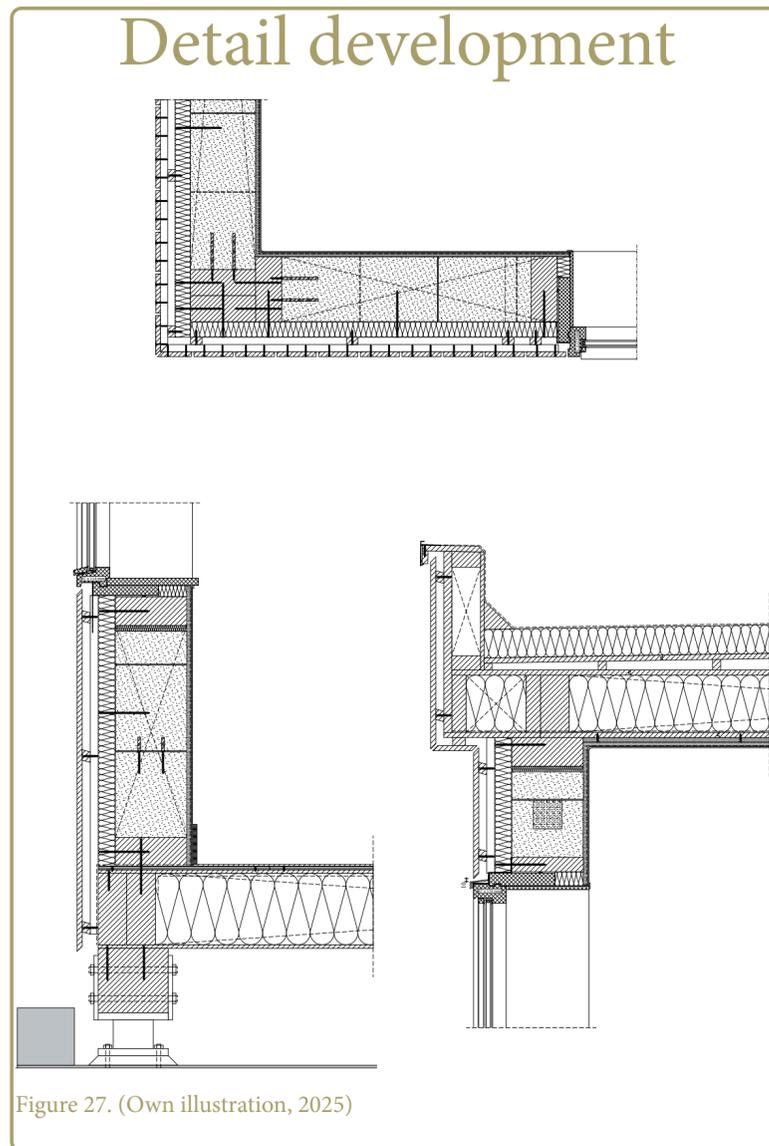
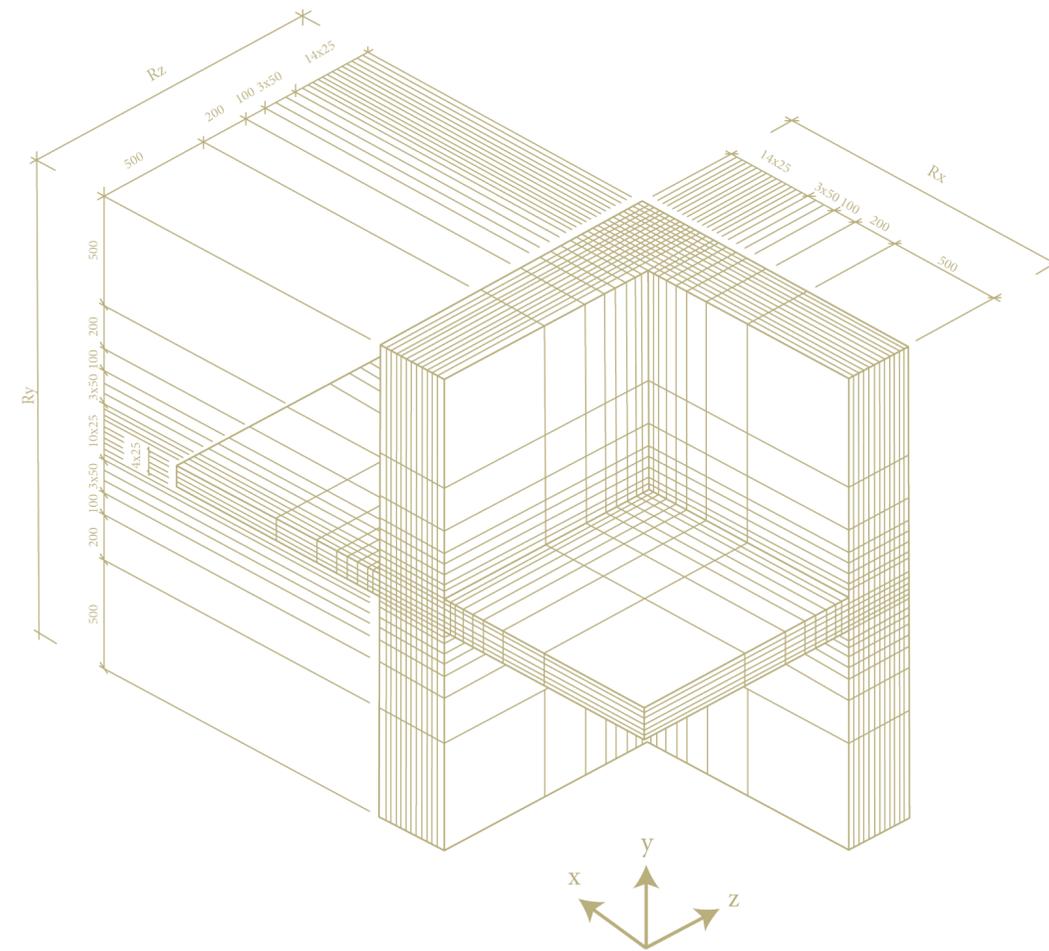


Figure 26. (Own illustration, 2025)

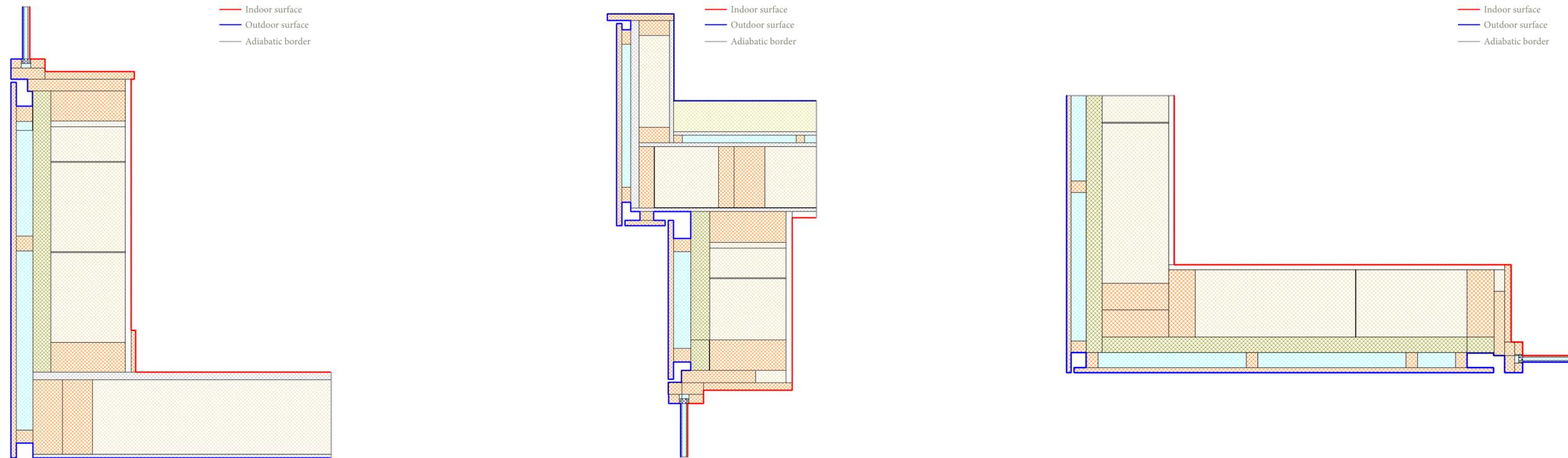
WUFI geometry



WUFI numerical grid



Boundary conditions



Isopleths

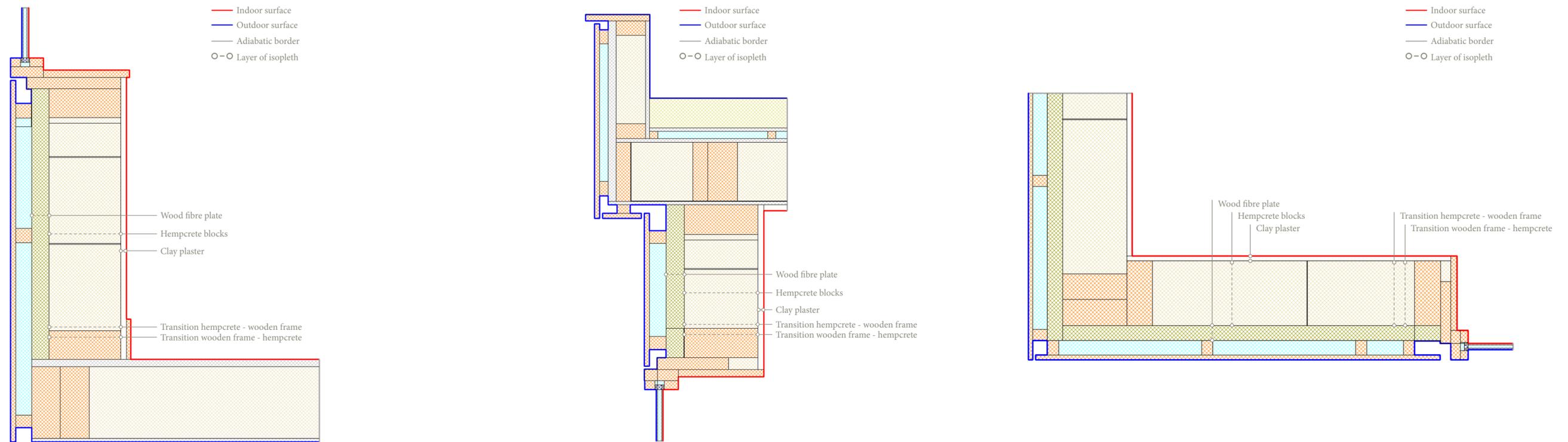
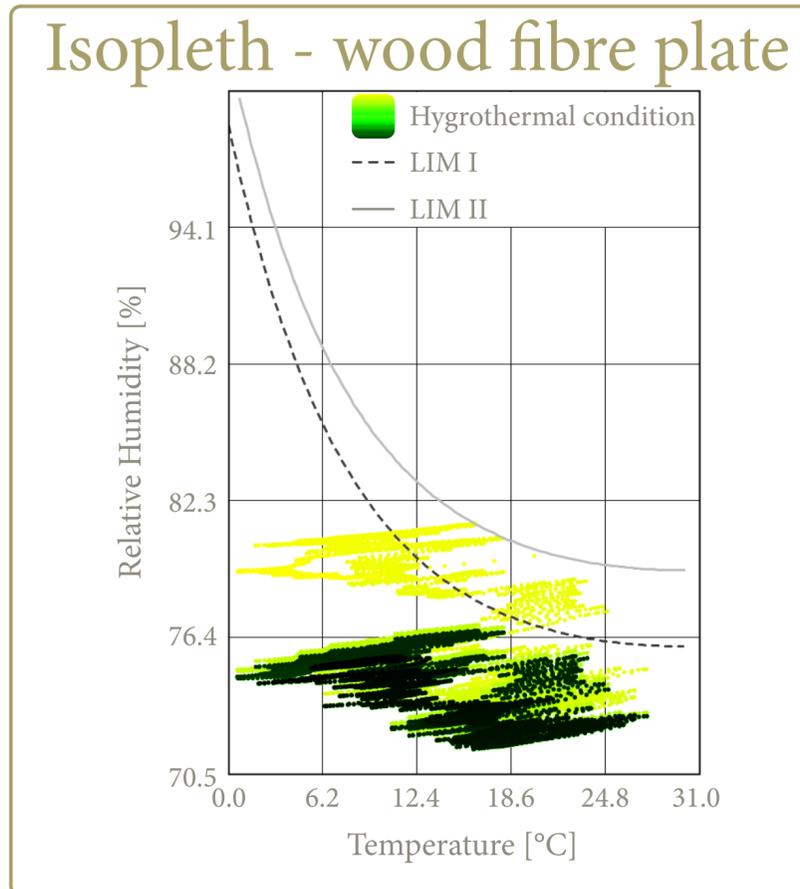


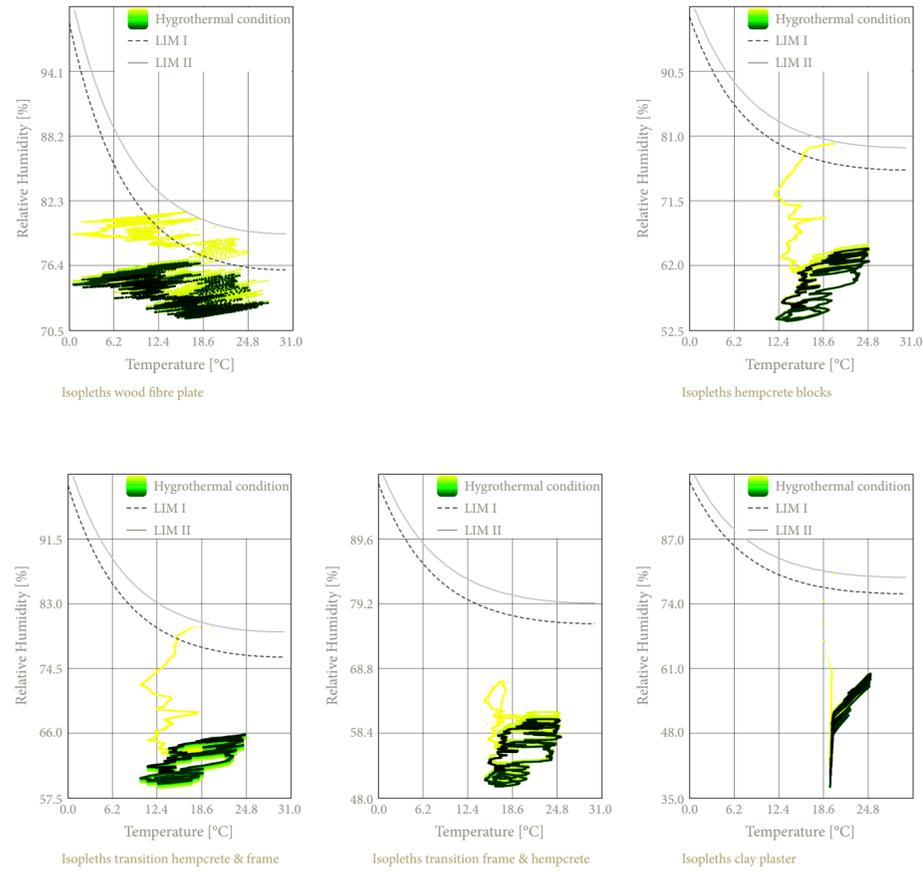
Figure 31. (Screenshot WUFI, 2025)

Isopleths

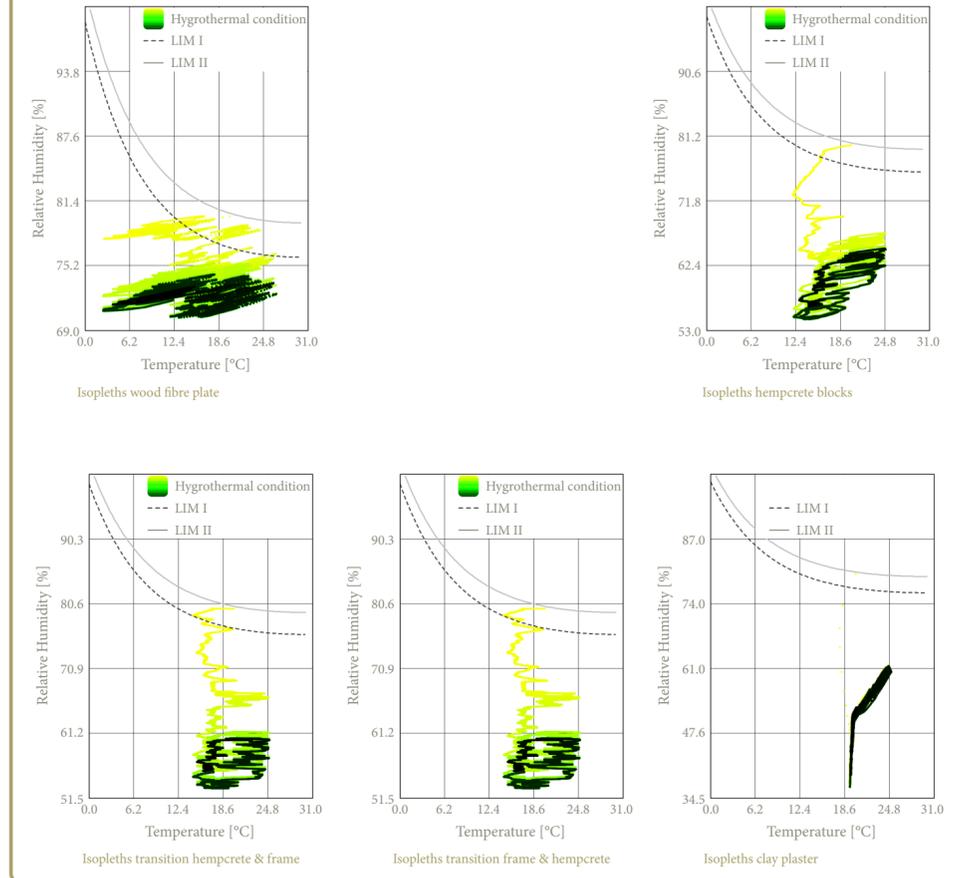


Isopleths

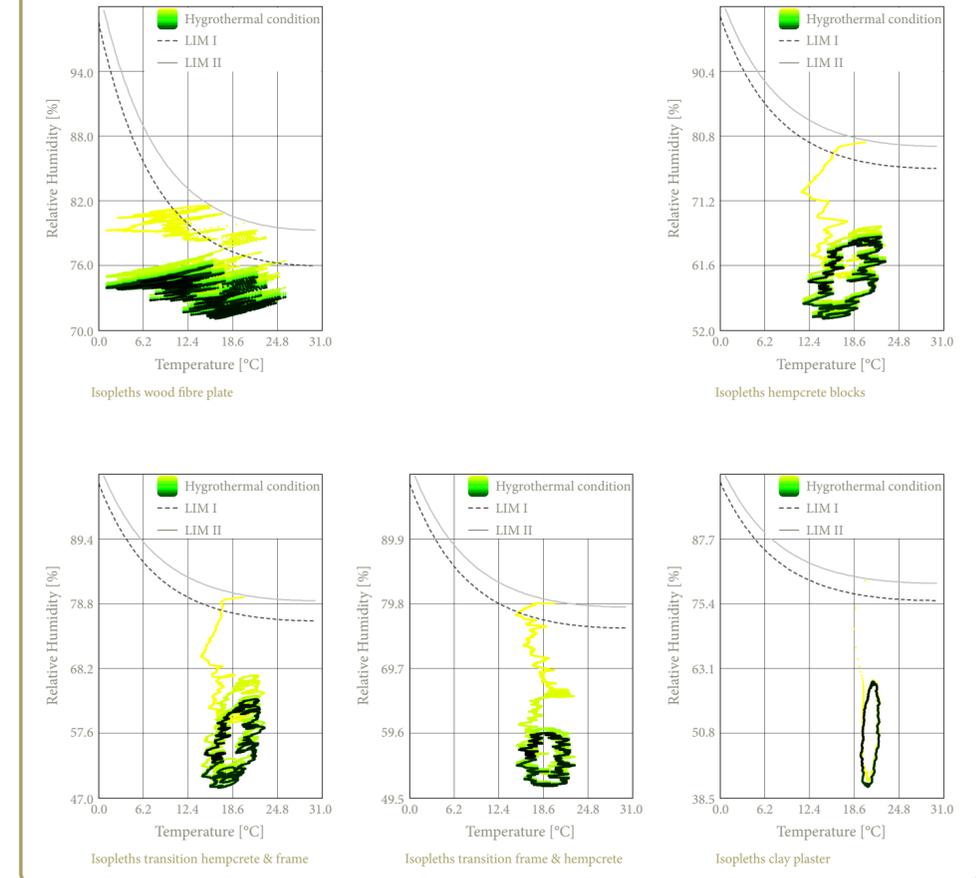
Isopleths - V1



Isopleths - V2



Isopleths - H1



Surface condensation

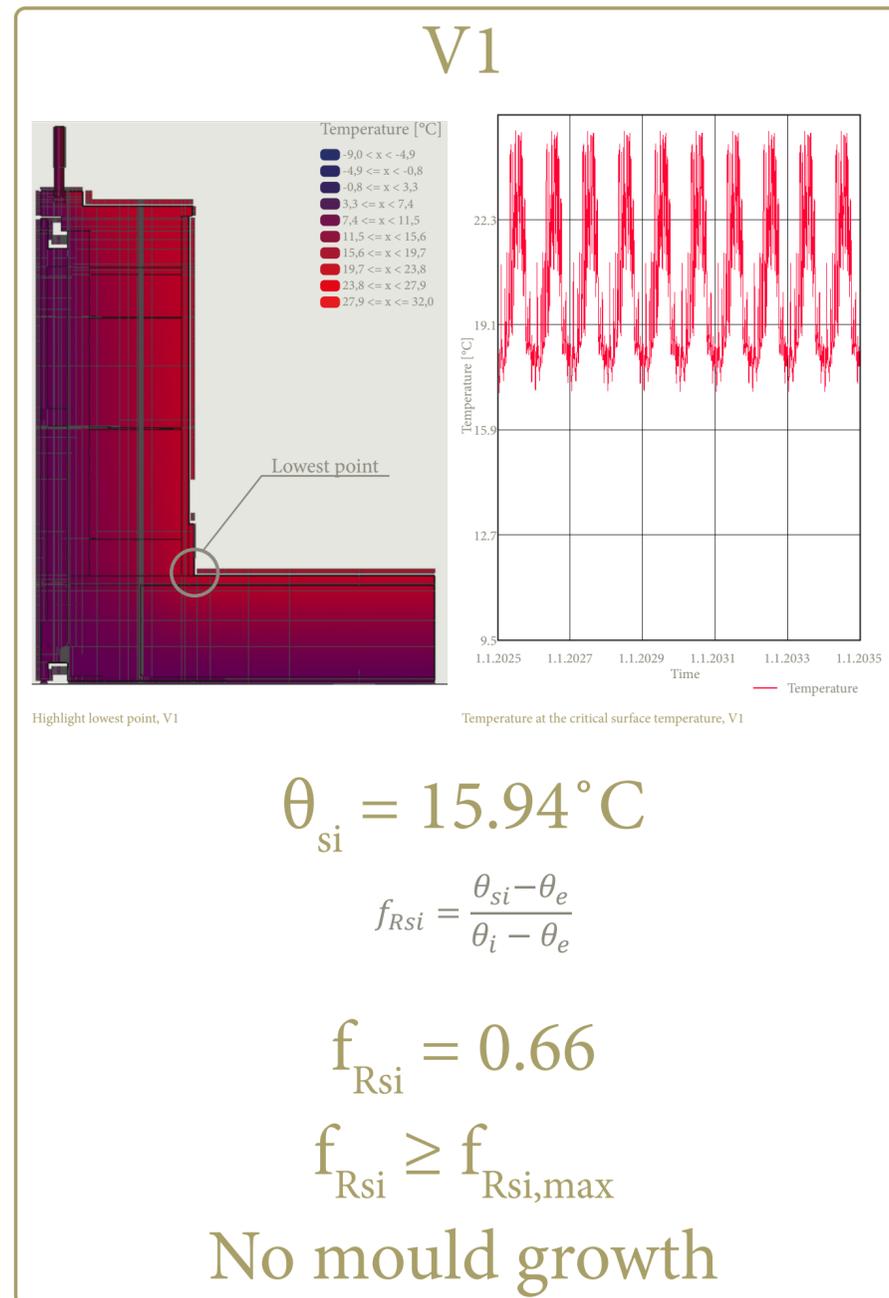
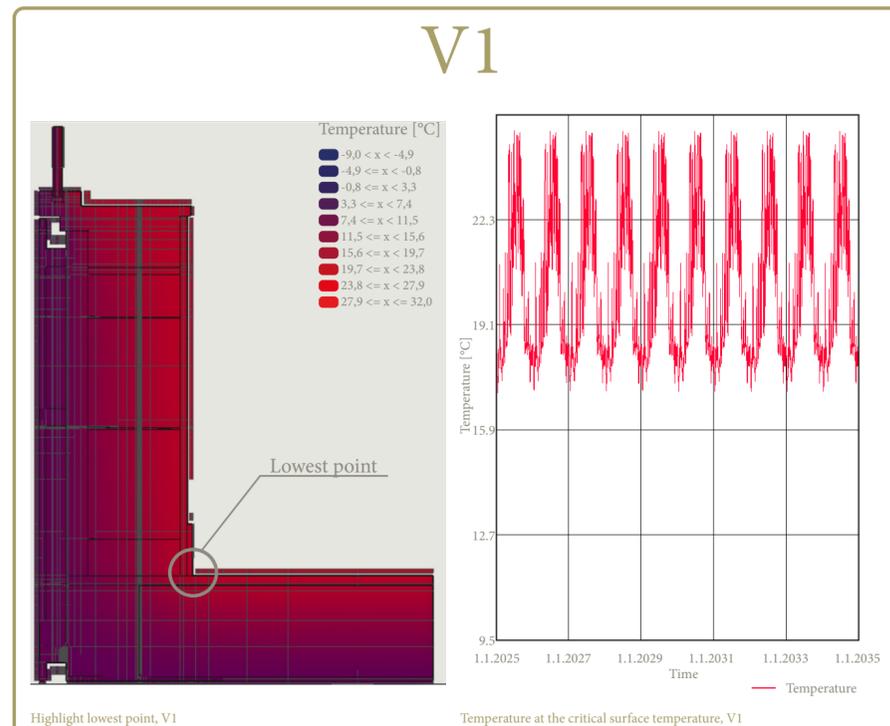


Figure 33. (Screenshots WUFI, 2025)

Surface condensation



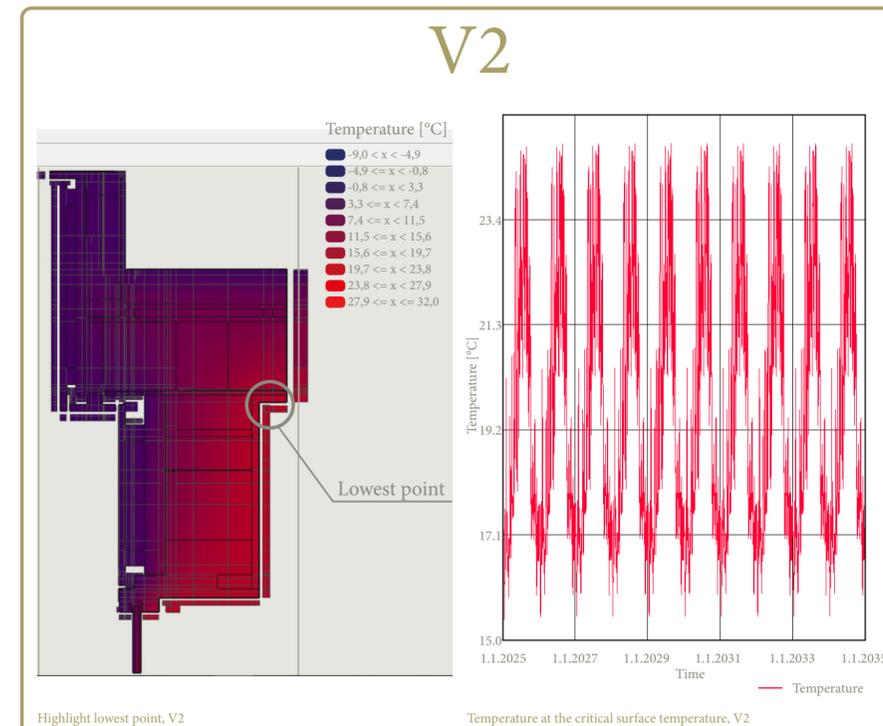
$$\theta_{si} = 15.94^{\circ}\text{C}$$

$$f_{Rsi} = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e}$$

$$f_{Rsi} = 0.66$$

$$f_{Rsi} \geq f_{Rsi,max}$$

No mould growth



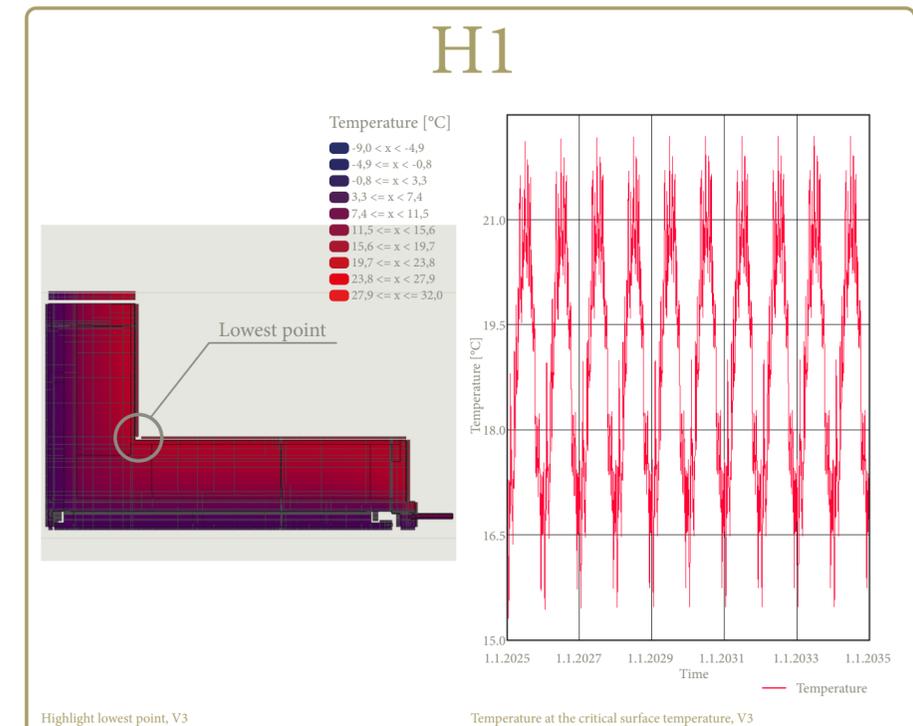
$$\theta_{si} = 15.40^{\circ}\text{C}$$

$$f_{Rsi} = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e}$$

$$f_{Rsi} = 0.62$$

$$f_{Rsi} \geq f_{Rsi,max}$$

No mould growth



$$\theta_{si} = 15.31^{\circ}\text{C}$$

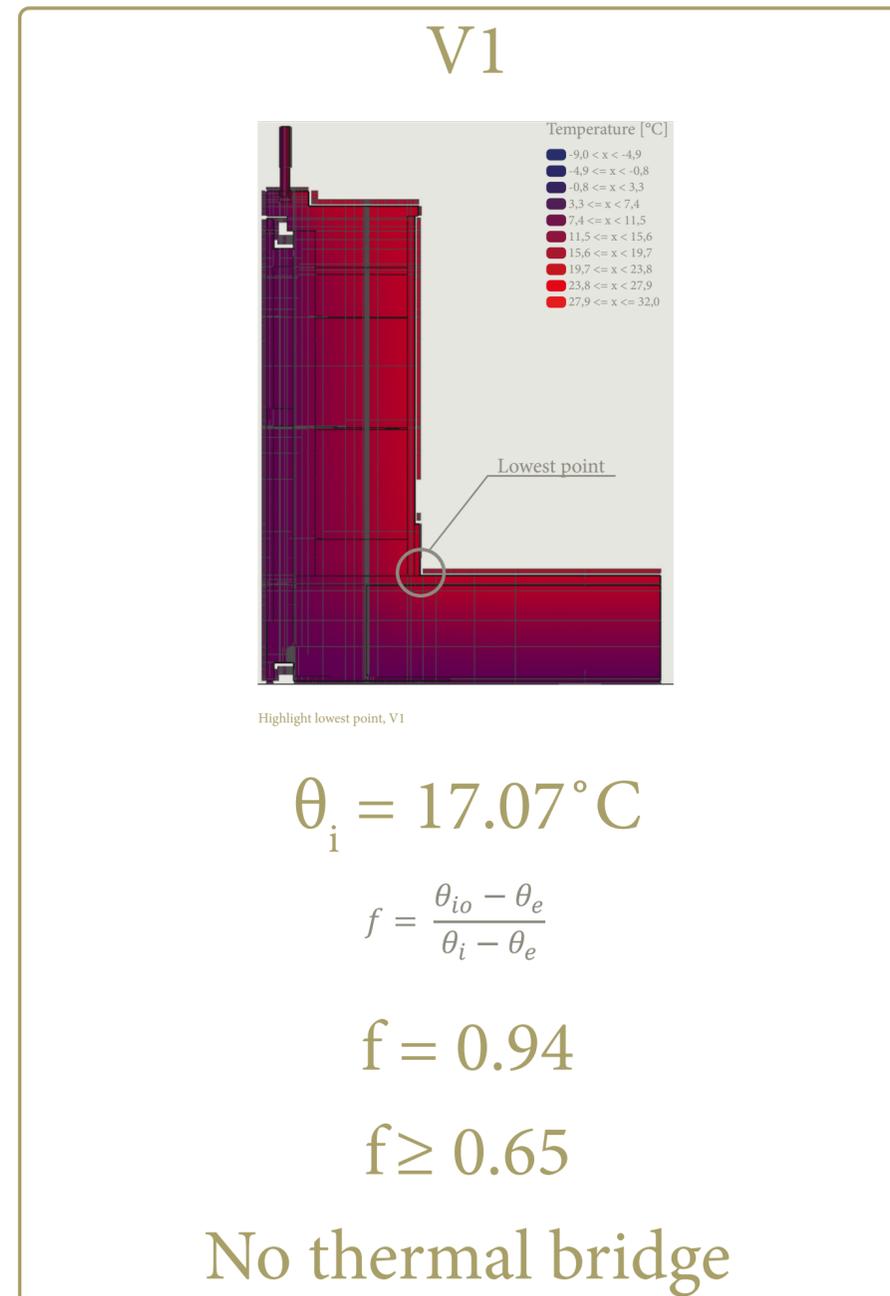
$$f_{Rsi} = \frac{\theta_{si} - \theta_e}{\theta_i - \theta_e}$$

$$f_{Rsi} = 0.61$$

$$f_{Rsi} \geq f_{Rsi,max}$$

No mould growth

f-factor



f-factor

V1



Highlight lowest point, V1

$$\theta_i = 17.07^\circ\text{C}$$

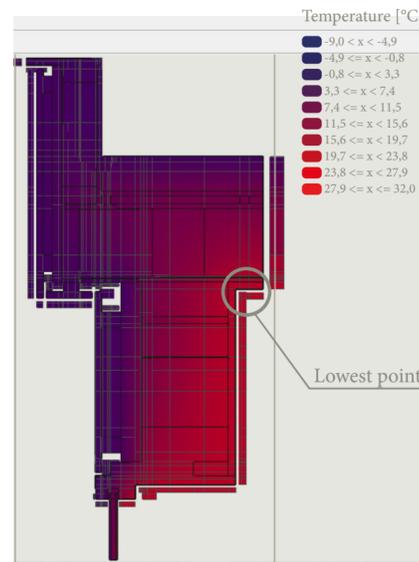
$$f = \frac{\theta_{io} - \theta_e}{\theta_i - \theta_e}$$

$$f = 0.94$$

$$f \geq 0.65$$

No thermal bridge

V2



Highlight lowest point, V2

$$\theta_i = 16.92^\circ\text{C}$$

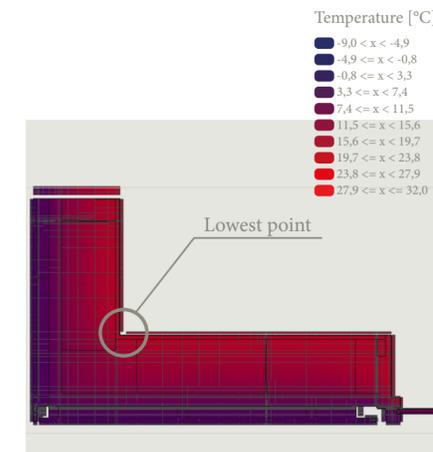
$$f = \frac{\theta_{io} - \theta_e}{\theta_i - \theta_e}$$

$$f = 0.94$$

$$f \geq 0.65$$

No thermal bridge

H1



Highlight lowest point, V3

$$\theta_i = 16.99^\circ\text{C}$$

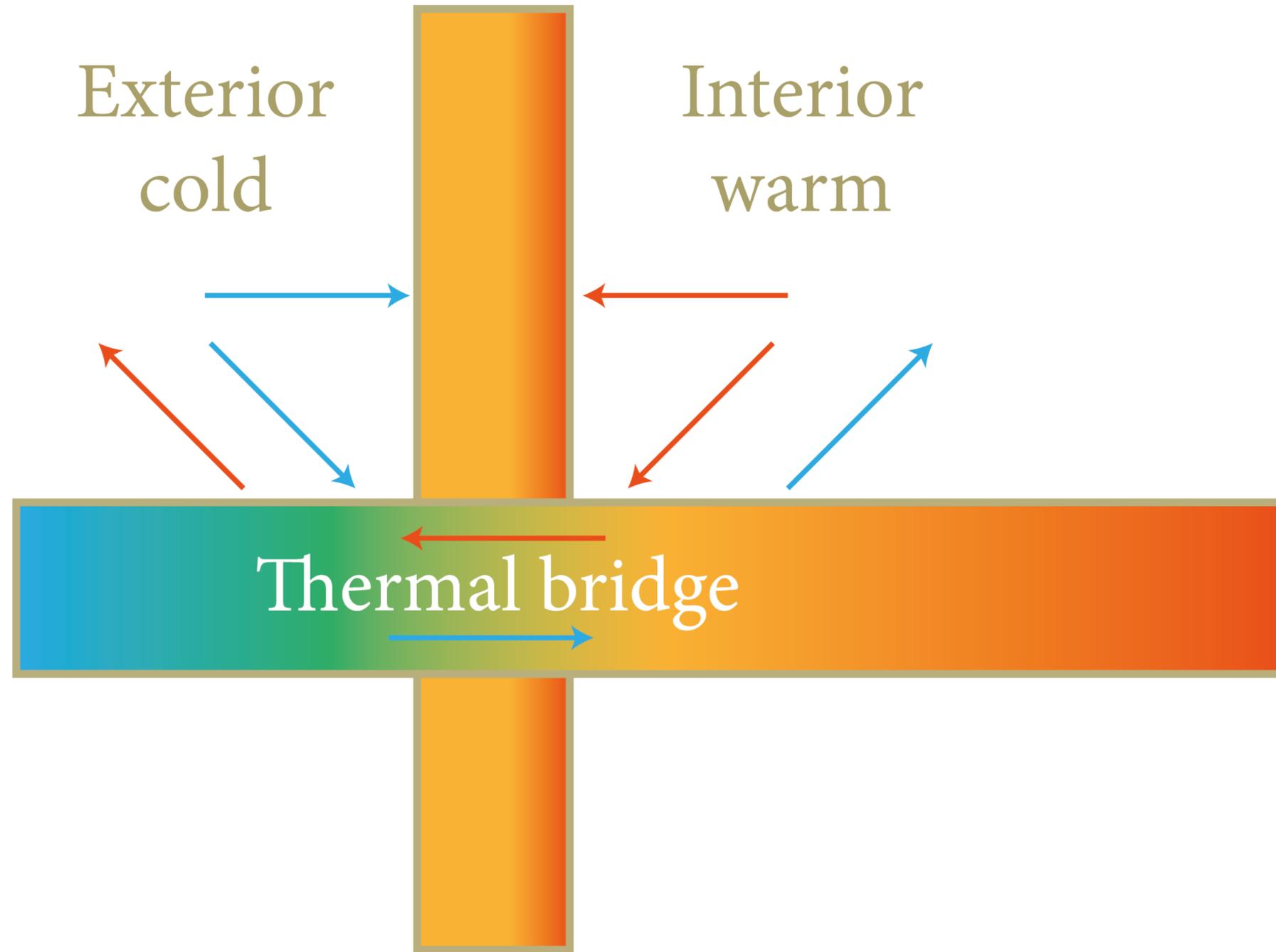
$$f = \frac{\theta_{io} - \theta_e}{\theta_i - \theta_e}$$

$$f = 0.94$$

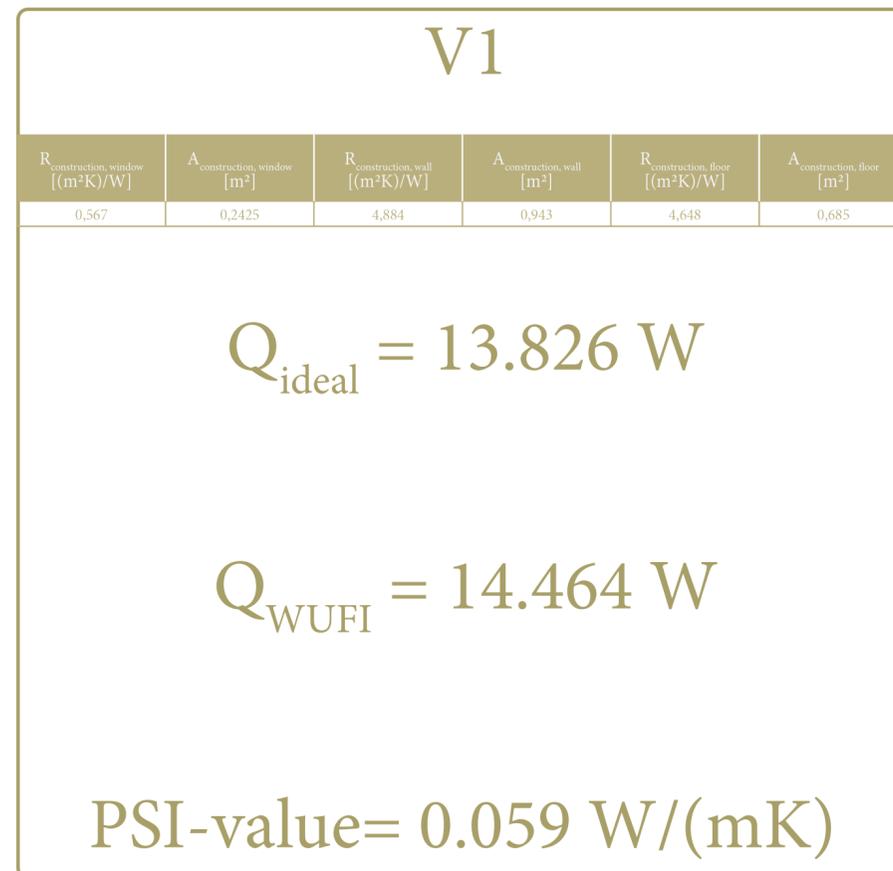
$$f \geq 0.65$$

No thermal bridge

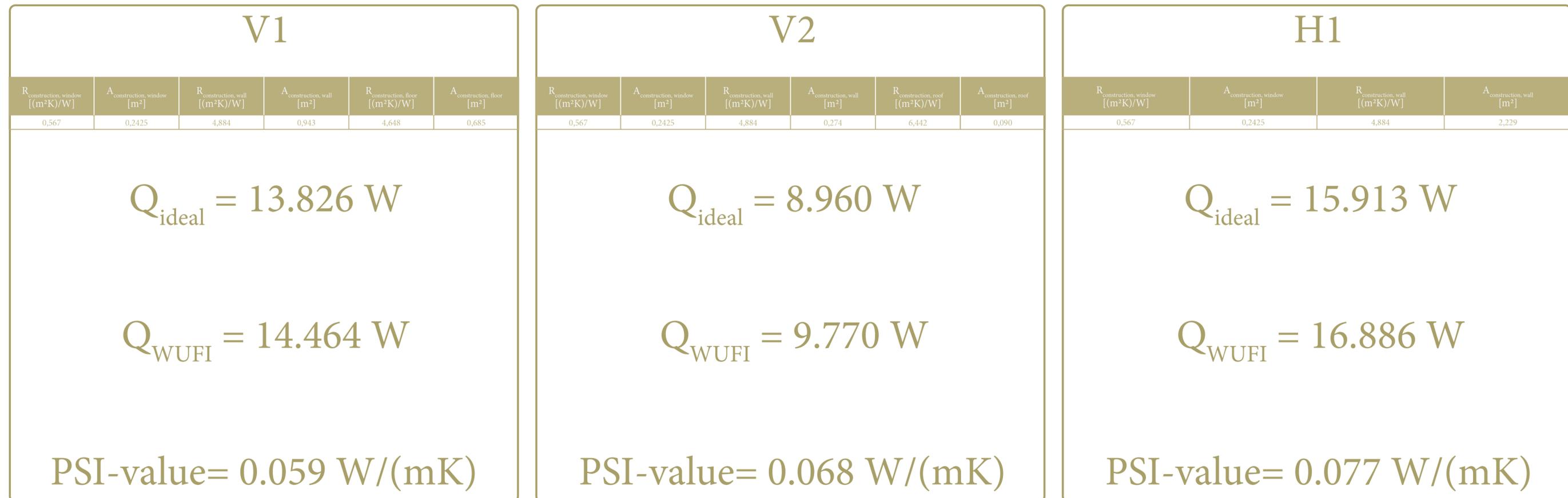
PSI - value



PSI - value



PSI - value

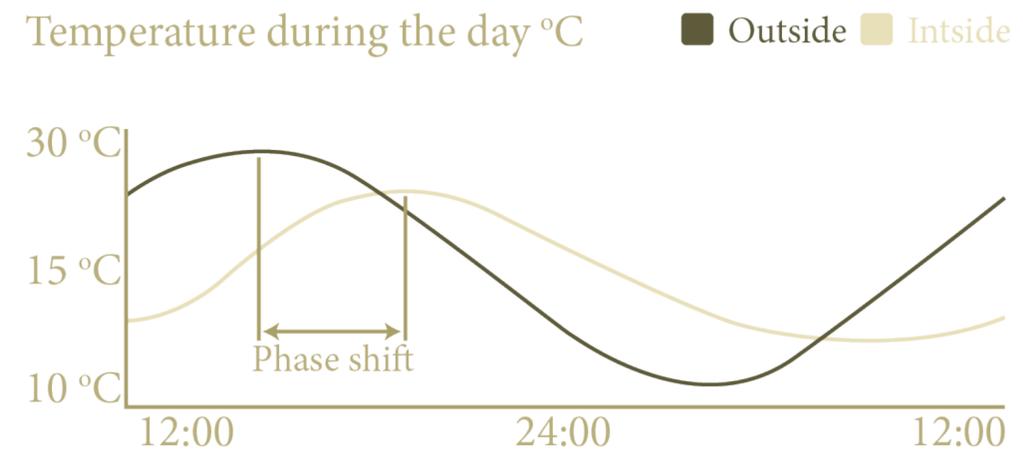


Density

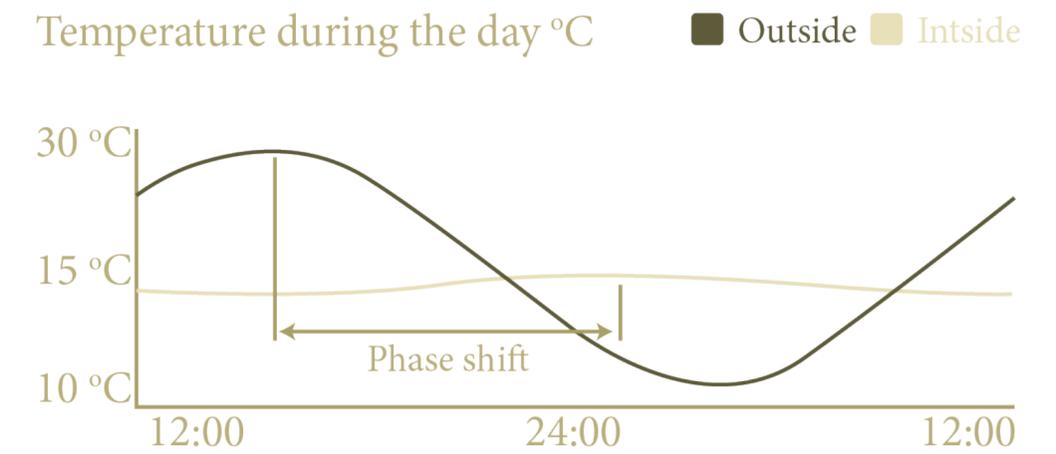


Phase shift & temperature amplitude

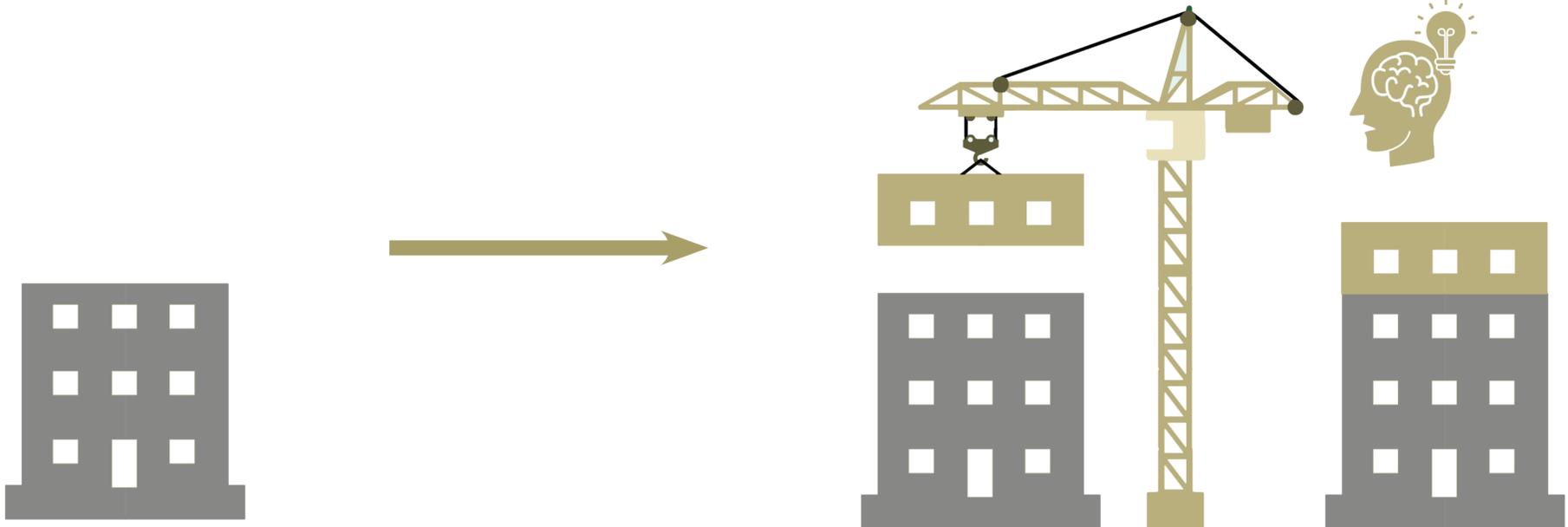
Low thermal mass constructions



High thermal mass constructions



What if?



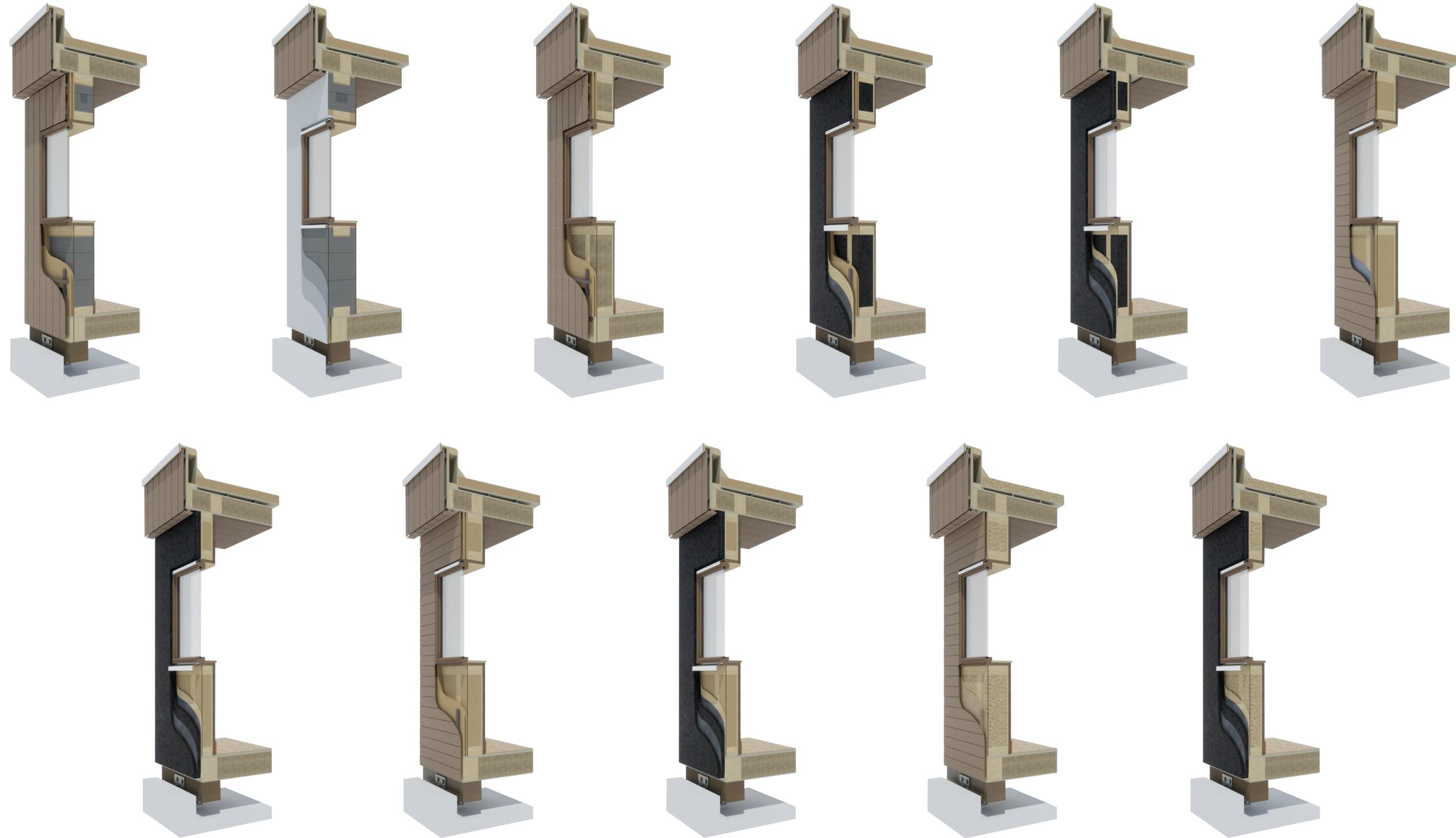


Figure 34. (Own illustration, 2025)

Bio-based reference façade wall details

Design and analysis of moisture transport and thermal bridges for Dutch residential top-up buildings

P5 Presentation

19-06-2025

Mark de Kanter