Integrating sustainability and health in buildings through renewable materials

InnoRenew CoE International Conference 2020

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*Unable to present

Using discrete optimization methods in decision support for structural design

Balázs Dávid, InnoRenew CoE / University of Primorska

Structural design process

Planning

- Development of the initial layout
- Positioning and orienting elements

Exact approaches:

Dorne et al. [7], Bendsøe & Kikuchi [3], Kirsch [9]

Heuristic methodologies:

Camp [4], Deb [6], Changizi & Jalalpour [5]

→ Preliminary design

Missing properties (e.g shape/size, material used)

Design

- Structural plan based on preliminary design

Solution approaches:

Baumann & Kost [2], Fedelinski & Gorski [8], Lamberti & Pappalettere [10]

Combination of planning and design:

Lamberti & Pappalettere [11], Azad & Hasançebi [1]

→ Draft of structural framing

Detailing

- Structural drawing
- Final review
- Preparation of plans

Optimization of structural design

Structural frame optimization problem

Structural frame is the skeleton of a modern building. It consists of separate levels and contains three element types:

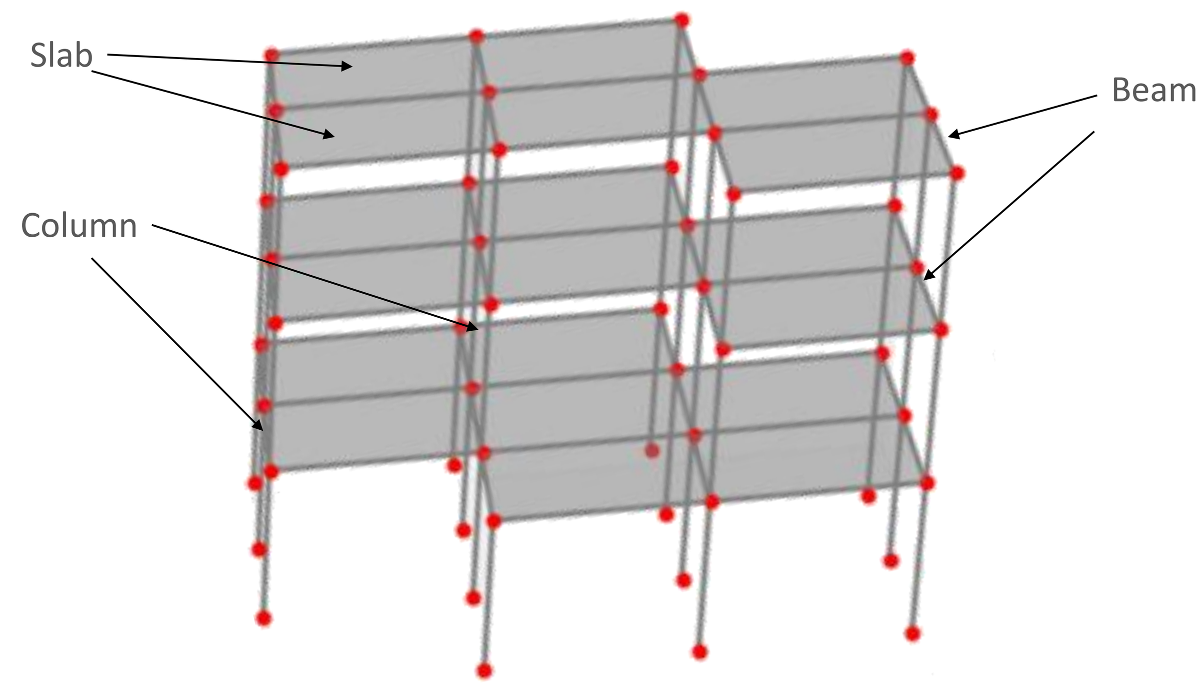
- **Slabs:** the plate elements of the structure
- **Beams:** horizontal elements that support the slabs
- **Columns:** vertical elements that support the beams and other columns

Various optimization constraints to satisfy:

- A material has to be chosen for each element.
- The cross-section of an element has to be chosen based on its desired material and the structural forces affecting it.
- Material and cross-section of certain elements has to be identical.

Multi-objective optimization problem:

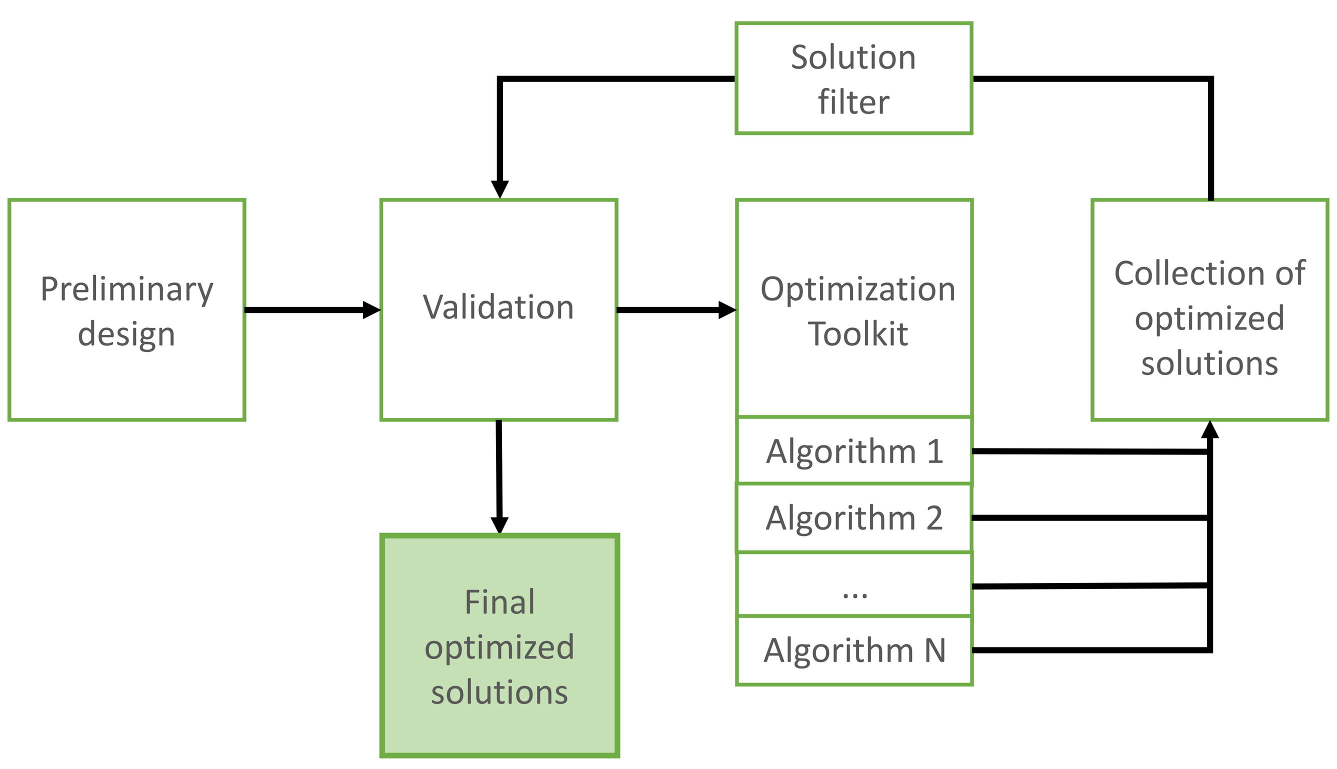
- Capital and operational expenses
- Environmental impact



Preliminary design of a structural frame

A decision support framework approach

- Starts from the preliminary design
- Optimization parameters set by the user
- Multiple optimization algorithms can run in parallel
- Every solution is collected to a common container
- After optimization, a chosen set of solutions is sent for validation
- If solutions are accepted: **END**, otherwise: re-optimize



Outline of the decision support framework

A Tabu search algorithm

Neighbourhood transformation: new material to a group of elements

```
Func OptTabu(p)
    s = preliminary solution p
    o = s
    TL = ∅
    while no terminating condition reached
        manage TL
        for all groups g
            for all materials m
                if (g, m) ∈ TL
                    continue
                p = change all elements in g to material m
                if cost(p) < cost(s)
                    candidate = p
                    cl = (g, old material of g)
        s = candidate
        TL = TL ∪ cl
        if cost(s) < cost(o)
            o = s
return s
```

How "good" is our solution?

Compare it to the optimum given by a mathematical model.

E: set of elements, G: groups of elements, $\forall\, e \in E$, let $g(e) \in G$, M: set of building materials

Variable x_{em}: decision of using material m for element e,

Variable y_e: cross-section of element e

$$minimize \sum_{e\in E}\sum_{j=1}^{|M|} c_{ej}\, x_{ej}$$

$s.t.$

$$\sum_{j=1}^{|M|} x_{ej} = 1, \forall e \in E \quad (1)$$

$$x_{im} - x_{jm} = 0, \forall i \in E, j \in g(i), 1 \le m \le |M| \quad (2)$$

$$y_{im} = max\{s_{jm}x_{jm} \mid j \in g(i), 1 \le m \le |M|\}, \forall i \in E \quad (3)$$

$$x_{im} \in \{0,1\}, \forall i \in E, 1 \le m \le |M| \quad (4)$$

$$y_i > 0, \forall i \in E \quad (5)$$

Constraint (1): each element will have exactly one material.
Constraint (2): elements belonging to the same group will have the same material.
Constraint (3): proper cross-section of every element, elements belonging to the same group should have the same cross-section.
Constraints (4) and (5): binary and non-negativity

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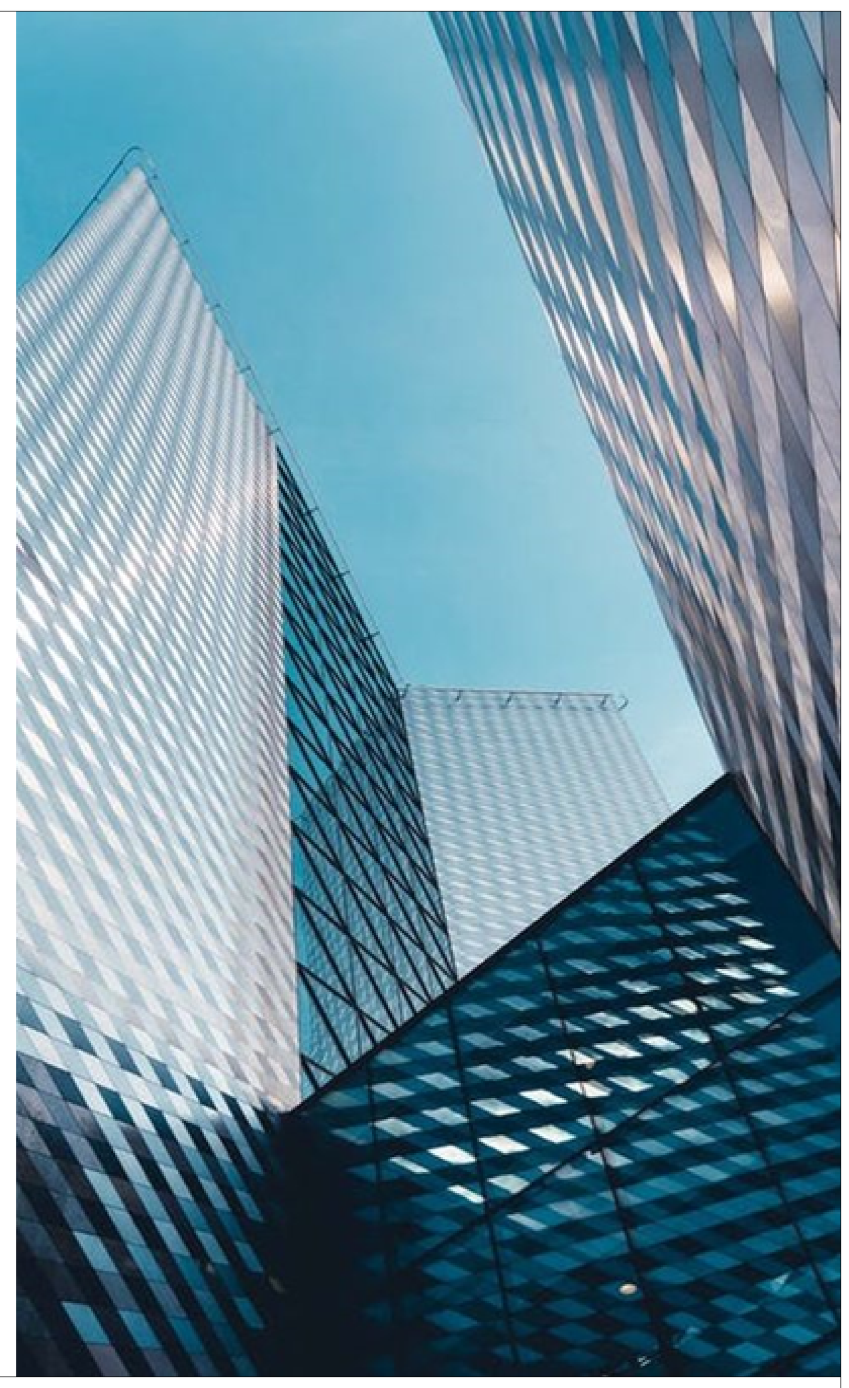
Optimal office building design using Energy Design Synthesis method

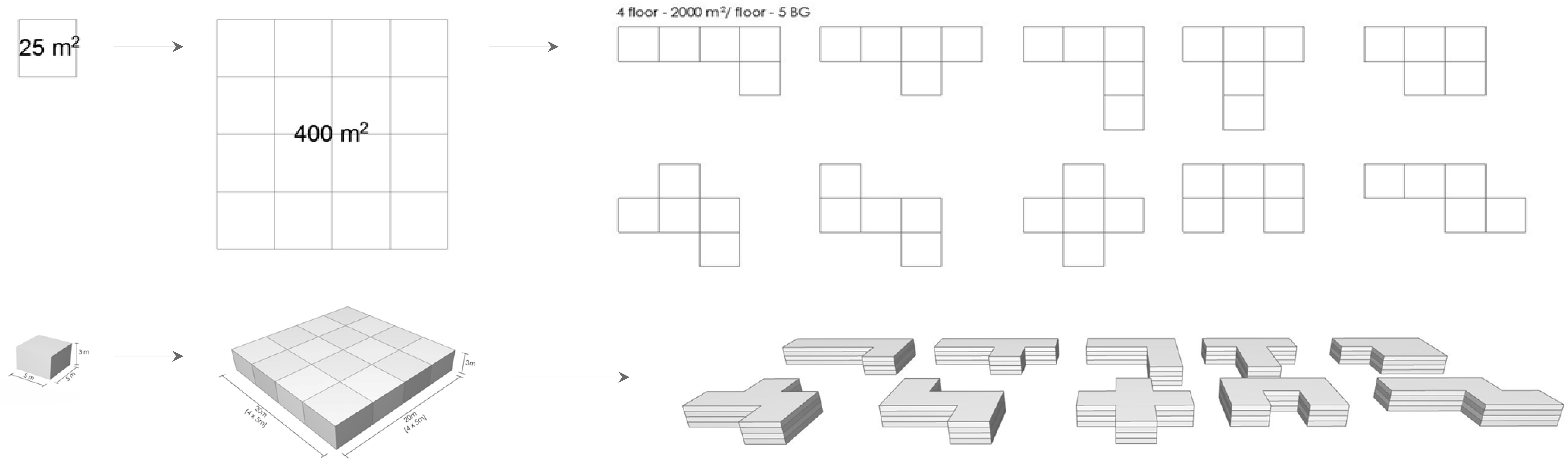


Method

- Defining rules to create space organized model combinations
- Generate all possible and potentially optimal building geometry within algorithmic rules
- Reduction of model samples due to energy demand performance ranking
- Selection of best, worst and avarage performing models
- The selected geometries applied by passive design strategies *(wall-window ratio, orientation, building strucures, shading)*
- Dinamic thermal simulation to assess energy-comfort performance
- Weighting systems according to user preferencies and/or absolut weighting ratios
- Order creation and optimum finding

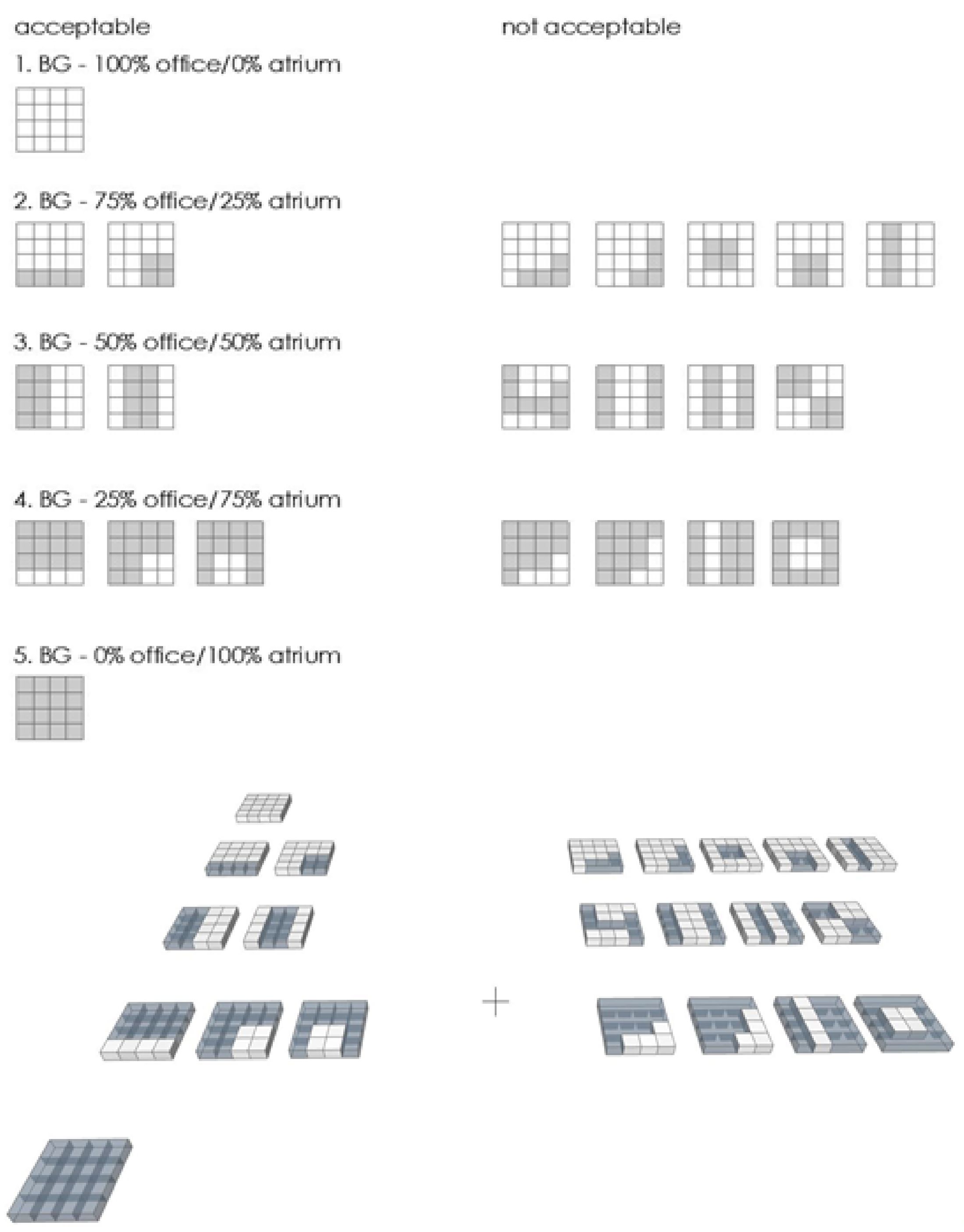
1.

Basic unit **Basic group** **Basic groups - lay outs**

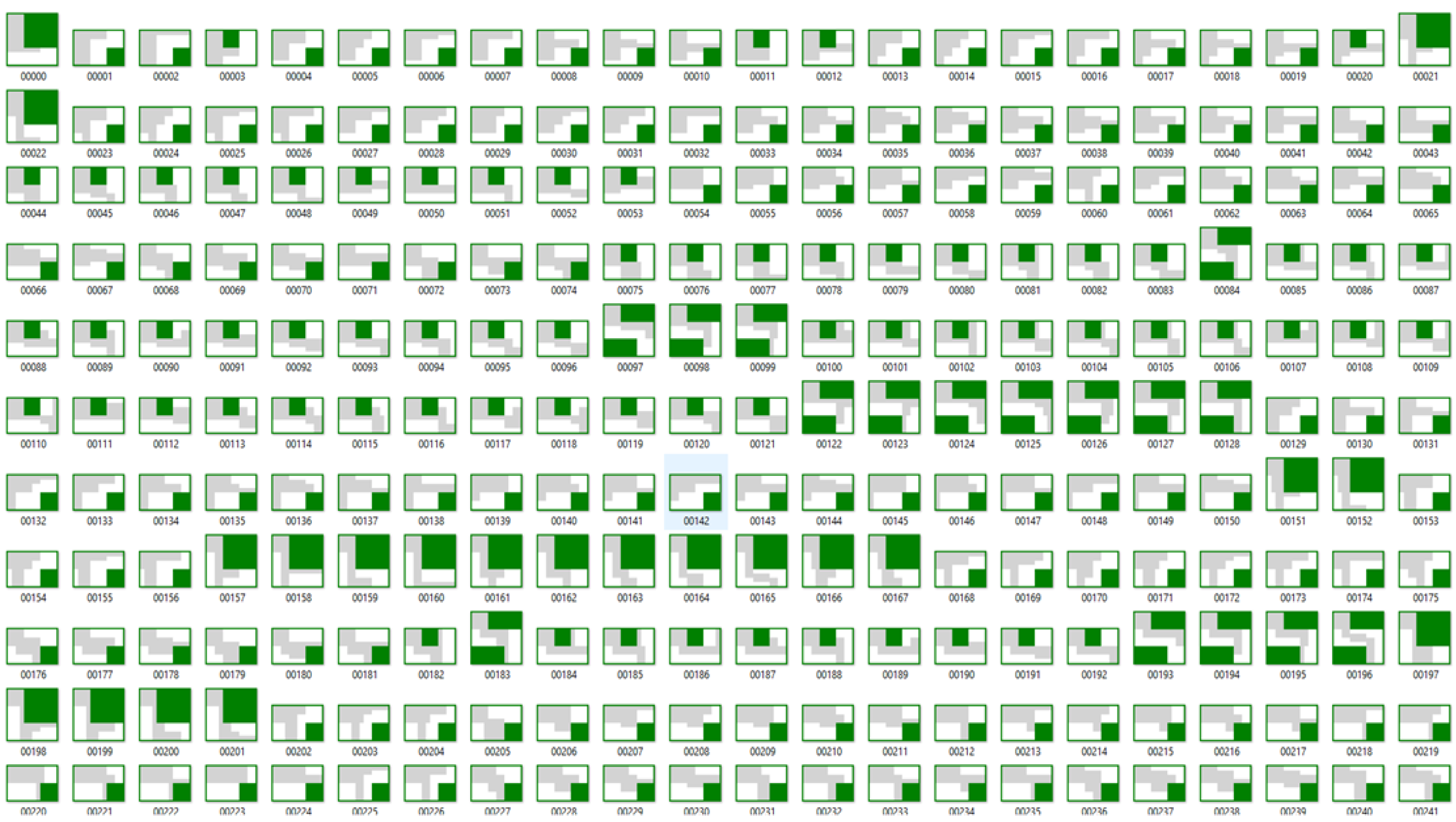


2.

Atrium - office rate

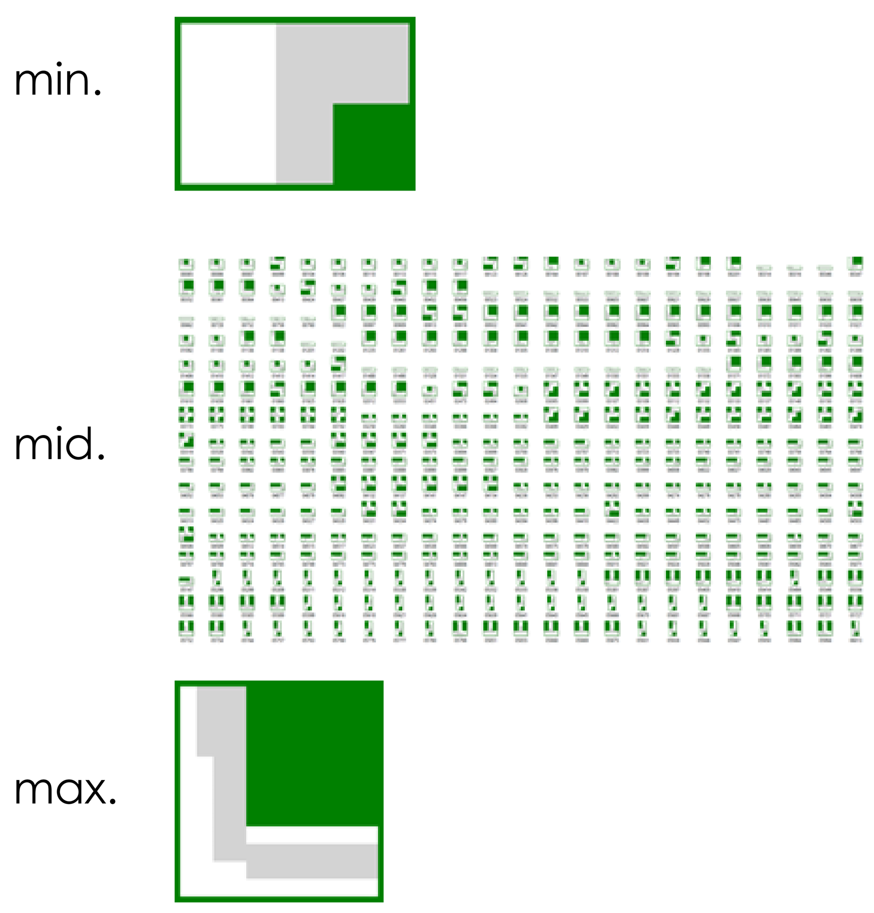


Results: 6311 model



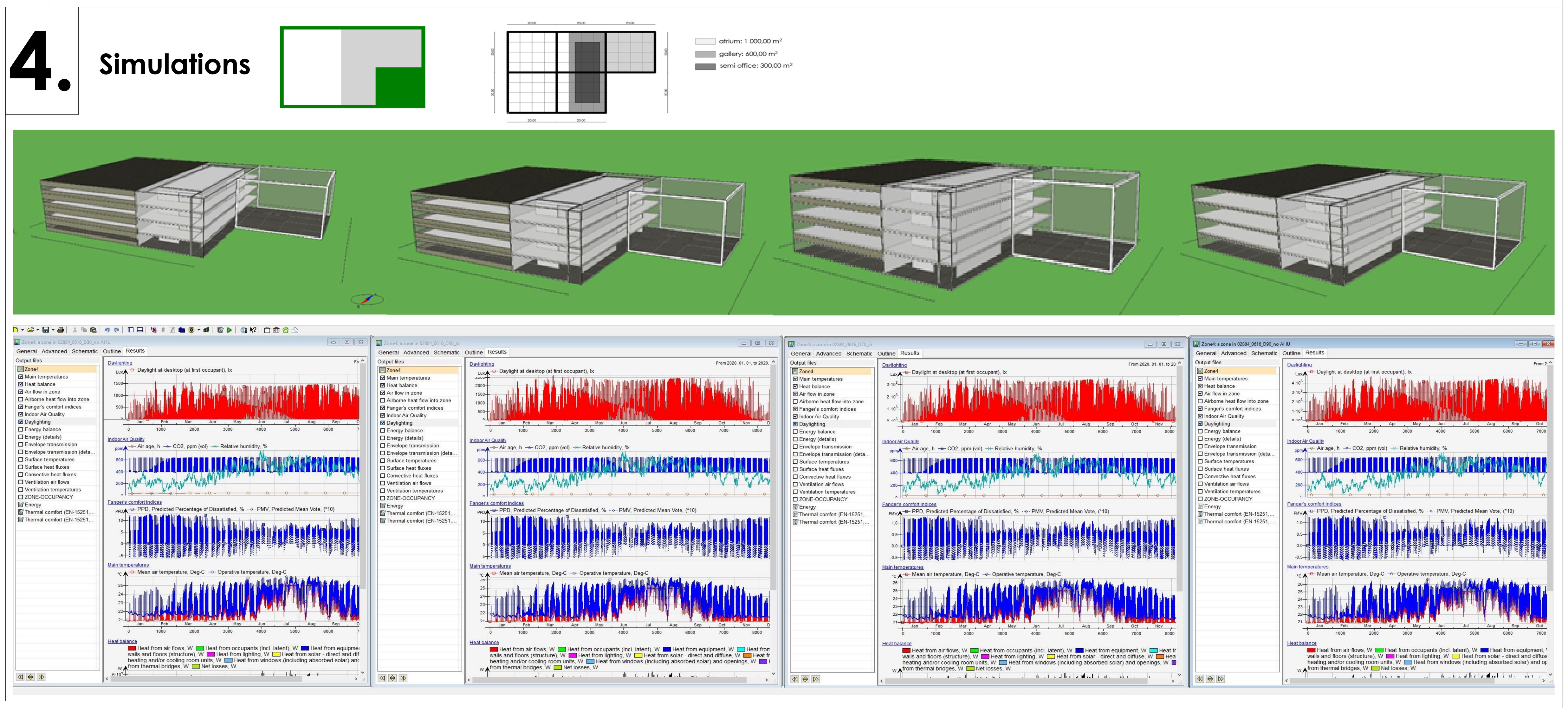
3.

A/S ranking



4.

Simulations



Optimal office building design using the Energy Design Synthesis method

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Dóra Zetz

Developing temporary housing solutions for displaced persons – a study of user needs

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Temporary housing solutions

Temporary housing solutions are needed in civil protection for offering shelter to people in disaster-affected areas and other displaced persons. According to UNHCR around 79,5 million people were displaced worldwide at the end of 2019. Often, shipping containers are used for shelters, and while some studies highlighted the positive aspects (Zhang and Elmpt, 2014; Hong 2017) and their sustainability (Islam et al., 2016), others have pointed out the need for better and more sustainable solutions (Perruci et al., 2016).

Different types of temporary housing of UNHCR in terms of durability:

UNHCR family tent : 1 year durability; polyester cotton blend and plastic sheeting

UNHCR Self- standing family tent: 1 year durability; high density polyethylene (HDPE) fibers, polyester cotton, plastic sheeting

Refuge Housing Unit: 3 years durability; steel frame, polyolefin foam panels, UV stabilized polymer plastic (doors and windows), woven high-density polyethylene fibers (floor)

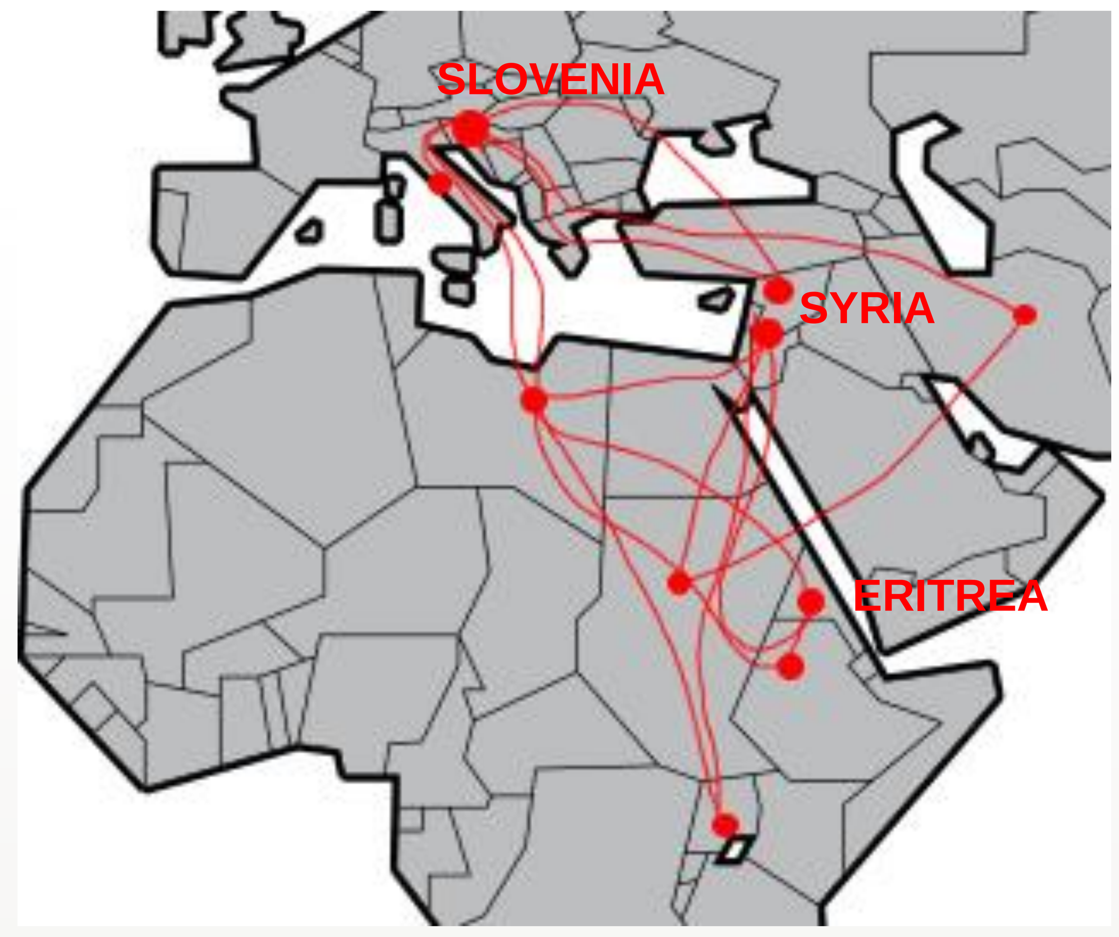
Transitional shelter: 2-4 years durability; steel structure and sheet metal, aluminum foam insulation

Durable shelter: 10 years durability; brick or concrete tiles, concrete, cement mortar, ceramic tiles or sheet metal (roof), steel beams

Material choice of the shelters is less environmentally friendly for the types with shorter durability. This is problematic since it causes enormous amounts of waste that cannot be recycled. Use of natural and biodegradable materials for the shelter design should be encouraged.

Study of user needs

- **Twelve in-depth interviews** with those that received refugee status in Slovenia, six of Syrian (4 male, 2 female) and six of Eritrean nationality (3 male, 3 female). Interviews took place in November 2018.
- They were asked to describe their dwellings in their home country, their accommodations on the journey to Slovenia and their current accommodation.



Journey of the interviewees from their hometowns to Slovenia:

Syria – Turkey – Slovenia

Syria - Turkey – Greece – Slovenia

Syria – Libanon – Egypt – Libya – Italy – Slovenia

Syria – Sudan – Iran – Turkey – Greece – Balkan – Slovenia

Eritrea – Sudan – Libya – Italy - Slovenia

Eritrea – Ethiopia – Sudan – Libya – Italy – Slovenia

- They were asked for feedback on a draft building plan to develop an adaptable and modifiable modular wooden building that could be used as a temporary dwelling.
- Dwelling features that the interviewees valued most were having **private bathrooms and kitchens and being settled in cities**, close to necessary infrastructure and integrated with the local population.
- They did not show strong preferences toward any construction materials, but some of them showed some concerns regarding the use of wood, especially those from Eritrea having less experience with wood as a construction material.

Discussion of results and future work

Study of user needs showed that natural materials are recognized as more desirable in most cases, because they form healthier and more pleasant living environments. However, there is some doubt about the durability of such materials, especially wood, which is also major obstacle to not using it in larger projects for shelter design at UNCHR. Therefore more investigation should be made into development of durable, lightweight and biodegradable materials for shelter design, that would allow easy transportation to areas of displaced people.

Quotations

Note: For purposes of confidentiality, pseudonyms are used instead of real names.

Q: Did you have any issues in the temporary dwellings you stayed in?

»Crowded metal containers in Turkey« (Carim, Syrian, Male, Single, no kids)

»In containers we were missing a closet for clothes and a place to cook and a place for hang clothes, there was also no washing machine« (Fakhir, Syrian, Male, Married with kids)

»I needed to get used to new things such as stove, electricity, vacuum cleaner« (Hadinet, Eritrean, Female, Single Mother)

»We didn't like the food given to us; we preferred to cook by ourselves« (Kidisti, Eritrean, Female, Married with kids)

Q: Would you be comfortable living in a dwelling like this?

»I would feel better in wooden houses, especially given climate conditions, also kids would prefer it to living in containers « (Bushra, Syrian, Female, Married with kids)

»It should be located close to the center of the city, to access offices, schools, supermarkets and other infrastructure « (Hadinet, Eritrean, Female, Single Mother)

Q: What materials would your ideal home use?

»Large windows because of ventilation, wooden are the best, then aluminum, then iron, fiberglass is also ok« (Adnan, Syrian, Male, Married with kids)

»For floor ceramics is better than wood because you just pour water and wash it, wood is more difficult to clean« (Bushra, Syrian, Female, Married with kids)

»Wooden floor because they look nicer and safer for kids« (Fakhir, Syrian, Male, Married with kids)

»I like wood and would like to have a white wooden board but for floor I prefer ceramics because it is more attractive than wooden« (Hadinet, Eritrean, Female, Single mother)

Q: What do you think about wood as construction material?

»Better and healthier than other building materials, gives the feeling of being in nature and it is soothing for psychological tension« (Carim, Syrian, Male, Single, no kids)

»I like it. When I was around ten years old my grandparents lived in a small wooden house in Syria« (Dabir, Syrian, Male, Married without kids)

»Wood not good for outside because cannot resist water as metallic or cement, sometimes it gest wet, also wood is not strong enough compared to concrete and metals« (Johnathon, Eritrean, Male, Married with kids)

»Wooden better than metal containers which can't resist heat and cold« (Layne, Eritrean, Male, Single, no kids)

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Evaluation of Biofinish for wood protection

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Biomimicry for sustainable building

Wood has been considered as an excellent material for sustainable building for decades according to its aesthetically pleasing and environmentally friendliness. However, as a natural material, wood is suffered by its sensitivity to environment and biodegradation. Therefore, wood products require protective measures to extend their service life in outdoor applications. For sustainable use, the environmental impact of such protective treatments should be as low as possible.

The idea to utilize natural organisms, that are not deteriorating wood, but their presence inhibit growth of other decaying fungi was motivation for this investigation. Consequently, such approach for wood protection will contribute toward development of a new environmentally friendly and sustainable wood treatments and trigger the utilization and production of green materials in the wood industry.

Biofinish is a fungal-based wood treatment with protective, decorative functionalities.

It has several advantages compare to the traditional wood coatings and chemical treatments e.g. its environmental friendliness, biodegradation, low maintenance cost, absence of harmful chemicals and self-repairing property.

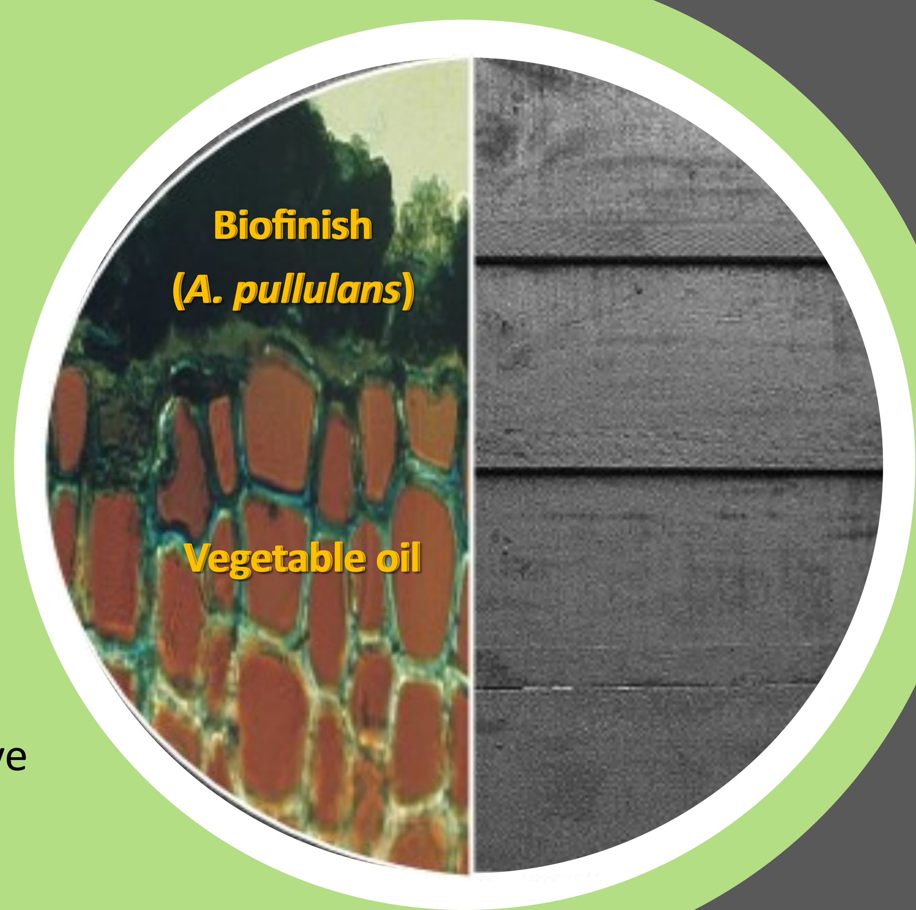
Concept

The concept is to treat wood with natural substances, such as vegetable oil, and the living fungus *Aureobasidium pullulans*.

Vegetable oil functions as nutrition source for *A. pullulans* at the same time enhance dimensional stability and hydrophobicity of wood substrate.

A. pullulans creates an aesthetically appealing dark living surface with protective functionality against environmental conditions and other microorganisms.

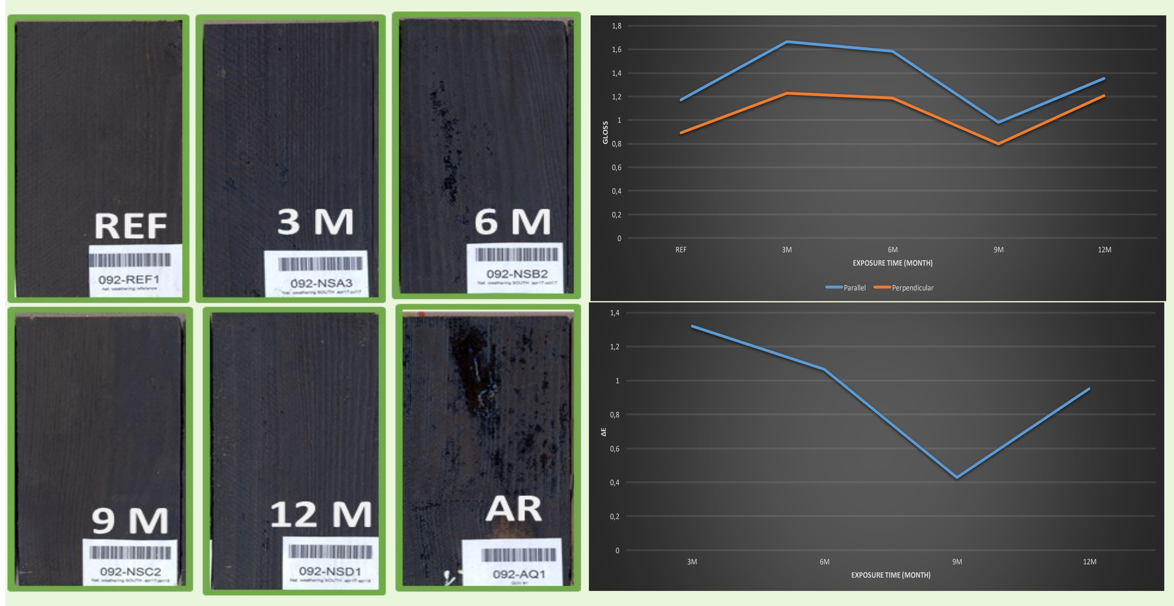
Wood material → Oil treatment → Fermentation → Biofinish treatment



- Environmentally friendly
- Non –toxic
- Low maintenance
- Self repairing

Biofinish for wood protection

Natural weathering tests were performed in San Michele, Italy, (46°11'15''N, 11°08'00''E). The weathering experiment was carried out for 12 months from March 2017 and measurement was performed in 3 months interval. **Artificial weathering** was performed using a weathering machine following the standard EN927.6. The weathering duration is 672 hours (UV and water spray). **Performance** of biofinish on wood surface was estimated based on color changes using a spectrophotometer (CIE $L^*a^*b^*$ system) and gloss measurement. Hyperspectral imaging was used to investigate the progress of degradation on entire surface.

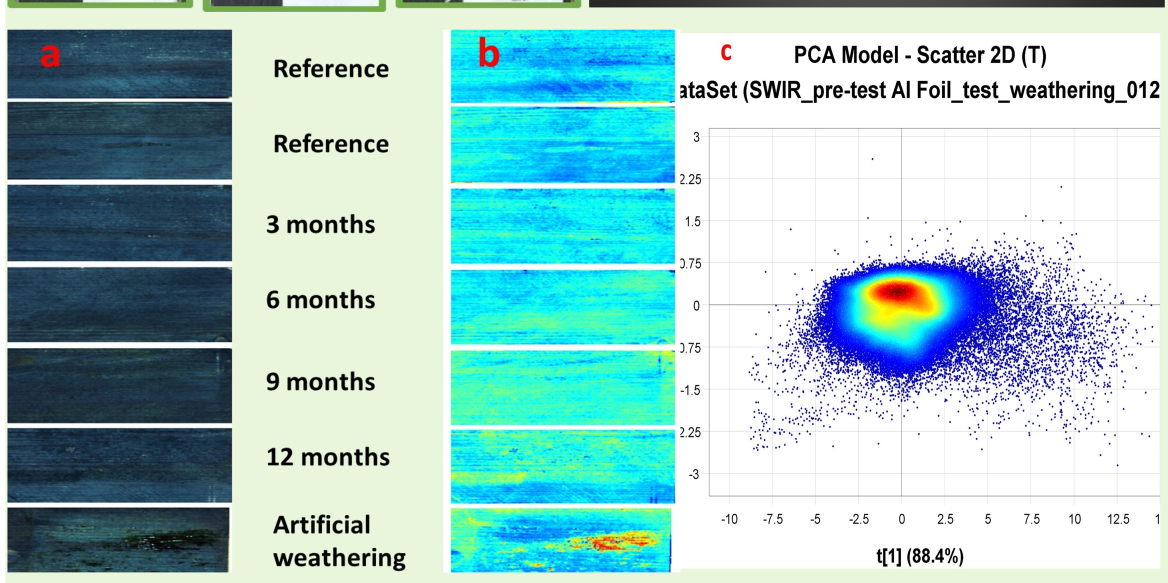


Result

Gloss evaluation and total color change

The gloss and total color of biofinish wood changes depending on the season. The highest gloss and total color change was found in May, August and March (spring and summer) respectively, the lowest was found in November (winter) Figure 1.

Figure1 RGB image (left), gloss (up) and total color change (down) of biofinish wood samples after weathering tests.



Hyperspectral Imaging shows slight change of biofinish wood surface after 6 months (Figure 2). The greatest changes due to secretion of vegetable oil were observed after artificial weathering. However, the spectral data on PCA score plot are clustered in one group which indicate the overall similarity of wood samples.

Figure2 RGB image (a), score on PC1 (b) and PCA score plot (c) of biofinish wood samples after different exposure time.

Conclusions

Biofinish coating protects wood from environmental conditions and provide good performance on wood surface.

The major problem was secretion of excessive oil to wood surface observed after artificial weathering

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Testing the Thermal Properties of Loose-Fill Straw Insulation

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Introduction

Straw is known to have suitable properties for thermal insulation. This natural material not only stores carbon in its structure but also is non-toxic, can be easily disposed of at the end of use, has low embodied energy and is abundant, which are all properties desired in sustainable construction. From the field straw is formed into thick, dense bales. In this research, loose straw insulation in traditional wall construction, that is thinner than a strawbale wall, was tested to evaluate its thermal properties in comparison with readily available synthetic insulation batts.

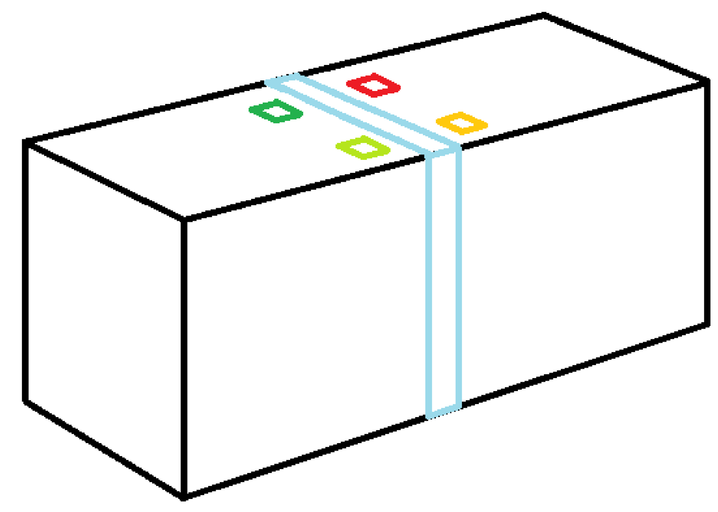

Fig. 1: Experiment setup

straw insulation	typically used	tested	tested commercial insulation
form	bale	loose	glass wool batt
manufacturing	machinery	manual	
thickness	45-60 cm	10 cm	5 cm
density	80-110 kg/m³	31 kg/m³, 54 kg/m³, 69 kg/m³	15 kg/m³

Fig. 2: Loose straw insulation in frame

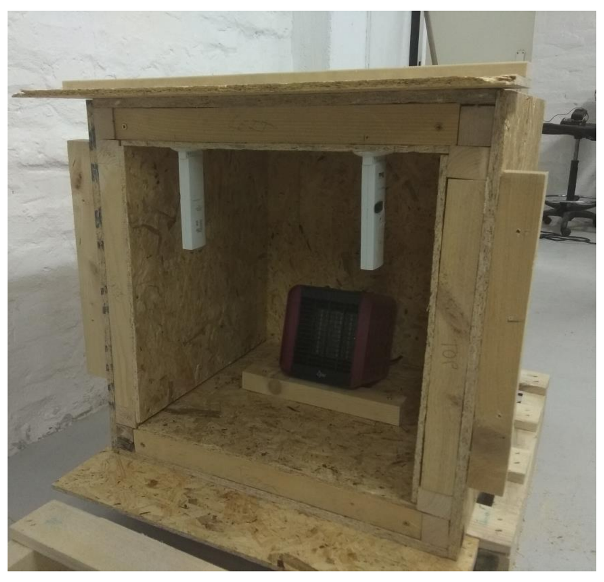

Fig. 3: Heated chamber

Fig. 4: Real setup

Process

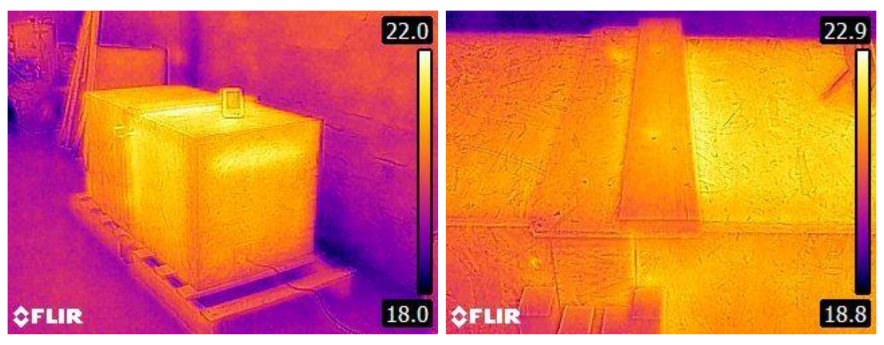

Fig. 5-6: Thermal picture of closed system

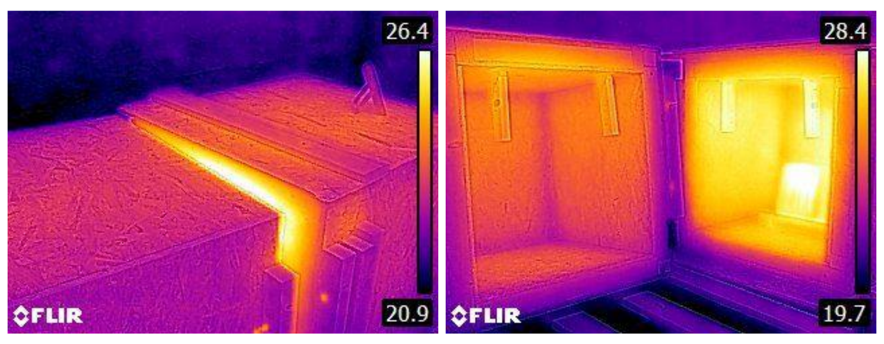

Fig. 7-8: Thermal picture of (semi-)open system

Two chambers, created from solid wood and OSB were insulated using commercial insulation (Fig. 1). The chambers were placed next to each other, with the adjacent sides left open. In one of the chambers a heat source was placed (Fig. 3) and both chambers were equipped with thermocouples. The insulation materials (commercially available synthetic batt of density 15 kg/m³ and three straw samples of different densities) were placed in the wooden frame and kept in place by metal mesh to minimize involvement of materials holding straw in place in the thermal performance (Fig. 2). The insulating material in frame was then placed between the two chambers (Fig. 4), the heat source was turned up until temperature in the „hot chamber" reached 40 °C. Temperature in both chambers was recorded for an hour. The chambers were photographed by thermocamera to observe possible leakages and visualize temperature differences (Fig. 5-8).

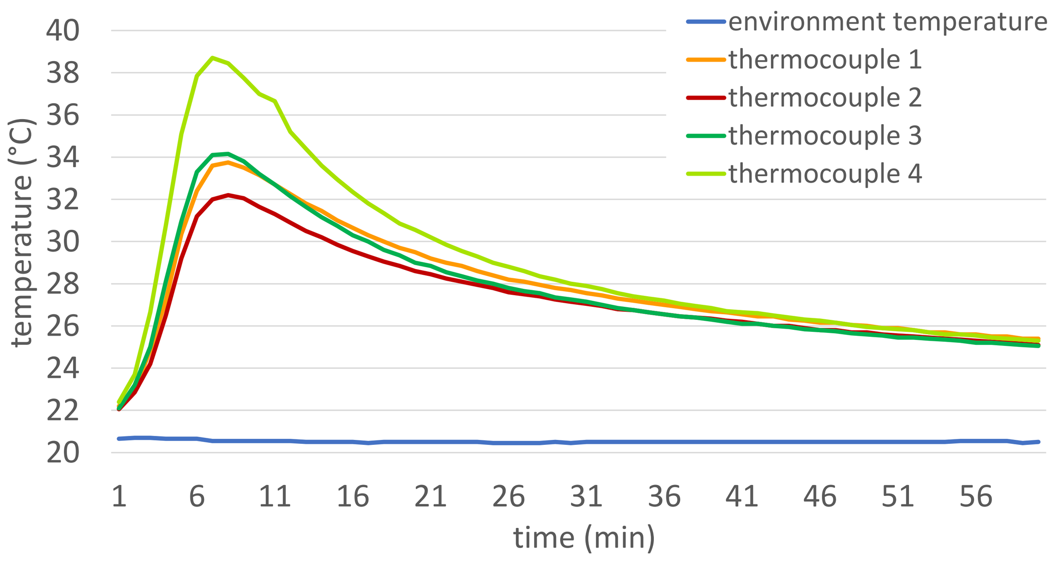

Fig. 9: Temperatures in chamber - no insulation

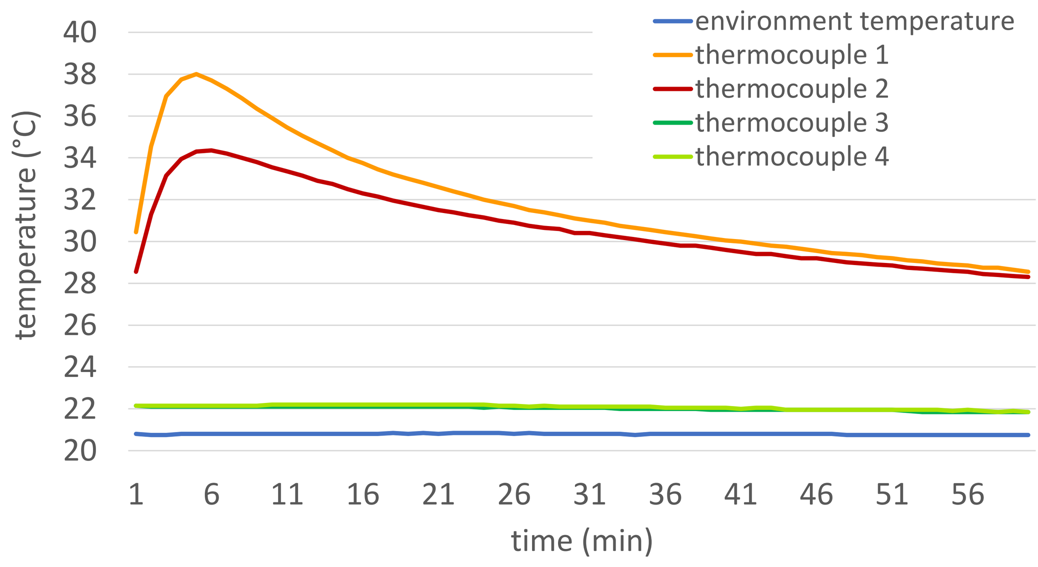

Fig. 10: Temperatures in chamber – commercial insulation

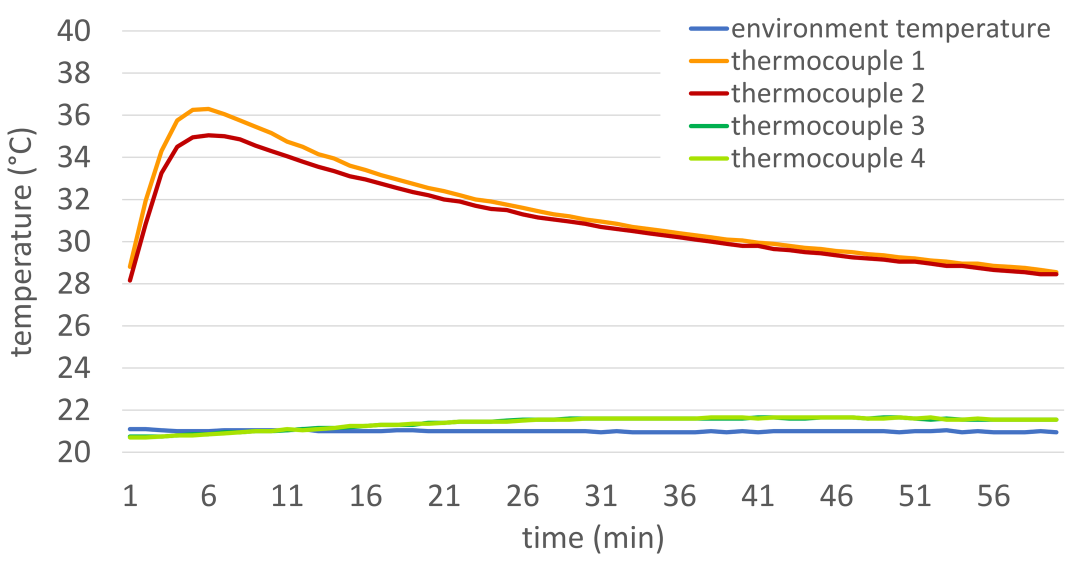

Fig. 11: Temperatures in chamber – straw 69 kg/m³

Results

The insulation properties of the straw were dependent on density; even the sample with the lowest density (31 kg/m³) acted as an insulator to the adjacent chamber. The highest density sample (69 kg/m³) resulted in the lowest temperature increase of 0.95°C (20.7°C to 21.65°C) compared to the synthetic batt which prevented any increase in temperature of the adjacent chamber.

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Thermo-Hydro-Mechanical Treatment of Australian Sawlog and Pulplog Hardwood Resources

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Introduction

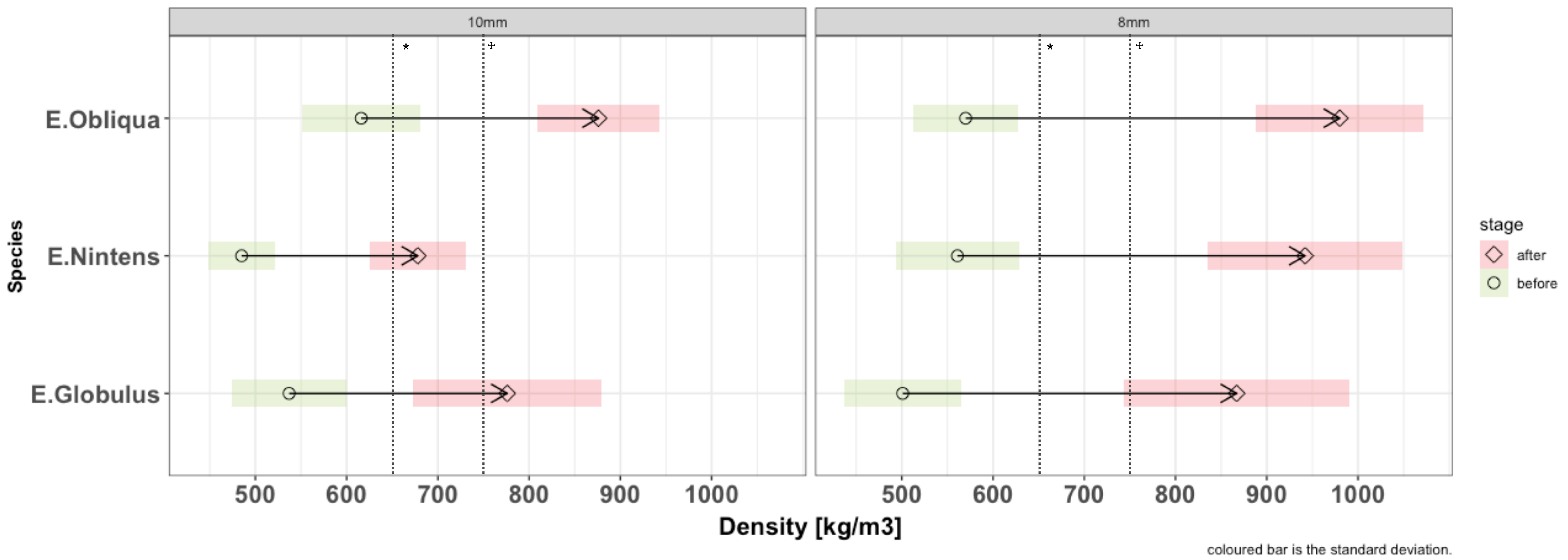
Eucalyptus trees of different sub-species are traditionally planted in Australian plantations where according to the Australian Bureau of Agricultural and Resource Economics and Sciences almost 85 % of logs end up in pulp and paper industries or being exported as woodchips. Declining volumes of lumber from native forests have led to imported hardwoods as the main source of construction lumber. The objective of this study was to add value to the lumber that is grown for pulp and paper to improve its low physio-mechanical properties and increase applications [1].

Materials and Methods

Thermo hydro mechanical (THM) densification was applied to increase the density of traditional Australian hardwood species: *Eucalptus obliqua, E. nitens,* and *E. globulus* to meet required densities according to Australian Standard (AS) 3959:2018—Construction of buildings in bushfire-prone areas standard [2]. Five boards from each wood species with 15 mm thickness were densified to 10 mm and 8 mm. The treatment temperature was 170 °C and was held for 2 min under pressure. It was then cooled to 80 °C while under pressure.

Results

The density of 15 mm specimens on average increased in density by 42 % while densified 10 mm thick specimens increased the density by average 71 %. A higher initial density of the board also resulted in a higher final density. The densification process showed potential to improve physical properties of selected species to be used in the frame of construction purposes in Australia in bushfire-prone areas. Standard [2] require 750 kg/m³ ⁜ or greater density for construction purpose and 650 kg/m³ * for use in window joinery, door frames and other framing.



[1]Derikvand M., Nolah G., Jiao H., Kotlarewski N. 2017. What to do with structurally low-grade wood from Australia's Plantation Eucalyptus; Building Application? BioResource, 12
[2] Council of Standards Australia. 2018. 3959 Construction of buildings in bushfire-prone areas. Standards Australia, Sydney, NSW.

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VOC-Emission Optimized Cross Laminated Timber (CLT)

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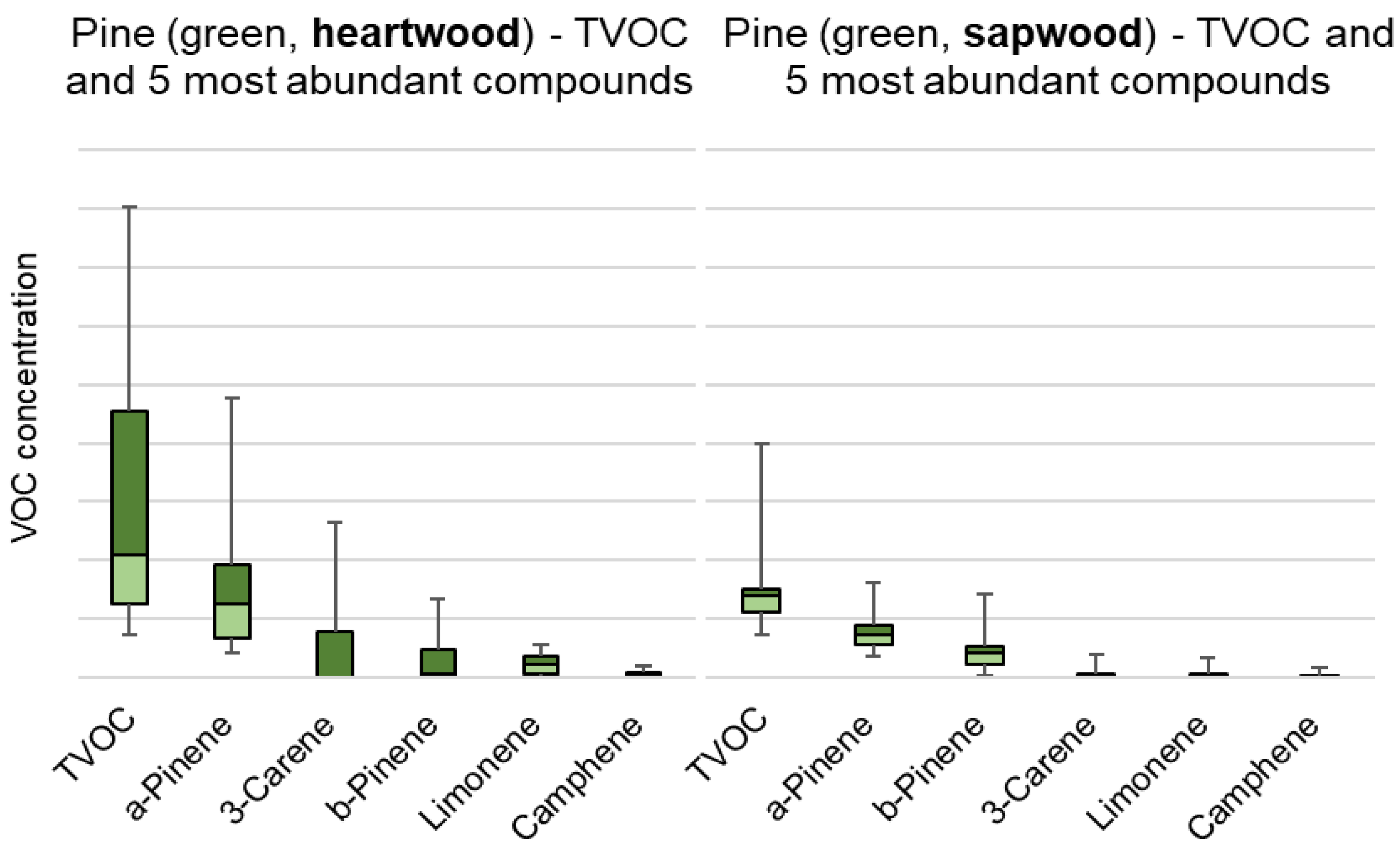
Introduction

Cross laminated timber (CLT) is one of the most popular engineered wood products. The main species used for this product in Europe is Norway spruce. To respond to the strongly increasing demand of CLT, it will become necessary to investigate additional raw material resources for its production. Scots pine – having in mind its availability, mechanical properties and ability to grow even in regions with poor growth conditions – could offer a high potential to serve as a new material for CLT in the future. However, Scots pine, as a high resin content species, generally emits considerably more volatile organic compounds (VOC) compared to spruce.

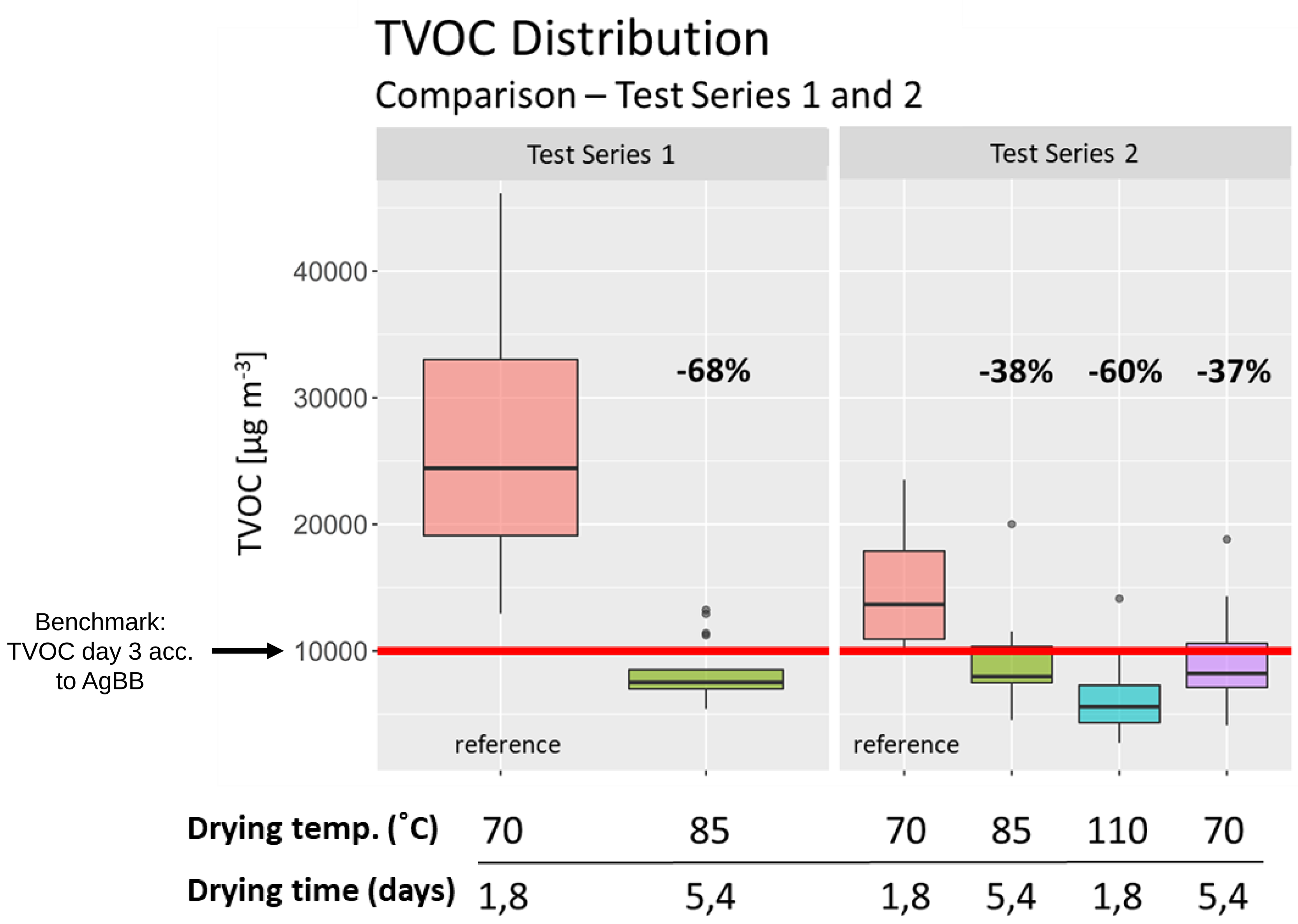
Material Characterization (Phase I)

The first phase of the study comprises the characterization and quantitative evaluation of VOC emissions from Norway spruce and Scots pine in order to draw conclusions about the levels and the variability of VOC emissions from these two species. Around 450 specimens from Austria, Slovenia, Germany, Finland and Russia were tested. A comparison of kiln-dried and green wood, as well as heartwood and sapwood, provided a sound basis for further investigations.



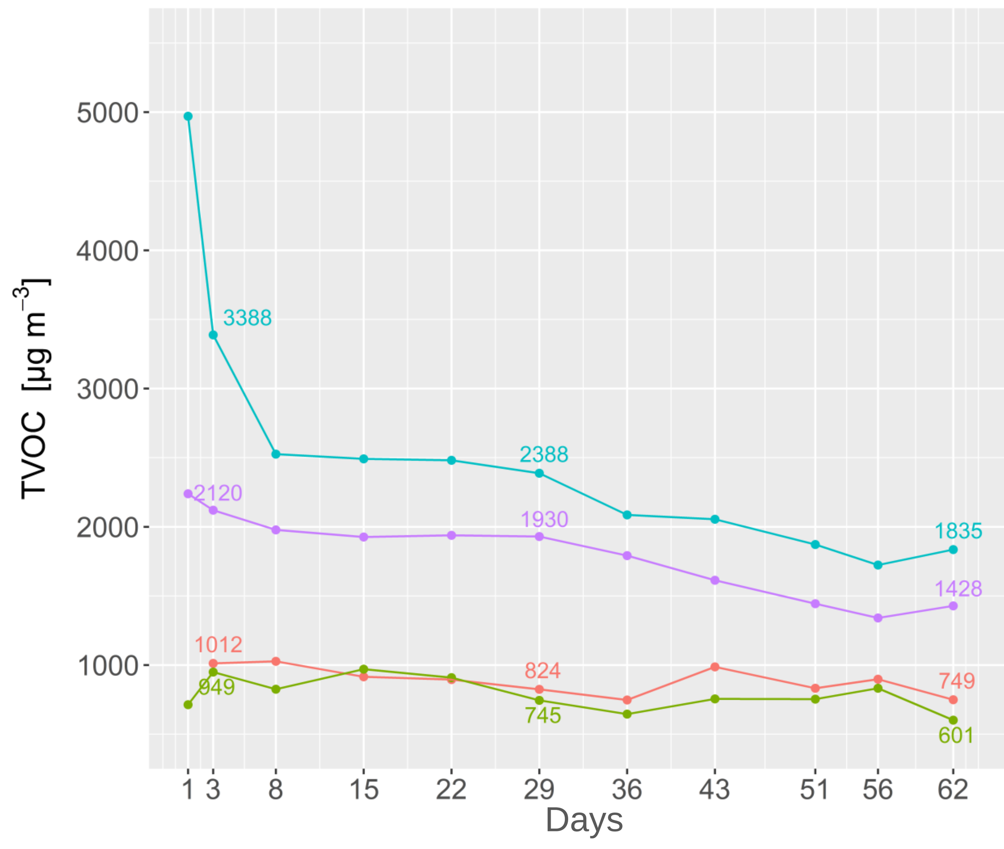
Technological Approach to Reduce VOC-Emission (Phase II)

The second phase covers the optimization of the CLT manufacturing process regarding VOC emissions. Based on findings from the first phase, process parameters such as drying temperature and drying time, along with gluing parameters and storage time were modified.



Model Room Tests (Phase III)

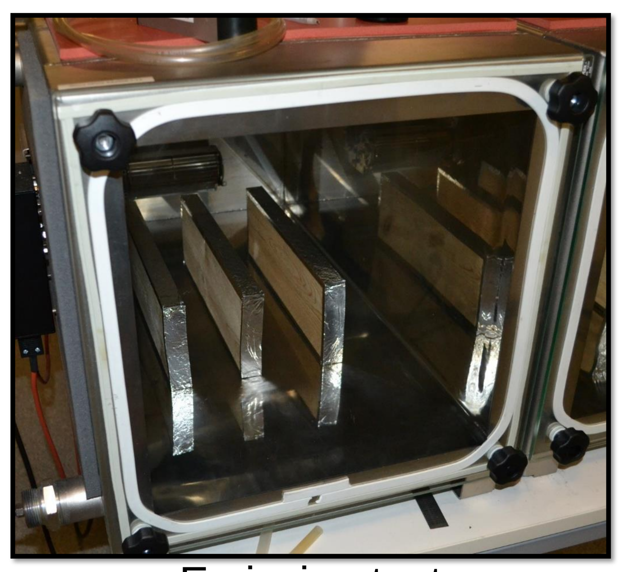
In the final phase, long-term tests (up to 6 months) were carried out in 30 m³ model rooms constructed of different CLT-variants. The aim was to evaluate the influence of wood drying schedule and the combination of wood species in the CLT lay-up on the VOC-emission in a close-to-reality scenario and controlled test conditions.



Model rooms

Analytics

Micro-chambers (Phase I), 0.225 m³ emission test chambers (Phase II), and 30 m³ model rooms (Phase III) were used to collect VOC that are emitted from materials and products.
A gas chromatography-mass spectrometry system (GC/MS) was used for the separation of analytes, and their subsequent quantitative and qualitative analysis. An automated thermal desorption unit was used for VOC-extraction, focusing of analytes and their introduction into a GC-column.



Emission test chamber

Micro-chambers

GC-MS

Preliminary Results

The results showed a significant influence of drying temperature and drying time on VOC-emission from pine wood. Additionally, the gluing step in the CLT production, as well as a combination of wood species (pine, spruce) used in the CLT lay-up, resulted in a considerable VOC-emission reduction from the final product.

Financial Support

The funding for this project is provided by The Austrian Research Promotion Agency (FFG) and the CLT-sector in Austria (CLT-producers and The Association of the Austrian Wood Industries)

Sustainability, health, and renewable materials – Trends in scientific publications

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Background

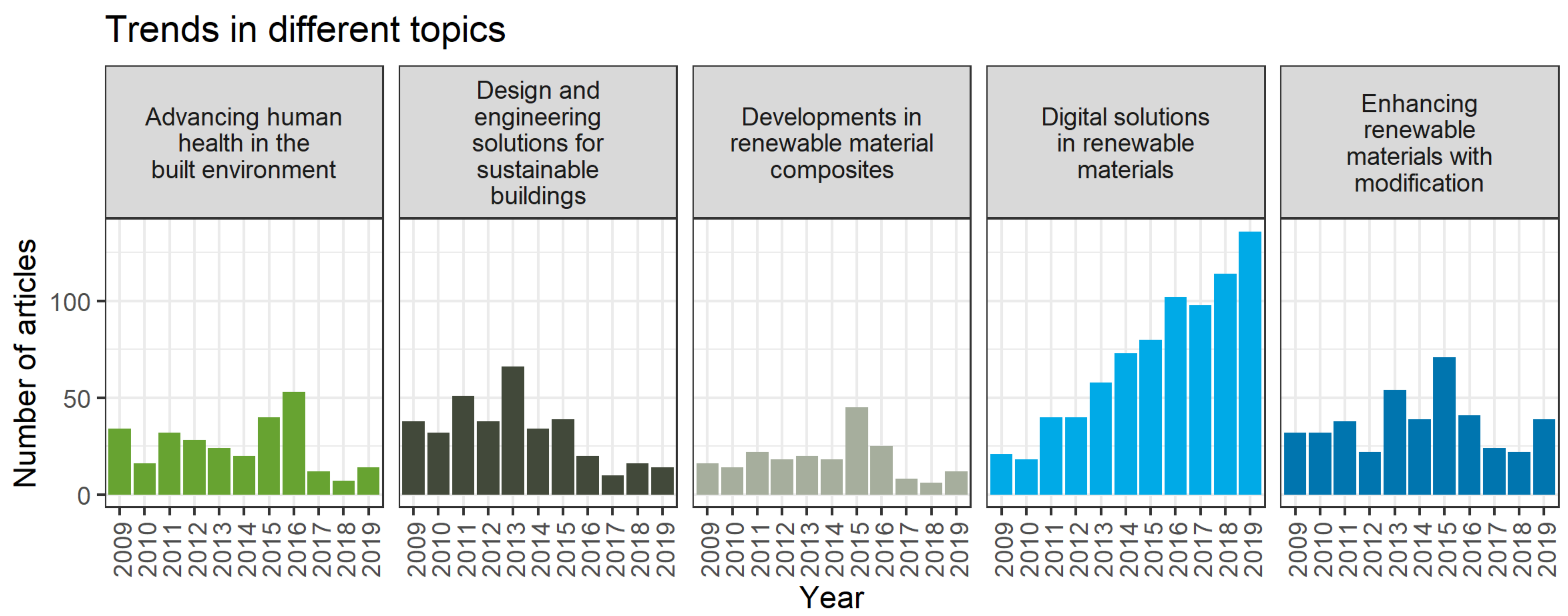
Building practices can have a large impact on human health and the environment, so it is crucial to strive towards sustainability and use of renewable materials in all stages of the construction process. As academic research accumulates, detecting trends can illuminate current developments in both research and practice.

Objectives and methods

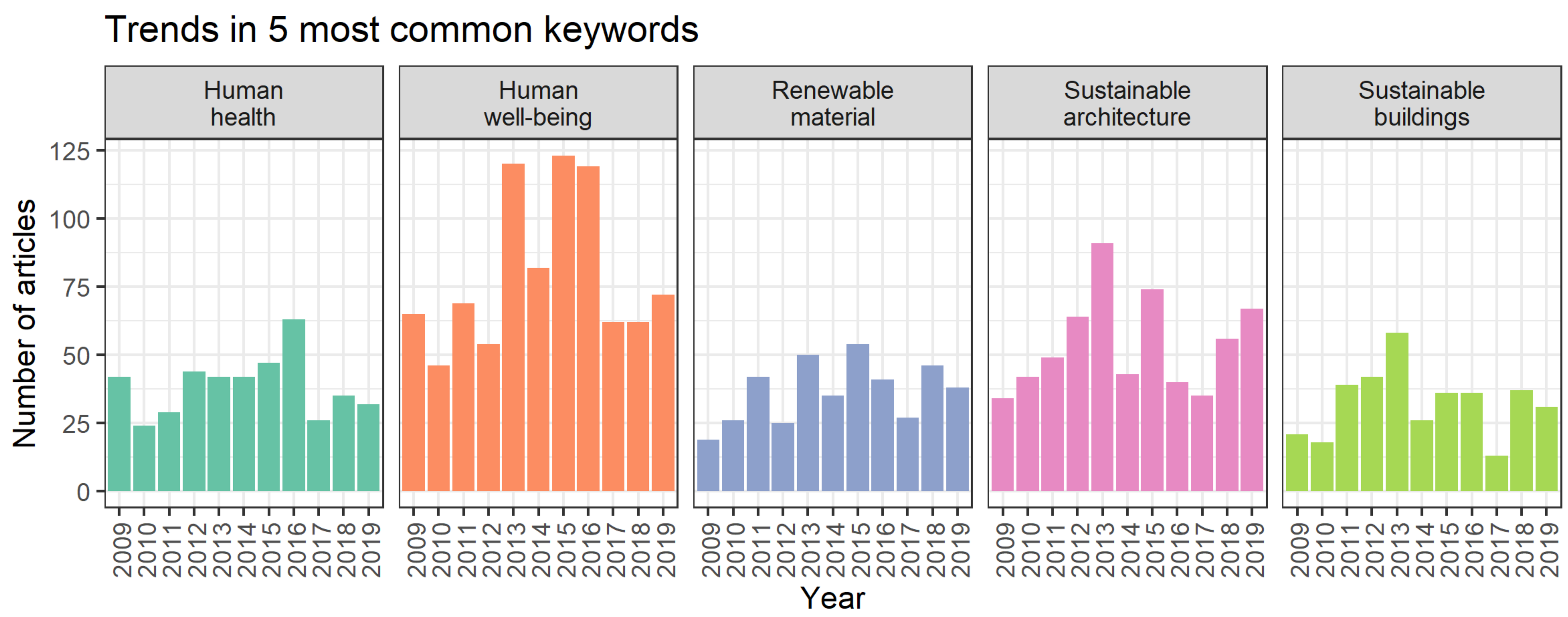
Our aim was to explore recent trends in scientific publications in five topics, selected as the most related to the conference's scope: "digital solutions in renewable materials", "enhancing renewable materials with modification", "developments in renewable material composites", "advancing human health in the built environment", and "design and engineering solutions for sustainable buildings". We used a Natural Language Processing based toolkit (Zdravevski et al., 2019) to perform an automatic quantitative analysis of scientific articles' titles and abstracts published in English. The search was performed in October 2019 and it included three databases (i.e., PubMed, IEEE Xplore, and Springer). In total, 2036 publications were identified and analysed based on the inclusion of specific keywords (e.g., "biophilic design", "timber", "circular economy") from three areas: health, renewable materials, and sustainability.

Results

The largest number of articles was found in the topic "digital solutions in renewable materials", followed by "enhancing renewable materials with modification" and "design and engineering solutions for sustainable buildings". Most of the topics peaked between the years 2013 in 2016, except for the topic "Digital solutions in renewable materials".



The most common keywords in the included articles were related to the topic of sustainability, ahead of keywords related to the topics of health and renewable materials.



Conclusions

The recent publishing trends suggest that the continuous growth of the topic "digital solutions in renewable materials" is unique among studied topics, which peaked in the past.

Zdravevski, E., Lameski, P., Trajkovik, V., Chorbev, I., Goleva, R., Pombo, N., & Garcia, N. M. 2019. Automation in systematic, scoping and rapid reviews by an NLP toolkit: A case study in enhanced living environments. In: Ganchev I., Garcia N., Dobre C., Mavro-moustakis C., Goleva R. (eds.) Enhanced Living Environments. Lecture Notes in Computer Science, vol 11369. Springer, Cham.

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The Influence of Four Commercial Wood-surface Treatments on Mould-fungi Growth in a Pure Culture

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INTRODUCTION

The aim of our study was testing of the protective effect of commercial surface coatings containing different biocides on single mould fungi growth in pure culture.

MATERIALS AND METHODS

Scots pine sapwood, heartwood, and Norway spruce were cut into 25(T)x15(L)x5(R) [mm]. Specimens were treated with four surface coatings containing biocides, i.e.:

Treatment 1: Pigmented primer with tetramethylol acetylenediurea and iodopropnyl butyl carbamate (IPBC). Applied average amount of the coating 0.2 g/g wood.
Treatment 2: Paint with a mixture of three biocides (IPBC, benzisothiazolinone (BIT), methylisothiazolinone (MIT) and 5-chloro-2-methyl-1,2-thiazol-3-one (CMIT)/MIT mixture). Applied average amount of the coating 0.15 g/g wood.
Treatment 3: Paint with IPBC. Applied average amount of the coating 0.01 g/g wood.
Treatment 4: Laqvin Tone contained three biocides 1,2-benzisotiazol-3(2H)-on, 2-oktyl-2H-isotiazol-3-on, 2-Methyl-4-isothiazolin-3-one. Applied average amount of the coating 0.14 g/g wood.

Wood samples (treated and untreated control) were placed on the Petri plate and 5 mm fungal inoculum placed in the centre of plate (Figure 1). Five pure cultures of fungi species were used in the study: *Aureobasidium* sp., *Trichoderma* sp., *Aspergillus* sp., *Cladosporium* sp., *Penicillium* sp.

The mould growth was estimated as the size of the inhibition zone of treatments and measured from the nearest border four times and average value presented in mm (Figure 2).

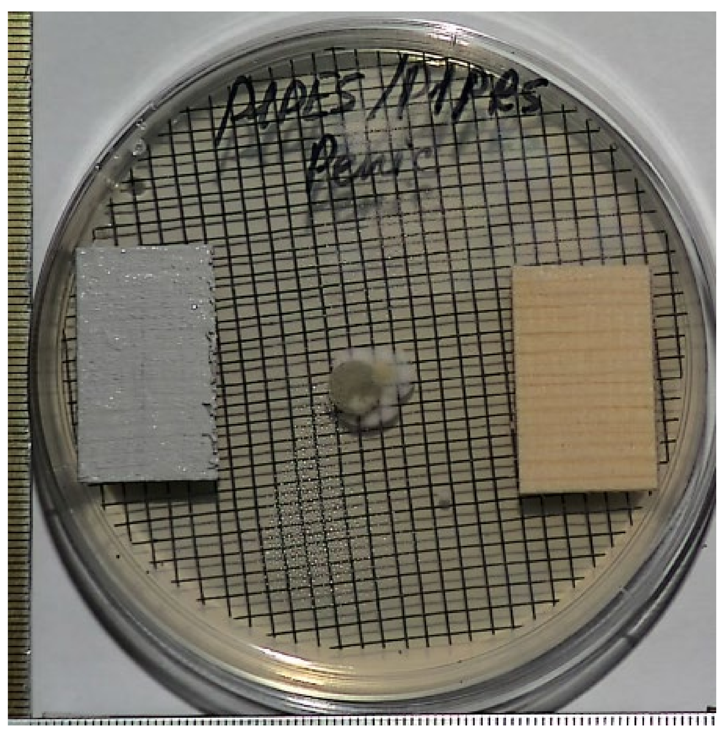

Figure 1. The example of specimens position and inoculation pattern (start of experiment).

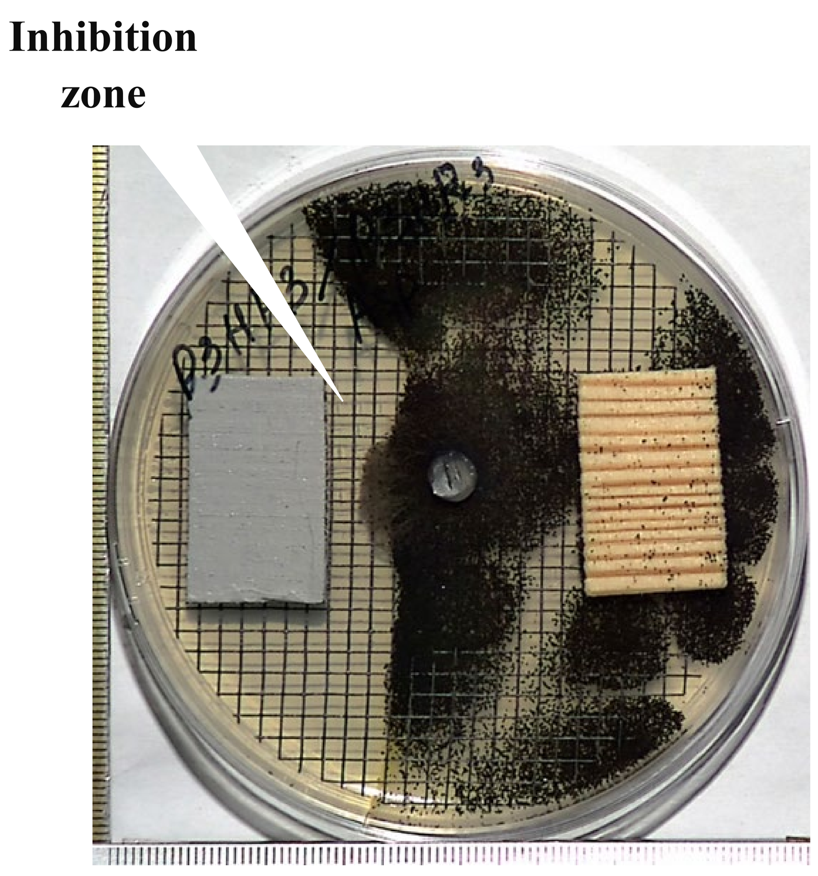

Figure 2. Measurement of the inhibition zone (red arrows).

RESULTS

The fungal growth was observed in all three types of untreated samples already after four days of incubation. In Table 1 size of inhibition of growth zone of fungus to treated specimens after 22 days of incubation is shown. *Trichoderma* sp. followed by *Penicillium* sp. was found to be the most resistant to biocides within the tested group of mould fungi. The specimens coated by treatment 4 were attacked already after eight days. Treatment 1 and 3 became free from a fungal mycelia inhibition zone after 22 days of incubation for all types of wood.

Table 1. The average value of the size of the inhibition zone of treatments (mm).

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
		Aureobasidium sp.		
Pine Sap	7.17	4.17	7.25	0
Pine Heart	11.08	4.58	8.33	0
Spruce	8.42	5.33	8.08	0
		Trichoderma sp.		
Pine Sap	0	0	0	0
Pine Heart	0	0	0	0
Spruce	0	0	0	0
		Aspergillus sp.		
Pine Sap	6.17	3.25	6.33	0
Pine Heart	6.92	2.83	5.08	0
Spruce	6.17	3.17	8.58	0
		Cladosporium sp.		
Pine Sap	7.58	1.33	2.58	0
Pine Heart	7.50	1.33	1.67	0
Spruce	7.50	1.33	4.42	0
		Penicillium sp.		
Pine Sap	0.83	1.33	1.75	0
Pine Heart	0.83	0.5	0.08	0
Spruce	1.75	0	0.44	0

The moisture content of treated and non treated specimens was similar for treated samples in plates with *Aureobasidium* sp., *Aspergillus* sp., *Cladosporium* sp., *Penicillium* sp., but was significantly higher for *Trichoderma* sp after the test.

CONCLUSIONS

1. The best effect to hinder fungal growth was found for the treatment 1, 2 and 3 whereas treatment 4 performed worst. The ranking in performance the best is a treatment 1, then treatment 3 followed by treatment 2.
2. The type of Nordic softwood does not influence general performance against mould attack under the used controlled conditions.
3. The moisture content of exposed specimens after the test was similar in the plates with fungi *Aureobasidium* sp., *Aspergillus* sp., *Cladosporium* sp., *Penicillium* sp. However, significantly higher for *Trichoderma* sp.

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Improving hydrophobicity and thermal stability of wood by esterification with fatty acids

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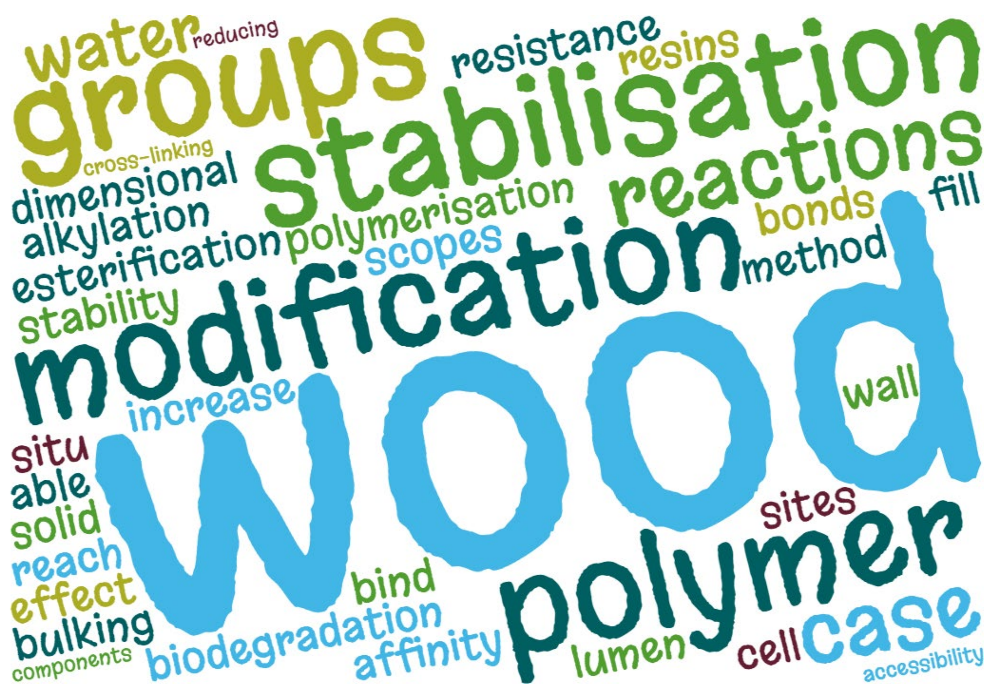
Introduction



The hygroscopic nature of wood is related to its structural anisotropy and to the presence of hydroxyl groups, making wood very reactive with water and highly sensitive to ambient humidity as well as to changes in temperature. Several treatments have been developed to ensure the long-term durability of wood and to focus the material on specific applications. The fatty acids chlorides (FA's) could be an interesting alternative to decrease the wood's hydrophilic character. FA's chlorides containing long hydrophobic chains that can provide a water-repellent effect, dimensional and thermal stability when are esterified into the wood matrix.

Materials and methods

Samples of Monterey Pine (***Pinus radiata***) were used for the esterification process; firstly, by extracts removal, then, three different reagent were used for modification process: hexanoyl chloride (P6), lauroyl chloride (P12) and steaoryl chloride (P18) at [0.1M; 0.5M; 1M]. Pyridine (10%) was used as a catalyst and the byproducts of the reaction were trapped by adding triethylamine.

Table 1. Procedure and esterification conditions

Sample	Pre-treatment	Fatty acid chloride	Molar concentration			Reaction conditions (ºC/h)
Pinus radiata			- R e f e r e n c e -			
P6	Solvent extraction	C:6	[0.1]	[0.5]	[1]	100/3
P12		C:12	[0.1]	[0.5]	[1]	100/3
P18		C:18	[0.1]	[0.5]	[1]	80/3

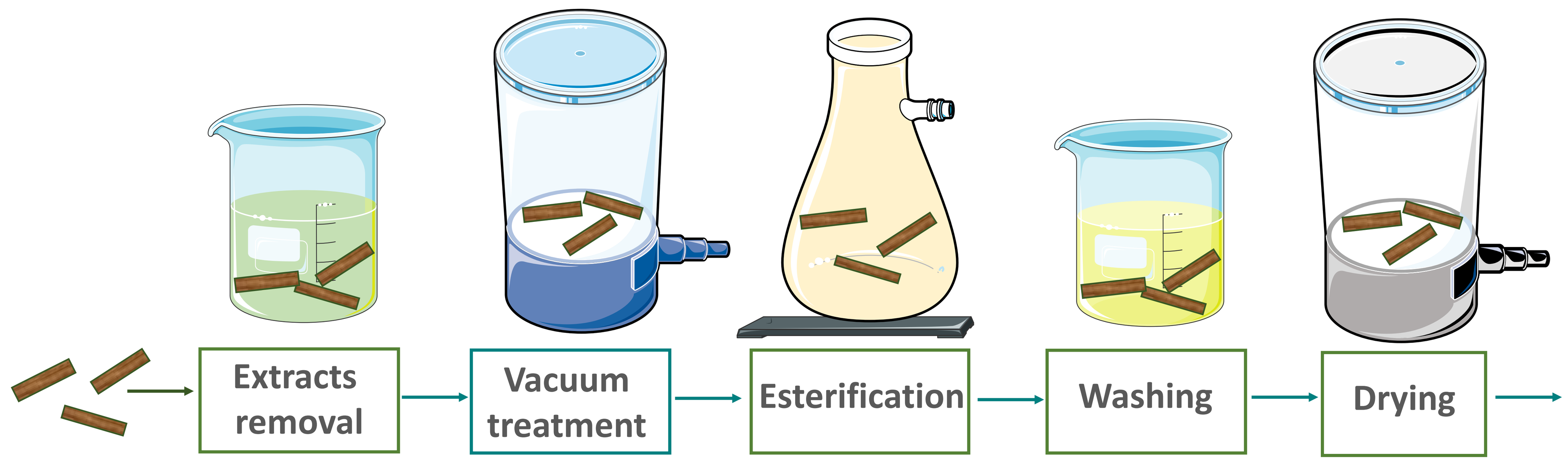
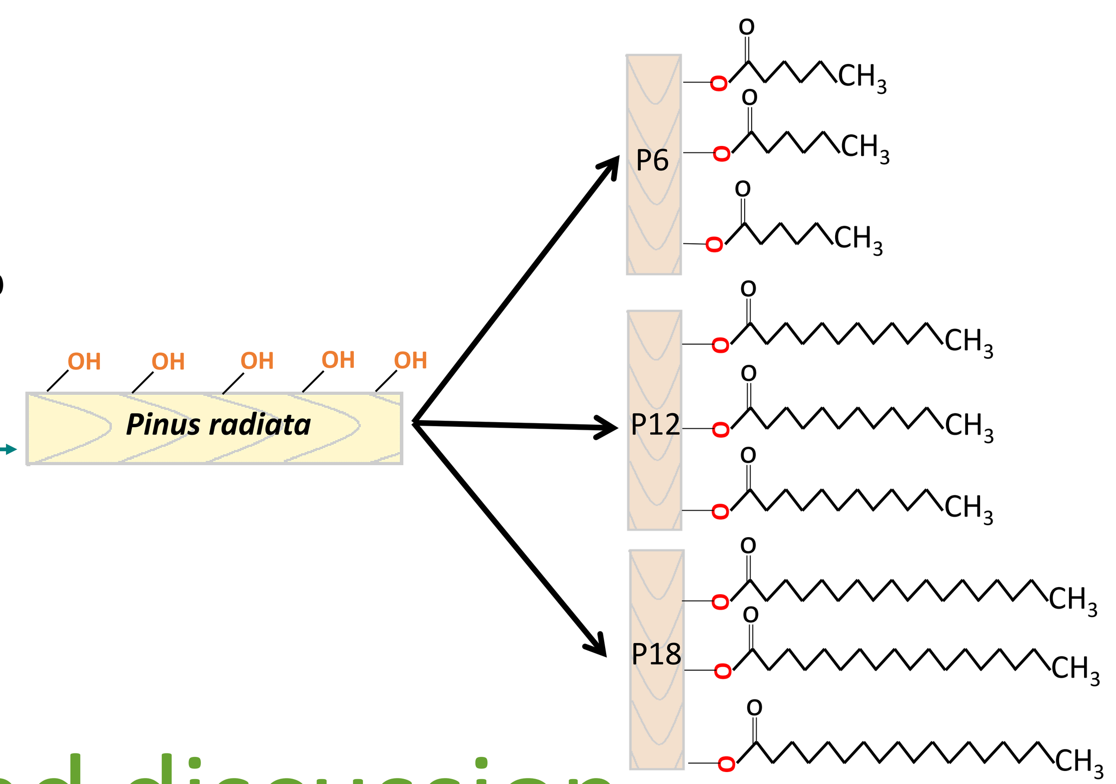


Figure 1. Wood esterification process



Characterizations

- Chemical changes
- Surface changes
- Moisture sorption
- Thermal resistance

Results and discussion

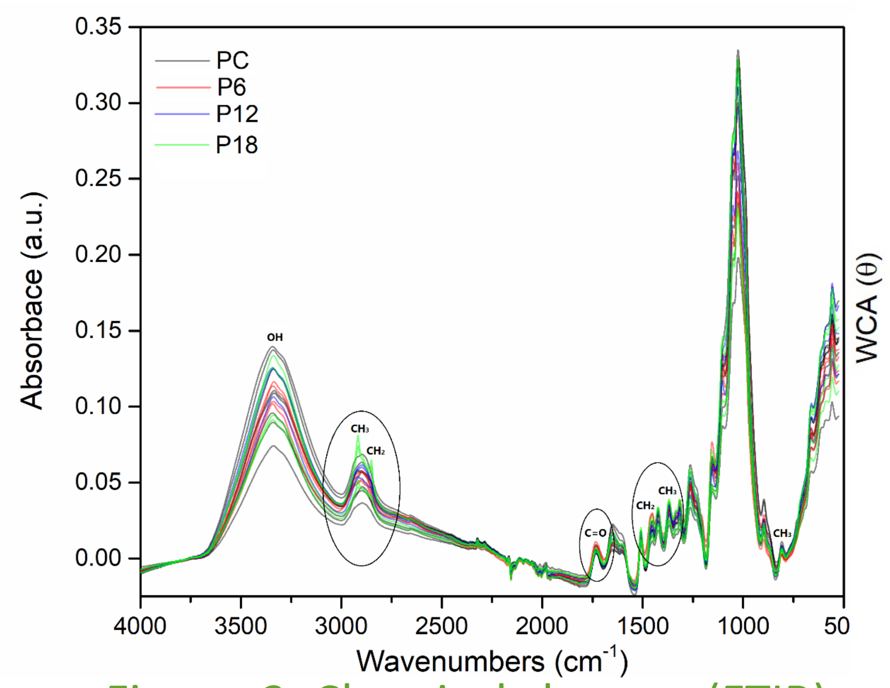


Figure 2. Chemical changes (FTIR)

The FTIR showed differences in the signals at 2925 cm^{-1} and 2854 cm^{-1} (CH_3-CH_2), 1744 (C=O), 1454 cm^{-1} and 1375 cm^{-1} (CH_3-CH_2). The differentiation in the CH_3-CH_2 were attributed to the vibrations of the aliphatic chain of acid chlorides attached to the wood, and the C=O was an indicative of degree of esterification.
The spectra of **P6** was clearly differentiated at all concentrations from untreated wood.

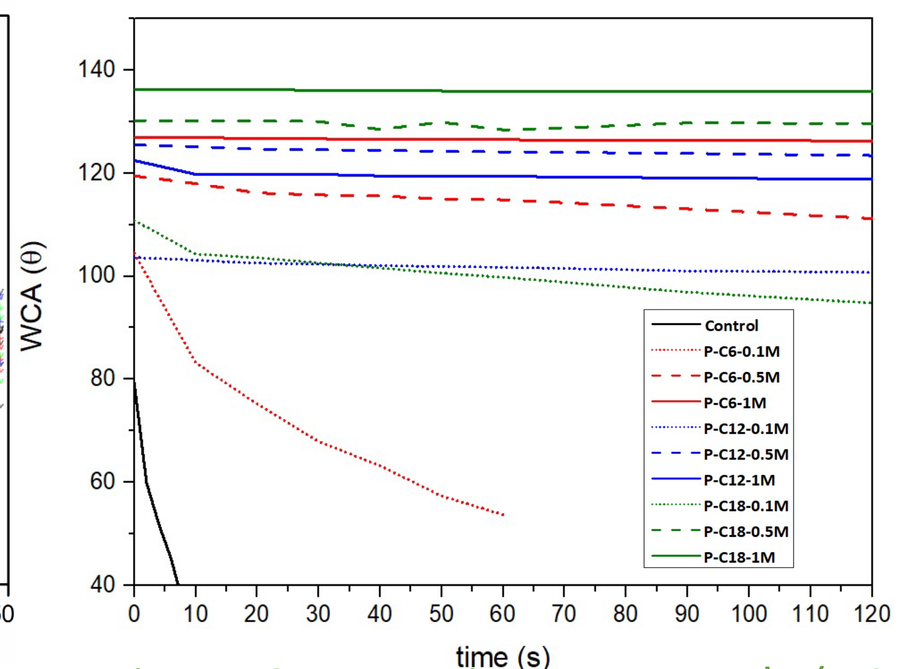


Figure 3. Dynamic contact angle (DCA)

The **DCA** showed significant differences between esterified simples and control, changing from hydrophilic to hydrophobic.
The [0.1M] was less effective than at higher concentrations.
The order of dynamic hydrophobicity was C6<C12<C18, showing that longer aliphatic chains are more stable, but in general the DCA was >120º.

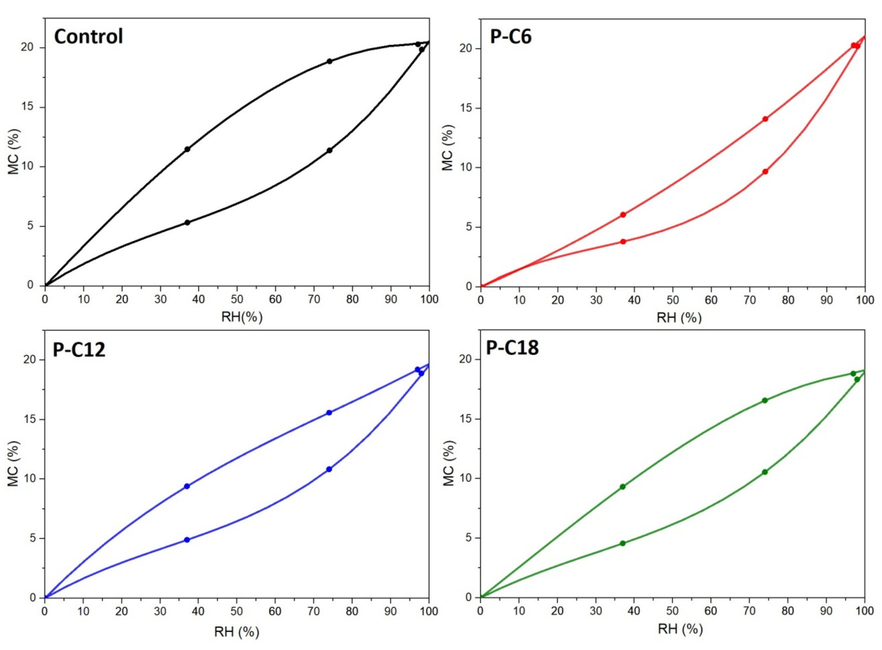


Figure 4. Moisture sorption-desorption (WVSD)

The **WVSD cycles** from 0% to 100% RH at 25 ºC exhibited different trends between control and esterified wood. **Control** wood showed a linear sorption isotherm compared with **P6** and **P12**, specially in the intermediate region (above 50 %MC). Irreversible desorption trend was presented in **P6** and **P12** (linear decrease). Control and P18 showed similar trends.

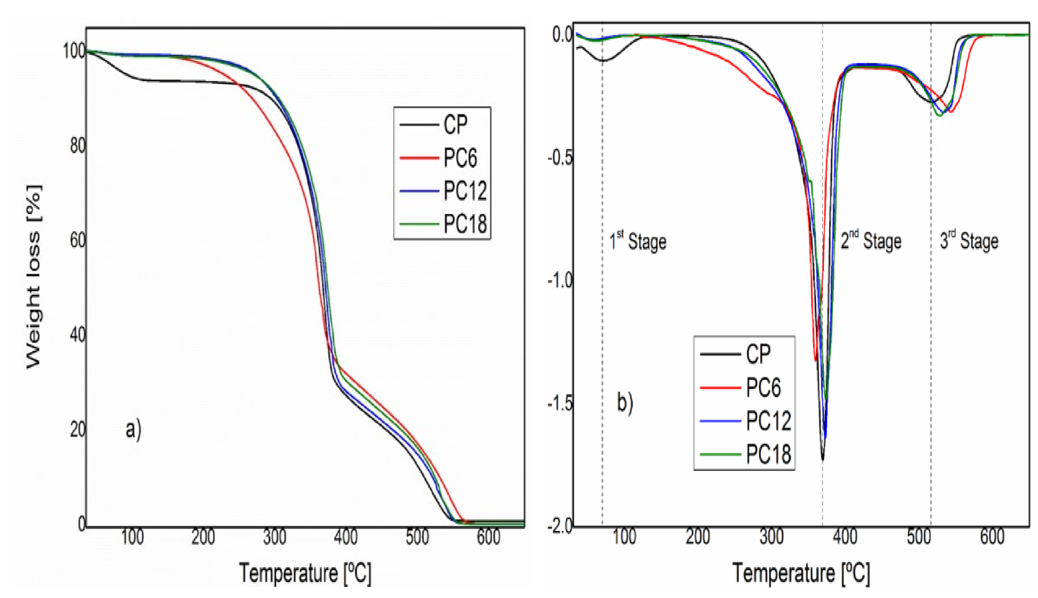


Figure 5. Thermal performance (TGA-TGA)

TGA-DGA presents the influence of the esterification between 50-700ºC. The **DGA** showed that thermal degradation occurred in three steps (T1, T2, T3). T1 (50-100ºC) was influenced by the treatments by reducing the hygroscopicity. T2 (300-400ºC) was attributed to the cellulose degradation, where **P6** presented the lowest degradation. The increment of the degradation in T3 presented the following tendency: **C6>C12>C18>CONTROL.**

Conclusions

- The esterification process was effective by reducing the hydrophobicity and thus increasing the dimensional stability.
- The free radical bonds interacting with water molecules were limited.
- The resistance to thermal degradation was enhanced by the esterification preferably with the short alkyl chain P6 and P12.

R. Herrera acknowledges the Department of Education of the Basque Government (post-doctoral grant POS-2018-1-0077) and the University of the Basque Country (EHU/UPV).
The authors gratefully acknowledge the European Commission for funding the InnoRenew CoE (Grant Agreement #739574) under the H2020 WIDESPREAD-2- Teaming programme, and the Republic of Slovenia investment funding of the Republic of Slovene and the European Union of the European regional Development Fund.

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Aspects of Residential Environment Included in Residential Satisfaction Questionnaires: A Systematic Review

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Residential satisfaction is a frequently studied topic in recent decades as it can offer important insights into the quality of residential environment, beneficial both from theoretical perspective as well as for practical purposes. One of the most prominently used methods of measuring residential satisfaction is the use of self-assessment questionnaires measuring satisfaction by assessing satisfaction with individual aspects of the residential environment. Developmental process of these questionnaires often takes an *ad hoc* approach, especially in terms of the selection of aspects to be included in questionnaire items, i.e. for the purposes of the study at hand, often without providing a solid rationale for the selection of these aspects. To authors' best knowledge, there are no established criteria and justifications for including specific aspects of the residential environment in the measurement of satisfaction, and also no reviews of these aspects to date. Therefore, the aim of the present study is to provide a systematic review of aspects of residential environment (on dwelling with building and neighbourhood levels), included in the residential satisfaction questionnaires. Since these include a great variability of aspects on many levels of specificity, the additional aim of the study is to categorize these aspects to possibly arrive at a comprehensive list of included aspects of environment in residential satisfaction questionnaires while also recognizing the most prominent categories used in the reviewed questionnaires.

Keywords: residential satisfaction, questionnaires, aspects of residential environment, systematic review

Background & aim:

Residential satisfaction (RS) is a frequently studied concept and therefore frequently measured, most often through self-assessment questionnaires. They mainly take one of the following approaches (see Pinquart and Burmedi, 2003): (1) one or more general items about RS (e.g. Lu, 1999; Li & Song, 2009; Dekker et al., 2011) or (2) the approach of items about specific aspects of residential environment, usually resulting in some form of a RS index (Wang in Wang, 2016).

In a systematic review of psychometric properties of questionnaires following the second approach, Smrke et al. (2018) found a »general lack of properly developed and validated questionnaires, lack of sufficient reporting on the origin, development, and psychometric characteristics of the questionnaires, and often too little thought and effort invested in developing and validating questionnaires« (Smrke et al., 2018, p. 67). Since adequate measurement is necessary for understanding any construct of observation (Gifford, 2014), we can conclude that the field of RS is in this regard insufficiently developed. Questionnaires of RS are often developed on ad hoc basis, especially in terms of aspects' selection for the questionnaire. Therefore, justifications and criteria for including specific aspects of the residential environment in the questionnaires of RS should be formed (Smrke et al., 2018).

The present review is a continuation of the aforementioned review. Its aim is to provide a systematic review of aspects of residential environment (on dwelling with building and neighbourhood levels) included in the RS questionnaires and to categorize these aspects in order to possibly arrive at a comprehensive list of included aspects and recognizing most prominent categories of aspects included.

Method:

For the study containing a questionnaire on RS to be included in the review, the following criteria had to be met:

- empirical, quantitative study with focus on residential, housing, dwelling and/or neighbourhood satisfaction (excluding community satisfaction and satisfaction with wider regions);
- focus on apartment buildings at the dwelling and building levels (excluding studies that focused solely on single-family homes, student dormitories, retirement homes etc.);
- assessment through a self-report questionnaire with items on multiple aspects of residential environment (excluding studies with only general questions about RS);
- adult population (excluding students, psychiatric patients etc.).

An original search of potential studies was performed from 28 August to 8 September 2017, and updated with a search on the 14 January 2019, both through the University of Ljubljana's digital library database within the following disciplines: architecture, psychology and environmental sciences (databases/content providers: PsychINFO, J-STAGE, Scopus, Complementary Index, Academic Search Complete, Science Citation Index, Social Sciences Citation Index, Supplemental Index, MEDLINE, GreenFILE, ScienceDirect, JSTOR Journals, ERIC, and PsychARTICLES). The search was limited to academic journals, dissertations/theses, conference materials, eBooks, and reviews, with no limit on the publication date. The search terms included residential, dwelling, housing and neighbourhood satisfaction alone and in combination with terms questionnaire, scale, and measurement. The search and review of the relevance to the criteria resulted in 55 unique questionnaires (Figure 1).

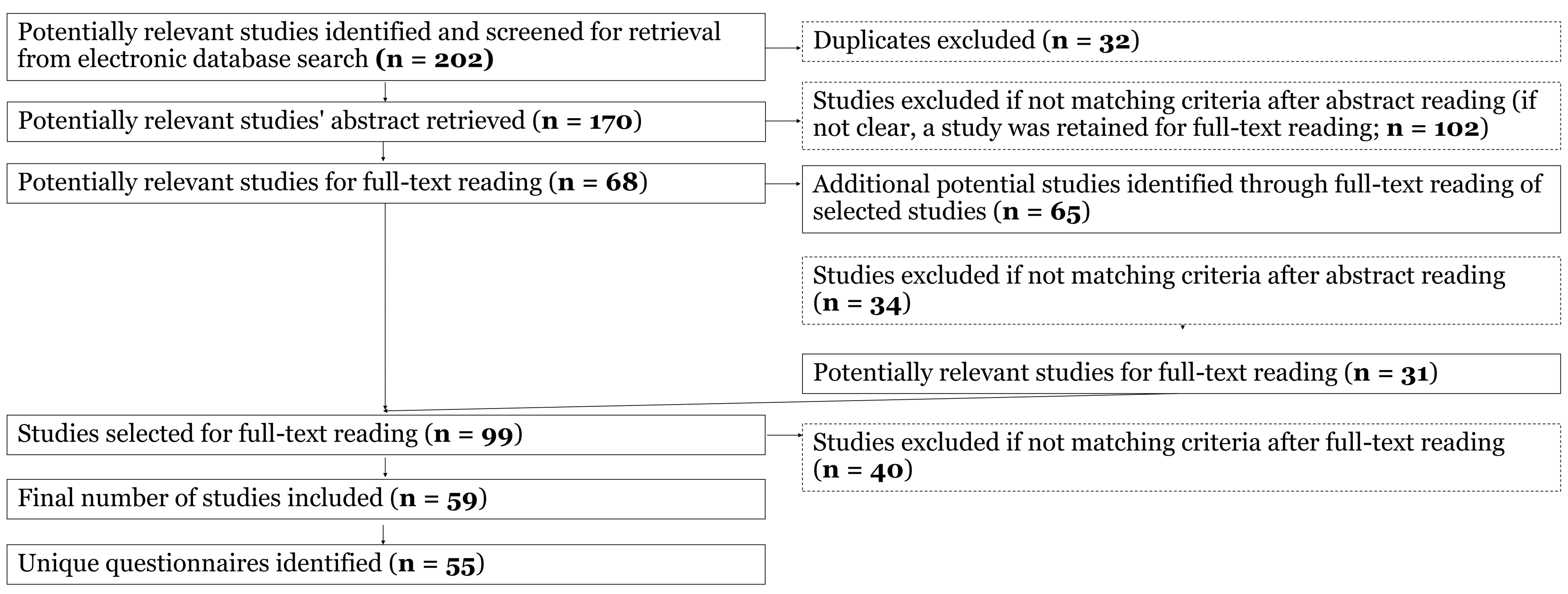

Figure 1. Flow diagram of selecting studies to be included in the review.

Table 1. *Categories of aspects – dwelling.*

L2	L3	N of questionnaires' items	N of questionnaires with items of specific category
Floor plan, size, and design of a dwelling		189	
	Interior design and appearance	116	25
	General evaluations of dwelling	18	9
	Privacy	18	15
	Floor plan	16	7
	Tenure & prices	13	10
	View	4	4
	Other people in dwelling	3	3
Installations, facilities, maintenance etc.		98	1
	Internal conditions of dwelling	82	17
	Installations & supply	12	8
	Maintenance of dwelling	3	3

Notes. L2 = Level 2, L3 = Level 3.

Table 2. *Categories of aspects – dwelling/building.*

L2	L3	N of questionnaires' items	N of questionnaires with items of specific category
Safety and security		36	18
Position of dwelling in the building		4	
	Orientation of dwelling	3	3
	Floor	1	1
Dwelling type		3	3

Notes. L2 = Level 2, L3 = Level 3.

Table 3. *Categories of aspects – building/complex.*

L2	L3	N of questionnaires' items	N of questionnaires with items of specific category
Installations, facilities, maintenance etc.		89	
	Management and maintenance	46	14
	Internal conditions of building	16	11
	Installations, supply, services, etc.	27	13
Design of a building		56	1
	Architectural style/design, outer appearance	13	10
	Building structure	18	11
	Common areas in the building	24	10
Parking		5	
	Parking in/around building/ complex	4	4
	Maintenance of parking areas	1	1
General evaluations / building as a whole		3	1
	Sustainability of a building	2	1

Notes. L2 = Level 2, L3 = Level 3.

Table 4. *Categories of aspects – building/neighbourhood.*

L2	L3	N of questionnaires' items	N of questionnaires with items of specific category
Other people in the building / neighbourhood		138	
	Residential community	115	34
	Sociodemographic characteristics of residents	13	10
	Population density and crowding	10	9
Micro-location		8	8

Notes. L2 = Level 2, L3 = Level 3.

Table 5. *Categories of aspects – neighbourhood.*

L2	L3	N of questionnaires' items	N of questionnaires with items of specific category
Traffic		106	
	Traffic infrastructure	45	22
	Public transport	36	26
	Accessibility to other parts of the city / other destinations	17	12
	Intensity of traffic	6	6
	Convenience of transport and commuting	2	2
Public utilities, pollution, cleanliness, management of a neighbourhood		100	1
	Health of environment/ pollution	67	33
	Public infrastructure & supply	13	6
	Upkeep	12	7
	Attitude of the city/ administrative authority towards neighbourhood	7	3
Open spaces, nature, meeting places / community facilities		96	2
	Open spaces and green areas	50	28
	Rest and recreation areas/facilities	30	21
	Community facilities	14	12
Safety & security		65	
	Safety from crime, vandalism and antisocial activities	21	18
	General safety and security	17	16
	Safety by services in the neighbourhood	10	6
	Safety of transportation, traffic safety	5	5
	Safety for walking / pedestrian safety	5	4
	Accident situation	3	3
	Feeling of safety	2	1
	Safety from disaster	2	2
	Safety of public infrastructure	1	1
Services, institutions etc.		62	2
	Entertainment and commercial services	60	31
	Work and education	51	27
	Social and health care services	32	21
	Other public services	30	17
Design of a neighbourhood (general)		59	
	Architectural quality of buildings	25	8
	Size and density of neighbourhood	14	7
	Landscaping	10	10
	General appearance	8	8
	Signage systems	1	1
	Type of environment	1	1
General evaluations of the neighbourhood		55	3
	Comfort in the neighbourhood	19	13
	Interesting, having things to do	9	5
	Environment (general)	5	5
	Attachment/feeling of home	2	1
	Comparing to other neighbourhoods	2	2
	General design and maintenance	2	2
	Good place for children	2	2
	Good/ideal place to live	2	2
	People leaving neighbourhood/ growth of a neighbourhood	2	2
	Would like to stay in the neighbourhood	2	2
	Facilities for the disabled	1	1
	Improvement of neighbourhood	1	1
	Neighbourhood attributes	1	1
	(Not)suitable place to live	1	1
	Would recommend the neighbourhood	1	1
Living costs & home value		8	
	Cost of living	7	6
	Home value	1	1

Notes. L2 = Level 2, L3 = Level 3.

Results:

List of included studies and characteristics of the questionnaires employed are available upon request. Aspects included in the RS questionnaires were categorized regarding the level of residential environment (level 1), and further on categorized on two lower levels (level 2 and 3). Tables 1-5 present aspects' categories for each of the included levels of residential environment with N of questionnaires' items and N of the questionnaires with items of specific category (these are often not equal since many of the questionnaires included more than one aspect of specific category).

At the level of dwelling, the most frequent category of aspects was '*floor plan, size, and design of a dwelling*' on level 2 and '*interior design and appearance*' on level 3. At the level of dwelling/building, the most frequent category was '*safety and security*' on level 2 and '*orientation of dwelling*' on level 3. At the level of building/complex the most frequent category was '*installations, facilities, maintenance etc.*' on level 2 and '*management and maintenance*' on level 3. At the level of building/neighbourhood, the most frequent category was '*other people in the building/neighbourhood*' on level 2 and '*residential community*' on level 3. At the level of neighbourhood, the most frequent category was '*traffic*' on level 2 and '*health of environment/ pollution*' on level 3.

Discussion/Conclusions:

In the present study, categorization of aspects of residential environment included in reviewed RS questionnaires is presented. Since this is, to the authors' best knowledge, a first review of the aspects included in RS questionnaire, it represents a starting point towards a comprehensive review of aspects of residential environment included in RS research. As such it may benefit researchers, aiming to include this kind of questionnaires in their research or developing their own.

This poster presents only part of the results of the review. More detailed paper with additional levels of categorization is in preparation. Further efforts should be invested reviewing the importance of specific aspects of residential environment for the satisfaction with residential environment.

Literature:

**References of the reviewed studies are available upon request, as are tables with codes of studies with questionnaires including items of specific category.*

Dekker, K., de Vos, S., Musterd, S. & van Kempen, R. (2011). Residential Satisfaction in Housing Estates in European Cities: A Multi–level Research Approach. *Housing Studies,* 26(4), pp. 479–499. https://doi.org/10.1080/02673037.2011.559751.

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Li, S. & Song, Y. (2009). Redevelopment, displacement, housing conditions and residential satisfaction: a study of Shanghai. *Environment and Planning A,* 41, pp. 1090–1108. doi: 10.1068/a4168.

Lu, M. (1999). Determinants of residential satisfaction: ordered logit vs. regression models. *Growth and Change,* 30, pp. 264–287.

Pinquart, M. & Burmedi, D. (2003). Correlates of residential satisfaction in adulthood and old age; A meta–analysis. In: Windley, P., Scheidt, R., & Wahl, H.-W. (eds.) *Annual Review of Gerontology and Geriatrics,* 23, pp. 195–222. New York, Springer Publishing Company.

Smrke, U., Blenkuš, M., & Sočan, G. (2018). Residential satisfaction questionnaires: A systematic review. *Urbani izziv, 29*(2), 67-82. doi: 10.5379/urbani-izziv-en-2018-29-2-001.

Wang, D. & Wang, F. (2016). Contributions of the usage and affective experience of the residential environment to residential satisfaction. *Housing Studies,* 31(1), pp. 42–60. doi: 10.1080/02673037.2015.1025372.

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Molecular Dynamics Investigation of Capturing Paracrystalline Cellulose Phase from mixed Crystalline and Amorphous Cellulose under Constant Load

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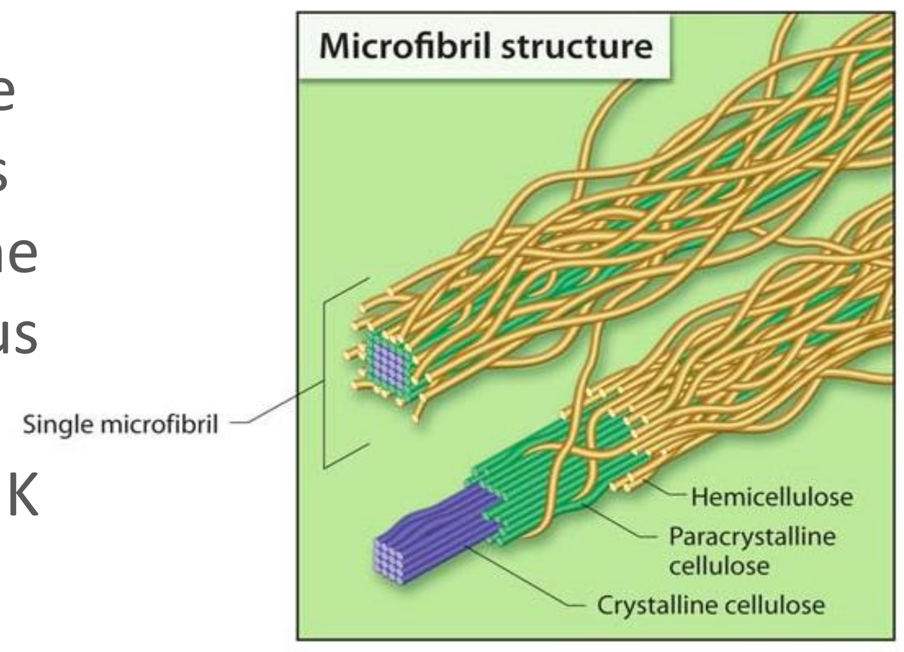
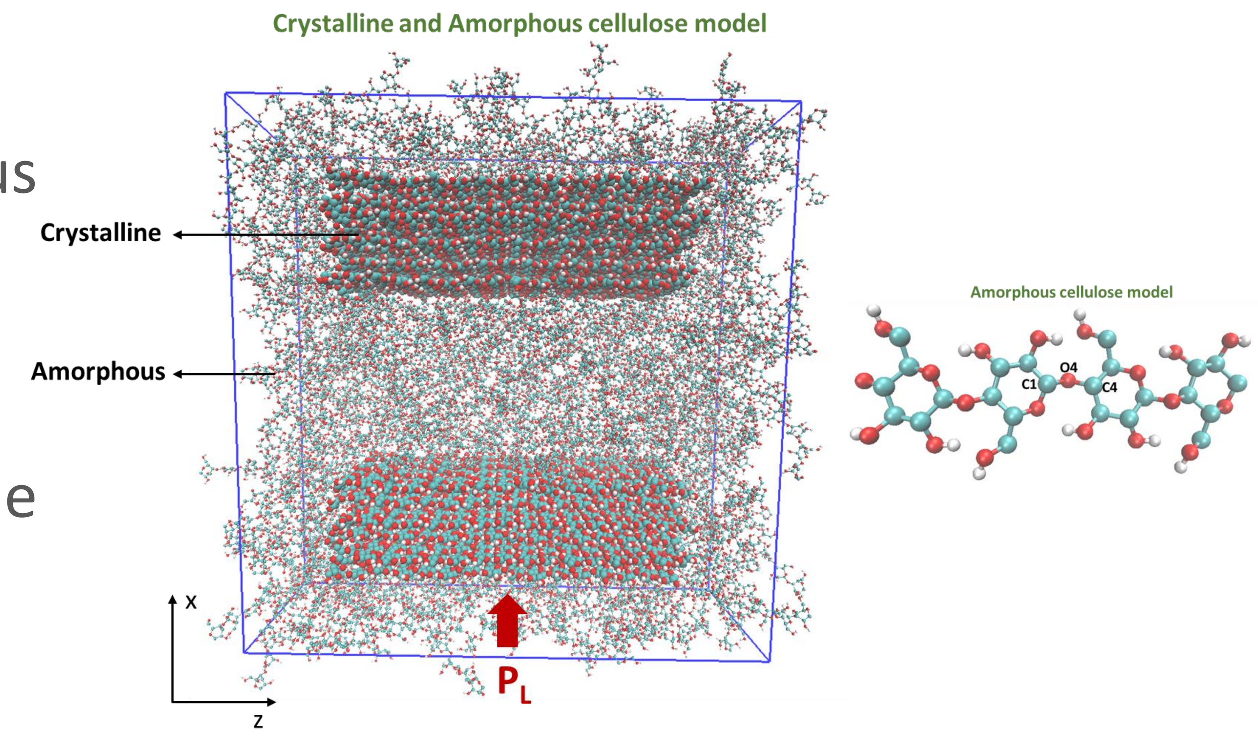
- Paracrystalline cellulose is a non-equilibrium structure between crystalline and amorphous cellulose
- Paracrystalline state is close to an amorphous state but possess random collinearity between chains
- Mechanical properties, angle distribution, hydrogen bonding and chain ordering of the paracrystalline cellulose showed to be an intermediary state between the crystalline and amorphous cellulose
- Disorder process of crystalline cellulose chain can be accelerated at temperatures higher than 700 K to obtain amorphous cellulose



The main purpose of this research is to provide a new computational protocol for obtaining paracrystalline structures by applying different pressure loads without increasing temperature

System and Methods

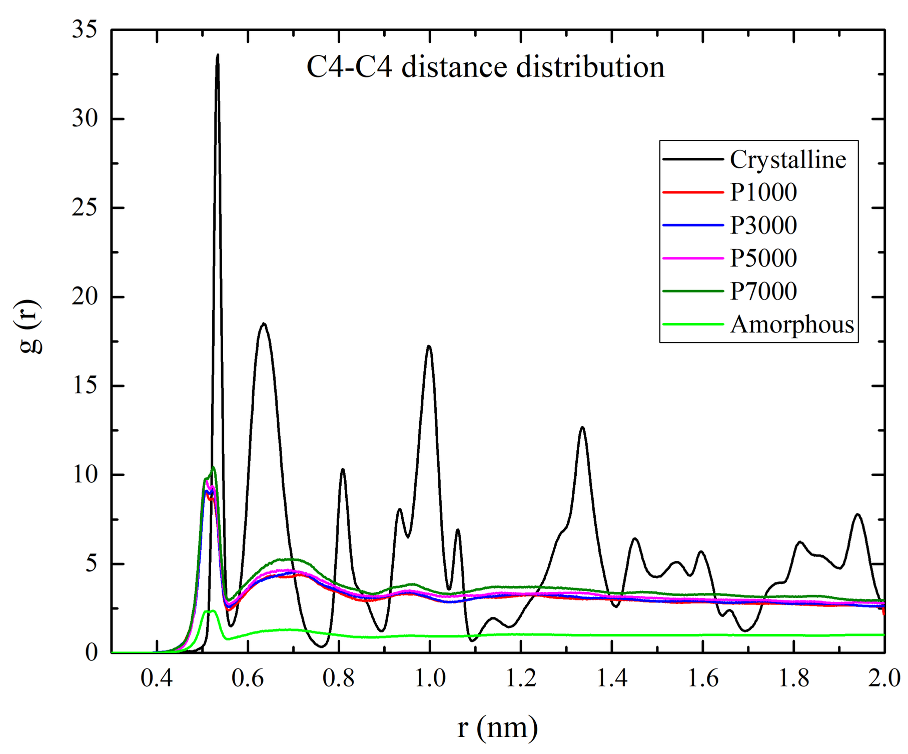
- Molecular dynamics (MD) simulations were performed for the confined amorphous cellulose between crystalline cellulose surface
- Package: GROMACS, Force field – GROMOS 53a6
- Temperature – 300 K and run the simulations for 10ns at 1 fs time step interval
- Apply different pressure loads - $\mathbf{P_L}$ (1000, 3000, 5000 and 7000 kJ mol^{-1} nm^{-2}) in the x-direction of the bottom crystalline wall



Results

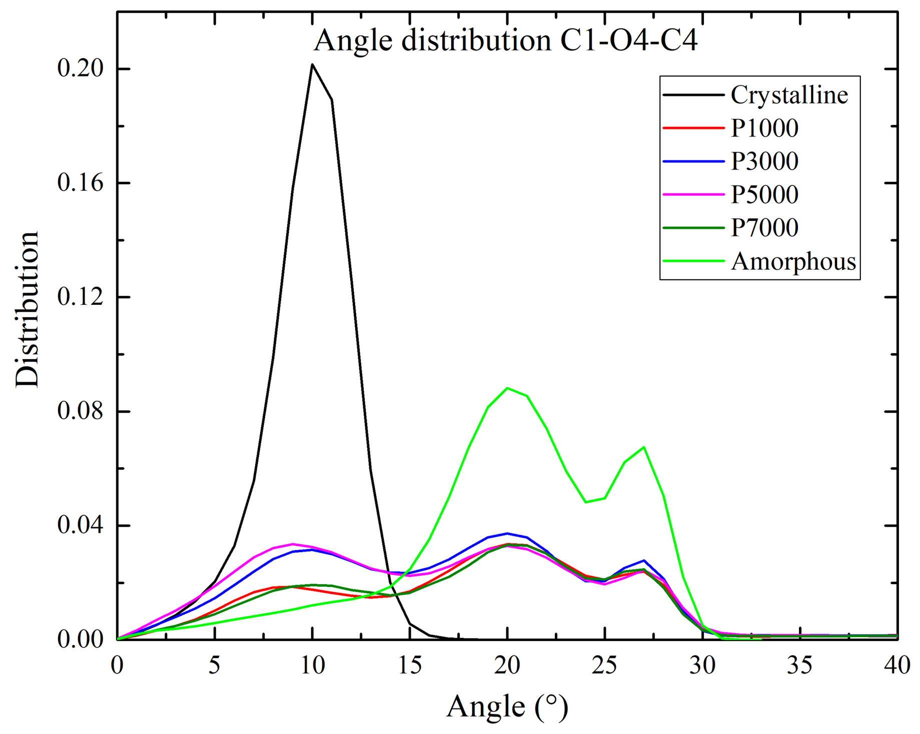
Radial distribution function (RDF)

- RDF is the probability of finding an atom at distance "r"
- Applied different P_L significantly improve the formation of paracrystalline phase
- Two intensive g(r) peak can be seen at 0.5 nm and 0.7 nm, however, amorphous exhibits a small g(r) around 0.5nm



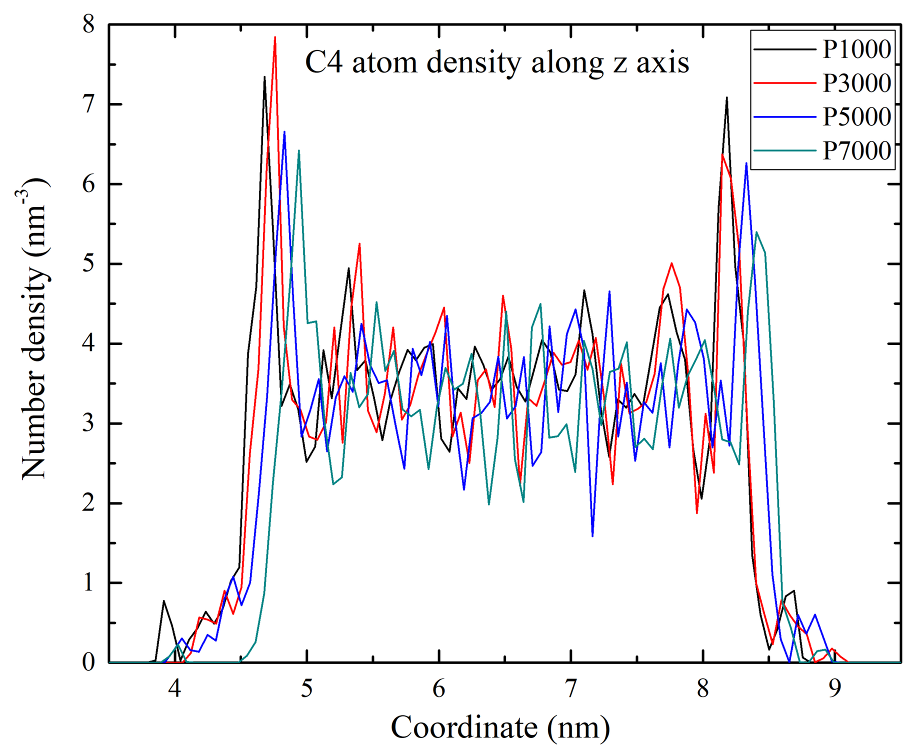
Angle distribution

- The typical angle of C1-O4-C4 atom was compared for crystalline and amorphous with different P_L applied systems
- Two angle distributions were found for P_L applied systems which again proved that they have both crystalline and amorphous character



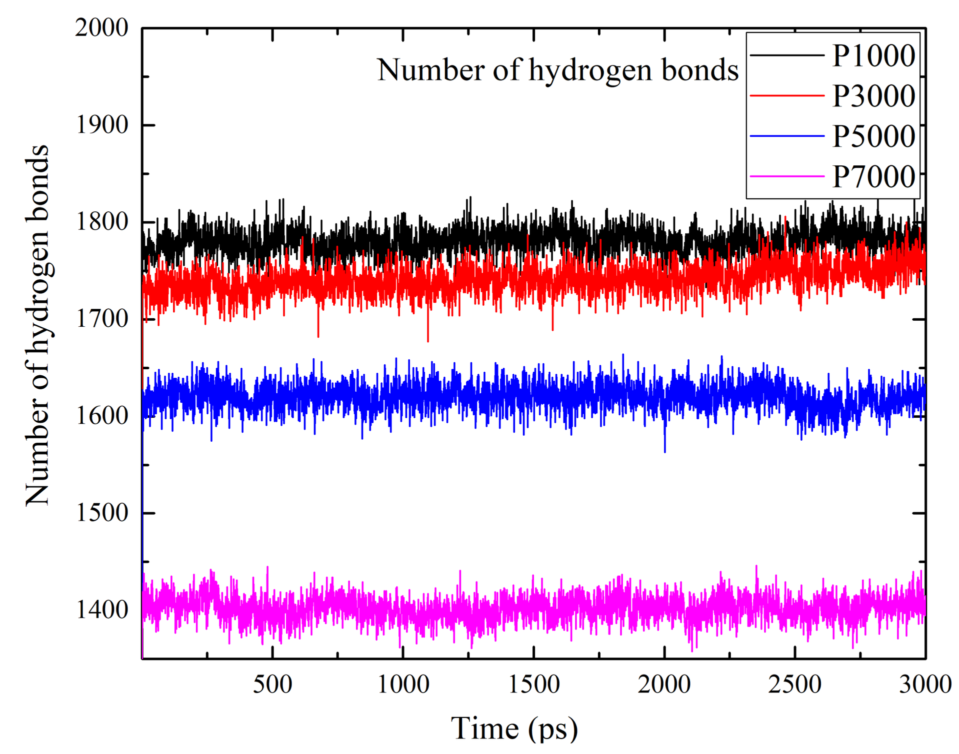
Density distribution

- The calculation of density distribution provides the structural arrangement at the interphase
- Density distribution of atom-C4 describes clearly that the paracrystallinity is more pronounced close to the crystalline surface at nearly all investigated P_L



Hydrogen bond characteristics

- Hydrogen bond analysis results showed that increasing pressure load decreases the number of hydrogen bonds which is due to the disruption of amorphous phase
- Higher P_L load leads to poor chain ordering



Conclusions

The obtained results have demonstrated that the confined amorphous cellulose between crystalline cellulose walls enhances the formation of intermediate paracrystalline phase by applying different pressure without increasing the temperature.

This analysis will provide significant insights for the development of phase separation of cellulose.

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Practical education of Smart Home Systems emphasizing sustainability

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Abstract:
Smart home systems can make the living more comfortable. Moreover they may provide ways to save energy, thus they can help to achieve sustainable buildings. The possibilities are wide and the energy savings can be as high as 45%. To achieve such high values the capabilities of the smart home system must be known to the person using it. The Department of Technology possesses a working smart home model. Our students can try its operation and they are also introduced to the various ways to program it. The different approaches of saving energy are presented during the education process, too.

Keywords:
energy, smart home, programming, education

1. Introduction

Home is still the place where someone wants to feel himself/herself comfortable. In our modern world there are a lot of automated or semi-automated systems to make the homes more and more comfortable. Some offer only a few features and at the other side of the spectrum there are the fully computer controlled integrated buildings.

Smart home systems are getting more and more popular. They are good to provide comfort and ease, but they are getting smarter, too. The systems can make suggestions on how to save energy, thus keeping the home sustainable. For example the german Gira home automation system promises up to 45% energy savings if the home is fully automated (www.gira.com, 2020).

2. Omizzy System (Legrand)

The best solution is a fully integrated, automated house. But if someone does not want to spend too much to try a smart home system, and may want to expand it later, it is now possible, too.

The Omizzy system of Legrand is quite flexible. One can start for example with 2-3 light switches and can iteratively expand the system to a full scale automatization. Every actuator is an intelligent device by itself. Every actuator has a programmable IC and the programming is not too difficult. A remote controller or a central interface unit can be purchased separately and they are not needed for basic operations. Moreover, no extra cabling is required, the actuators communicate with each other by putting the signal on top of the regular AC. One can easily program a switch to drive other actuators inside the building. By using a central interface unit, more possibilities are available (see Figure 1).

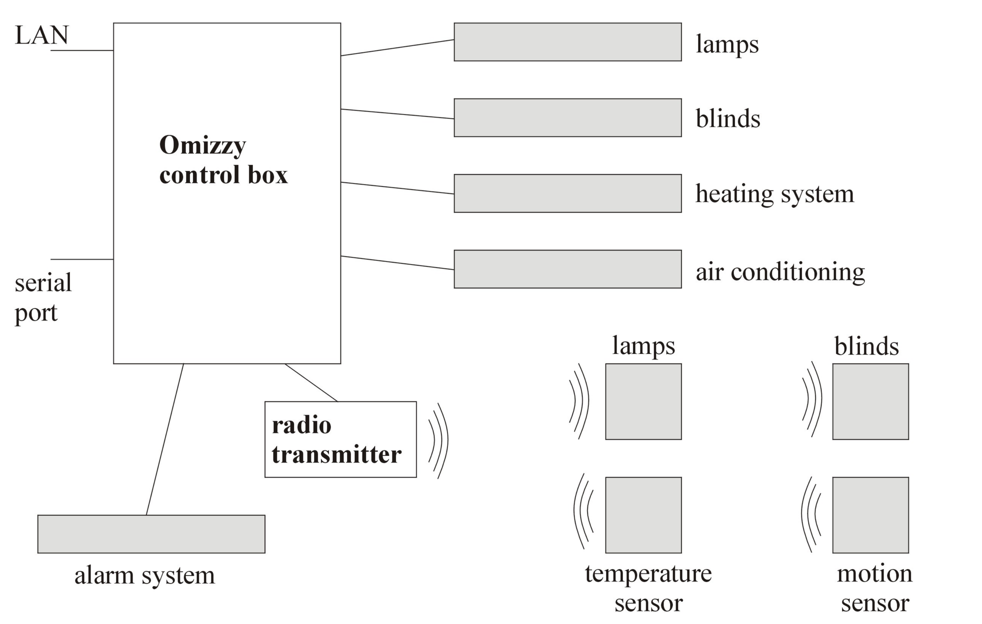

Figure 1: Complete Omizzy intelligent home system

The central unit can be reached by various ways: from a PC or from a phone (see Figure 2).

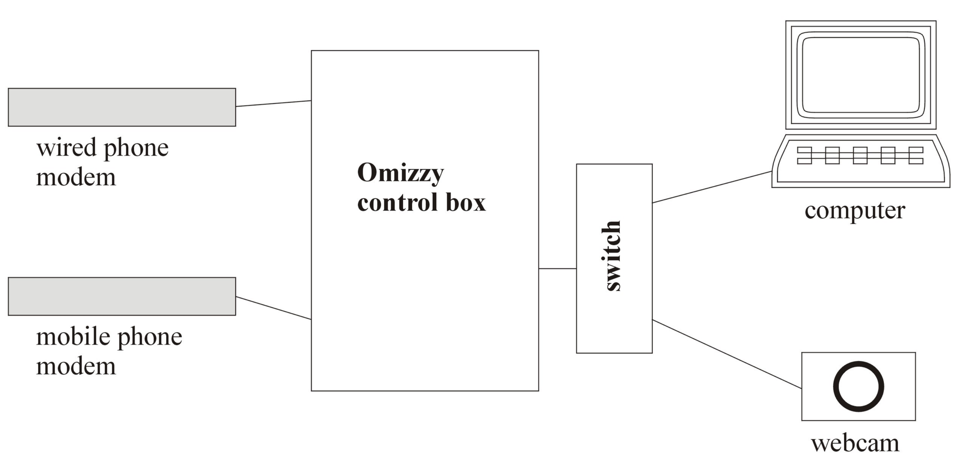

Figure 2: Omizzy controlling scheme

3. Educational System

The Department of Technology of University of Szeged received a fully functional programmable home automation system for education purposes. It consists of four panels with roll-up blinds, lights, outlets, switches, a separate Omizzy control unit and a remote controller (see Figure 3 and 4).

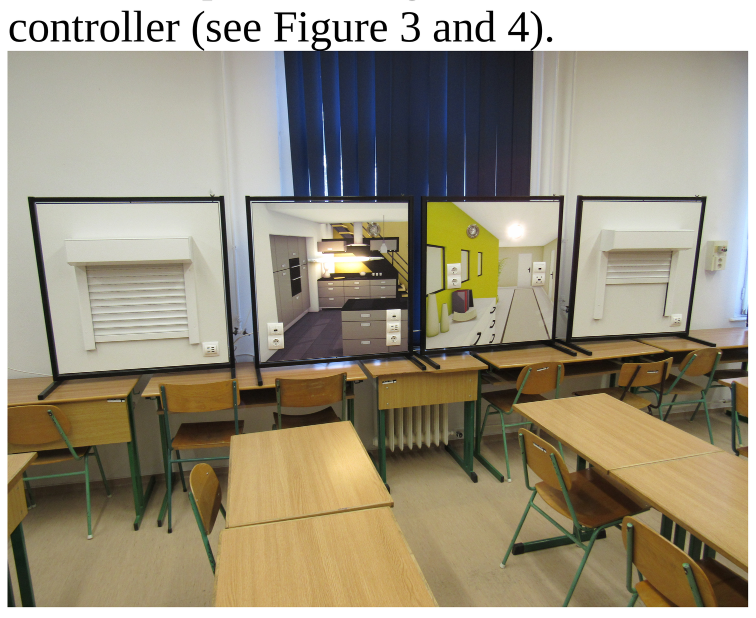

Figure 3: The four functional panels with the actuators

Figure 4: The Omizzy central unit and the remote controller

The students learn all the possibilities: they learn how to program directly the IC-s built inside the actuators; they learn how to program and use the remote controller; and they learn how to connect the actuators through the control box to a computer and how to command everything with the computer. Each and every way is carried out step by step so the students can achieve an adequate knowledge about programming an intelligent home system. They learn by practicing. The ways for saving energy are explained during the practice. They learn how to build a scenario and how to make it energy efficient (see Figure 5).

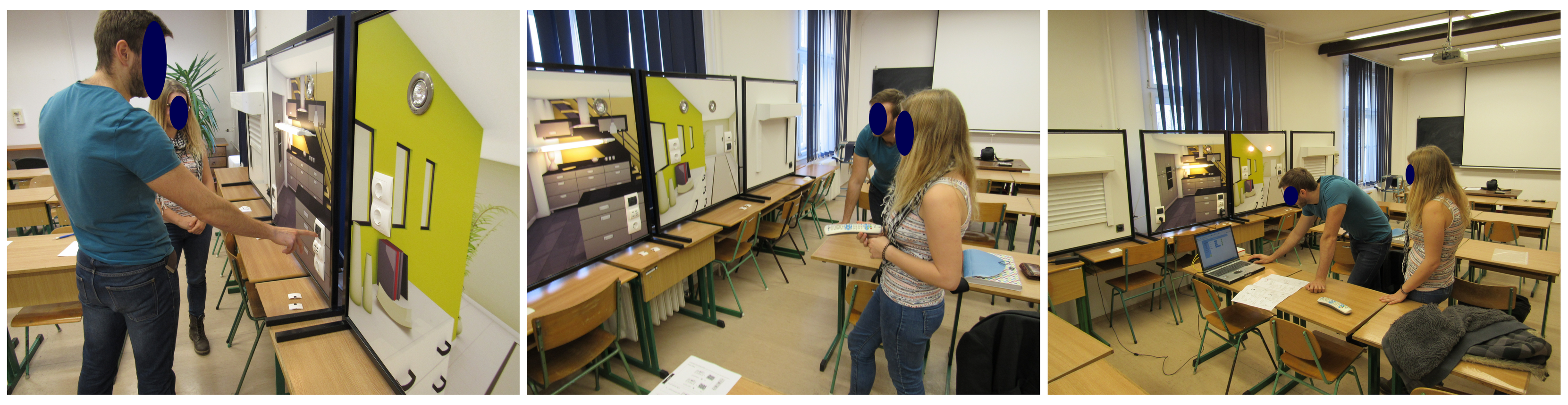

Figure 5: Students programming the actuators directly, by the remote controller and by computer (author's photos)

4. A New System

From the next semester the students will learn a newly bought system, too (see Figure 6).

It consists of a control box, a remote control and two switchable plug-in outlets. The system uses radio communication for the outlets and WIFI for command. The students have to download a program to the smartphone, and they can control the outlets from the phone. Naturally, the system can be expanded at will with different devices: switches, IP cameras, thermostat, motion sensors, smoke detectors can be added; just to mention a few.

Figure 6: HomeWizard intelligent home system basic set (author's photo)

5. Theoretical Education

The students learn about modern, energy-conscious, eco-friendly building methods using various materials. They also learn about the Gira home automation system (www.gira.com, 2020). They also produce small presentations to show each other the modern eco-houses around the world (see Figure 7).

Figure 7: Student's presentation about eco-houses (portion)

6. Conclusion

The Department of Technology now has various tools to teach the basic principles of modern home automation systems through practice. The students are eager to try these devices, they enjoy if the programming is successful and because of their highly elevated attention it is easier to teach them the importance and the different ways of saving energy thus achieving sustainability. Sustainability is a key for mankind to live on. The future teachers of technology must have enough knowledge about it.

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HomeWizard connect kit system manual, 2018
Omizzy (Legrand) system manual, 2010

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