IRIC 2022

Rethinking buildings and materials for a sustainable future

BOOK OF ABSTRACTS

17–18 NOVEMBER 2022
IZOLA, SLOVENIA

innorenew.eu
InnoRenew CoE is funded by the European Commission under Horizon 2020, the EU Framework Programme for Research and Innovation (H2020 WIDE-SPREAD-2-Teaming #739574), and by investment funding from the Republic of Slovenia and the European Regional Development Fund.

InnoRenew CoE International Conference 2022
Rethinking Buildings and Materials for a Sustainable Future
17–18 November | Izola, Slovenia
Book of Abstracts

Published by
Innorenew CoE, Livade 6a, 6310 Izola, Slovenia
University of Primorska Press, Titov trg 4, 6000 Koper, Slovenia

Izola and Koper, 2022

InnoRenew CoE International Conference Series
E-ISSN 2784-6679

Electronic Edition
https://www.hippocampus.si/ISBN/978-961-293-193-3.pdf
https://www.hippocampus.si/ISBN/978-961-293-194-0/index.html
https://doi.org/10.26493/978-961-293-193-3

Kataložni zapis o publikaciji (CIP) pripravili
v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID 128390147
ISBN 978-961-293-193-3 (Univerza na Primorskem, PDF)
ISBN 978-961-293-194-0 (Univerza na Primorskem, HTML)

EVROPSKA UNIJA
EVROPSKI SKLAD ZA REGIONALNI RAZVOJ

Life cycle assessment of sustainable neighborhood

Mohamad ACHOUR[1], Mohamad TOUFAILY[1], Gilles BETIS[1]*

[1] Institut de Recherche en Constructibilité, Ecole Spéciale Des Travaux Publics, Université Paris-Est, 28 Avenue du Président Wilson, 94234 Cachan Cedex, France, machour@estp-paris.eu

* Corresponding author: machour@estp-paris.eu

The built environment is the most energy consuming and environmentally damaging sector, where it consumes more than two-thirds of the global energy and accounts for more than 70% of the global CO2 emissions (Hong et al., 2020). This has led to the increase in research on efficient ways to achieve sustainability in cities and develop tools to quantify the environmental impacts they are causing. Life Cycle Assessment (LCA) is considered the most reliable tool to assess these impacts (Loiseau et al., 2012) and has been used immensely by researchers, most notably in the construction sector, to compare between various types of buildings. Recently, focus has shifted towards LCA of neighborhoods, whether to improve urban sustainability policies or to assist eco-design urban development projects (Lotteau et al., 2015).

Unlike LCA of buildings, the Life Cycle Assessment of neighborhoods is more complicated and does not only analyze the activities happening within buildings, but rather analyzes the interaction between the different components of the neighborhood, which are the buildings, open spaces, public networks and the transportation sector (Lotteau et al., 2015). Differences in scope, goals, life cycle inventory, and life cycle impact assessment make the comparison between LCA of neighborhoods very difficult.

The aim of this study is to conduct a Life Cycle Analysis of a new sustainable neighborhood, under renovation in Dijon, France called Fontaine d'Ouche, which is one of two energy-positive pilot projects adopted by the European Program "Response". Innovative techniques and solutions are implemented in this neighborhood and the LCA study will attempt to quantify the effect of these solutions on the environment. A simulation tool, called Pleiades, complemented by the environmental database "EcoInvent" will be used for the analysis. Comparison of results will be provided, limitations and uncertainties will be addressed, and recommendations for improvement will be presented.

Keywords: Environment, life cycle assessment, sustainability

Acknowledgment: The authors gratefully acknowledge receiving funding from IRC: institut de recherche en constructibilité

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Analysing carbon footprint and life cycle cost (LCC) of a one family dwelling for more sustainable building solutions

Erwin M. Schau[1], Tim Mavrič[1], Eva Prelovšek Niemelä[1], Željko Vene[2], Sebastjan Molnar[2], Barbara Kobale[2]*

[1] InnoRenew CoE, Livade 6A, SI-6310 Isola-Izola, Slovenia
[2] Marles, Limbuška cesta 2, SI-2341 Limbuš, Slovenia
* Corresponding author

There is an urgent need to reduce greenhouse gas emissions by at least 55% by the year 2030 and to reach climate neutrality by 2050. The building sector is one of the largest emitters of CO2 to the atmosphere. Including energy use in buildings, the sector contributes 31% of the global CO2 emissions (Cabessa et al, 2022). However, the cost of climate friendlier buildings needs to be affordable for the purchaser, while taking into account the emitted CO2 during the use phase. This calls for a carbon footprint evaluation along with an LCC. In this contribution, we investigated an existing prefabricated wooden single-family house and compared it to two different hypothetical scenarios of design with different materials. This building serves as a model for the Slovene construction company Marles, for further development of prefabricated home models. In the first scenario we dealt with the optimisation of the existing building in terms of carbon footprint. We changed the insulation materials from less environmentally friendly to bio-based and reduced the concrete parts in the structure (foundation plate). This change increased the cost of construction. In the second scenario we evaluated the change of construction materials from the existing wooden structure into brick with concrete reinforcement elements and slabs. In this scenario we presented a less environmentally friendly solution but managed a lower cost of investment for the purchaser.

The results show that, even with increased energy performance for construction materials, the energy consumption in the use phase dominates the carbon footprint. Nevertheless, there is time to stress the importance of reducing the carbon footprint of construction materials, since energy-reduction policies in the use phase of the buildings are well known and have been put into practice. Detailed analysis of the impact of different construction materials on carbon footprint and LCC, gives better insight into how future construction should be developed.

Keywords: Carbon footprint, life cycle cost (LCC), buildings, family house

Acknowledgment: The authors from InnoRenew CoE gratefully acknowledge the European Commission for funding the InnoRenew CoE project (Grant Agreement #739574) under the H2020 Widespread-Teaming programme, and the Republic of Slovenia (Investment funding of the Republic of Slovenia and the European Union of the European Regional Development Fund).

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TimberLoop – The answer to high value circular timber use

M. Weigl-Kuska[1], C. Fürhapper[2]*

[1] Holzforschung Austria, Franz-Grill-Str. 7, 1030 Vienna, Austria, m.weigl-kuska@holzforschung.at
[2] Holzforschung Austria, Franz-Grill-Str. 7, 1030 Vienna, Austria, c.fuerhapper@holzforschung.at
* Corresponding author

TimberLoop is a basic research project that started in 2022, which will guarantee high value reuse of wooden building products. This contribution aims to catalyze a kick start for cooperation and exchange.

Due to further CO2 storage and resource savings in each new life cycle, previously used construction timber has a high potential for transitioning to a circular bio-recycling economy. The state of the art is based on shredding recovered wood and using it in the wood-based panels industry or as an energy source. This represents a disproportionate downcycling in the cascade use of wood. Treatment with wood preservatives is a general obstacle to material and energetic recycling. The goal of TimberLoop is to preserve the structure of wood from previous use as much as possible, to integrate it into the recycling system without complex preparation measures, and to minimize waste streams. The basics for recycling wood from the building industry for the building industry in building products for static load-bearing applications and small-volume wooden building products are created. The wood preservative-free recycling is an essential goal for this. However, apart from individual niches, neither extraction, logistics, technology, products nor the market are established for a large-volume real cradle to cradle-based circular economy that spans the entire wood industry. TimberLoop closes the central gaps in knowledge and is accompanied by life cycle analyses, design concepts and solutions for the recycling and upcycling of this valuable raw material and, thus, avoids the early release of CO2 stored in the wood.

A wide range of key players in the Austrian wood industry are working in a network with pioneers of the circular bioeconomy, on solutions for how to use wood in domestic material flows in an innovative and sustainable way while preserving the structure and value.

Keywords: circular economy, reuse, recycling, wood construction products, network

Acknowledgment: The authors gratefully acknowledge receiving funding from Österreichische Forschungsförderungsgesellschaft FFG within the THINK.WOOD.Innovation.Kooperative F&E Projekte program [FFG-Nr. 893366], and financial as well as cooperative support from a wide range of industrial partners.

Integration of high-speed 3D laser scanning and photogrammetry for CFD simulation of the airflow around the building

Richard Acquah[1,2], Anna Sandak[1,2], Jakub Sandak[1,2]*

[1] Innorenew CoE, Livade 6a, richard.acquah@innorenew.eu, anna.sandak@ innorenew.eu, jakub.sandak@ innorenew.eu
[2] University of Primorska, FAMNIT, Koper, richard.acquah@famnit.upr.si, anna.sandak@famnit.upr.si, jakub.sandak@famnit.upr.si
* Corresponding author

The use of 3D laser scanning and photogrammetry technologies within the architectural, engineering, and construction industry has increased significantly over the past two decades. Integration of photogrammetry with 3D laser scanning to model buildings and their external environment create a possibility to compensate for the individual weakness of both techniques.

Though the methodology of integrating 3D laser scanning and photogrammetry is promising and has been widely used for several applications, its application as a basis for computational fluid dynamics (CFD) simulations has not been explored enough. This is partly because, creation of meshes from cloud point data usable for performing CFD simulations can be complicated.

The aim of this study is to demonstrate the application of high-speed 3D laser scanning technologies and photogrammetry for CFD simulation of wind flow in micro-urban spaces.

The methods within this research can be classified into four main steps. The first step included setting-up and acquiring microclimate data as well as point cloud data of the sub-urban space under study using 3D scanner and a drone for aerial photography capture. The second step involved pre-processing of captured data. In step three, the data collected was imported and used to perform wind flow simulations around buildings and within the case study area. The fourth step involved post-processing and analysis of simulation results.

The results show that the workflow presented in this study is an efficient way of performing CFD simulations of existing structures. The findings in this study also indicate that these two technologies compensate for one another. Findings from this study also suggest that integrating these two technologies help in capturing and creating a more accurate and detailed 3d model of micro-urban spaces.

Keywords: computational fluid dynamics, wind, 3D laser scanning, photogrammetry, micro-climatic data.

Acknowledgement: The authors gratefully acknowledge the European Commission for funding the InnoRenew project (grant agreement #739574) under the Horizon2020 Widespread-2-Teaming program, the Republic of Slovenia (investment funding from the Republic of Slovenia and the European Union's European Regional Development Fund) and infrastructural ARRS program IO-0035. Part of this work was conducted under the project WoodLCC funded by ForestValue.

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In-situ measurements and FE numerical study of InnoRenew CoE building's dynamic performance

Igor Gavrić[1,2], Iztok Šušteršič[1,2], Rok Prislan[1,2]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia; e-mail: igor.gavric@innorenew.eu, iztok.sustersic@innorenew.eu, rok.prislan@innorenew.eu
[2] University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Glagoljaška 8, 6000 Koper, Slovenia
* Corresponding author

This study presents the results of ambient and vibration-based testing of a 4-storey InnoRenew CoE hybrid timber structure within the Dynamic Response of Tall Timber Buildings under Service Load (DynaTTB) research project (Abrahamsen et al., 2020). The main objective of the project is to identify experimentally a number of full-scale tall timber buildings (existing or currently being built) and, based on these, develop representative finite element (FE) models for predicting the vibration response of TTBs exposed to wind-induced dynamic loading. The main outcomes of this project will be included in a Guideline for practicing engineers with recommendations for the design of TTBs subjected to wind loads in the Serviceability Limit State (SLS).

In-situ measurements were performed at different construction stages. The first experimental data set refers to ambient vibration measurements with two independent sets of measurement devices. The second experimental data set was obtained by exciting the structure at different positions with APS 400 vibration exciter during construction, and the third one after the building was finished. The experimental results were then compared to FE models which represent the building's dynamic response in terms of eigenfrequencies and mode shapes and was further updated and validated. The effects of parameters such as connections' stiffness, foundations, mechanical properties of timber (elastic and shear modulus) and non-loadbearing structures such as screeds, partition walls, and façade were analysed.

In this study we critically discuss the influence of aforementioned parameters on the building's lateral stiffness, compare the results with the FE model used for the structural design of this building, and provide insights that are essential in determining the correct building stiffness for both seismic and wind design cases.

Keywords: cross-laminated timber (CLT), in-situ testing, dynamic response, finite element modelling

Acknowledgement: The authors gratefully acknowledge funding received from the ForestValue Research Programme which is a transnational research, development and innovation programme jointly funded by national funding organisations within the framework of the ERA-NET Cofund "ForestValue – Innovating Forest based bioeconomy". The results of the Slovenian part of the project were co-financed by Ministry of Education, Science and Sport of the Republic of Slovenia. Authors also gratefully acknowledge receiving funding from programme Horizon 2020 Framework Programme of the European Union; H2020 WIDESPREAD-2-Teaming: (#739574) and the Republic of Slovenia.

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Optimizing neural networks for building energy demand estimation

Tamás Storcz[1], István Kistelegdi[2], Zsolt Ercsey[3]*

[1] Department of System and Software Technology, University of Pécs, Boszorkány u. 2, 7624 Pécs, Hungary, storcz.tamas@mik.pte.hu
[2] János Szentágothai Research Centre, Energy Design Research Group, University of Pécs, Ifjúság u. 20, 7624 Pécs, Hungary, kistelegdisoma@mik.pte.hu
[3] Department of System and Software Technology, University of Pécs, Boszorkány u. 2, 7624 Pécs, Hungary, ercsey.zsolt@mik.pte.hu
* Corresponding author

For energy optimization, it is necessary to know the energy (e.g. annual heating energy) demands of buildings. Basically, building energy demand simulations are done by complex software systems, where environmental, building, and engineering parameters must be set and then an accurate simulation is computed. It takes a lot of time to configure the system, calculate and process the simulation result. Moreover, this process requires time of architect and IT experts.

Using regression models to replace these resource demanding simulations would simplify and accelerate optimization processes. Among available regression models, a neural network-based regression model could be suitable for energy demand estimations. Structural flexibility of neural networks makes them a good choice and popular these days.

In this study, the process and results of hyper parameter selections for a neural network regression model is presented. Effects of input selection, network structure, and initialization are measured to support and validate the selection of hyper parameters of the network and model creation. Simplification of network structure and reducing model complexity, has multiple effects. It reduces learning time and could increase generic regression accuracy by less chance of overfitting.

The overall result is a dense neural network-based regression model with maximized network performance and minimized network structure and length of learning process. This model can be integrated into building energy demand optimization processes with ease or can serve as base of experiments enhancing regression models by changing input structure.

Keywords: energy, building, demand estimation, neural network

Acknowledgment: This work was partially supported by the [2019-2.1.11-TÉT Bilateral Scientific and Technological Cooperation].

Sensitivity analysis of comfort parameters

*Nándor Vincze[1], István Kistelegdi[2], Zoltán Kovács[3], Zsolt Ercsey[4]**

[1] Department of Applied Informatics, University of Szeged, Boldogasszony u. 6, 6725 Szeged, Hungary and Department of Basic Sciences, Faculty of Mechanical Engineering and Automation, John von Neumann University, Izsáki út 10, 6000 Kecskemét, Hungary, vincze@jgypk.u-szeged.hu
[2] University of Pécs, János Szentágothai Research Centre, Energy Design Research Group, Ifjúság u. 20, 7624 Pécs, Hungary, kistelegdi.istvan@mik.pte.hu
[3] Optin Ltd. Oroszlán u. 4., 6720 Szeged, Hungary, zoltan.kovacs@optin.hu
[4] Department of System and Software Technology, Faculty of Engineering and Information Technology, University of Pécs, Boszorkány u. 2, 7624 Pécs, Hungary, ercsey.zsolt@mik.pte.hu
* Corresponding author

Energia Design method (Kistelegdi, I. et al., 2013) integrates both energy related issues as well as comfort and quality of life related questions. As its extension, Energia Design Synthesis (EDS) method concentrates on the generation of all feasible and potentially optimal building combinations based on mathematical rigor. For a certain class of family houses, complex dynamic building simulation database was created with IDA ICE. Previously, energy related issues of the database were deeply investigated. (Vincze, N. et al., 2022)

In this paper, output parameters related to comfort are considered as a basis of the building design investigations. Based on the results of the simulations, the most influential parameters and their dependencies were identified. Fifteen building design variables were selected, for example structure, wall window ratio, orientation, specific surfaces, edges, and vertices together with a complex descriptor specified by architect experts. Morris' Elementary Effect method was used for the sensitivity analysis performed. The order, dominance, monotonicity, and linearity of the parameters were carefully investigated together with their joint effects. The results were compared to the results of some previously performed energy related investigations.

Keywords: sensitivity analysis, building simulation database, evaluation

Acknowledgment: This work was partially supported by the [2019-2.1.11-TÉT Bilateral Scientific and Technological Cooperation].

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Point cloud and NURBS for modeling a decorative wall panels BIM element

Nikolina Raguž-Lučić[1], Dina Stober[1], Zlata Dolaček-Alduk[1], Danijela Domljan[2]*

[1] Faculty of Civil Engineering and Architecture Osijek, Vladimira Preloga 3, 31000 Osijek, Croatia, nrl@gfos.hr, dstober@gfos.hr, zlatad@gfos.hr
[2] Faculty of Forestry and Wood Technology, Svetošimunska cesta 23, 10000 Zagreb, Croatia, ddomljan@sumfak.unizg.hr
* Corresponding author

Industrial production is undergoing a transformation under the influence of digitization and automation. Rationalization of resource consumption, time, and spent energy are the goals to be achieved, and solutions are sought in the precise monitoring of the production process, identification and utilization of residues, possibilities of product variability and satisfactory product quality. The paper presents results of the concept verification of digitalization of residues in production, for designing new products in the wood industry. As part of the research project for the development of innovative decorative wall panels at the company Spačva Ltd. the development of aesthetic components for wood products from sliced Slavonian oak (Quercus robur) veneer production waste is carried out.

Based on the reviewed literature in the field of BIM (Building Information Modeling) and data transformation, the concept of data format conversion from point cloud to NURBS (Non-Uniform Rational Basis Spline) for use in the BIM approach was set (Barazzetti et al., 2015). This work will present the initial part of the research, the goal of which is to create a digital BIM model of the selected wood residue. Concept verification begins with creating a point cloud by laser scanning the residue followed by converting the point cloud into a mesh of surfaces and finally, creating its three-dimensional representation sufficient for further processing in BIM software (Beale et al., 2019).

The results of the research will be used to improve the methodology of scanning and data transformation of selected production residues. This improved methodology of scanning and data transformation will later be applied in further research and procedures for creating informational digital models of new veneer wall covering products for Spačva Ltd.

Keywords: NURBS, point cloud, wooden wall coverings

Acknowledgment: The authors gratefully acknowledge receiving funding from European Regional Development Fund, OP Competitiveness and cohesion 2014-2020, Strengthening the economy by applying research and innovation, Research and development of innovative wooden wall coverings, partitions and load-bearing walls for sustainable construction in the company Spačva Ltd., KK.01.2.1.02.0244.

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Antimicrobial polylactic acid/lignin/Cu nanoparticles composite film preparation for food packaging applications

Esakkiammal Sudha Esakkimuthu[1], David DeVallance[1,2] , Maja Leitgeb[3], Mika H. Sipponen[4]*

[1] InnoRenew CoE, Livade 6, 6310 Izola, Slovenia. sudha.esakkimuthu@innorenew.eu, devallance@innorenew.eu
[2] University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Glagoljaška 8, 6000 Koper. david.devallance@famnit.upr.si
[3] University of Maribor, Faculty of chemistry and chemical engineering, Smetanova ulica 17, 2000 Maribor, Slovenia. maja.leitgeb@um.si
[4] Department of Materials and Environmental Chemistry, Stockholm University, Svante Arrhenius väg 16C, SE-106 91 Stockholm, Sweden. mika.sipponen@mmk.su.se
* Corresponding author

Polylactic acid (PLA) is a biopolymer, widely used in plastic films, bottles, and biodegradable medical devices (Huang et al., 2018). Due to its slow crystallisation, poor thermal stability, and high cost, it is not suitable for long shelf-life food storage applications. Lignin was introduced to improve the thermal and mechanical properties of PLA. Lignin is a three-dimensional aromatic biopolymer which is obtained as a byproduct from the pulp and paper industry. Our preliminary results (mechanical and thermal properties) have shown that 5 wt% and 10 wt% of Kraft lignin (KL) are better weight composition in PLA matrix (Esakkimuthu et al., 2022). Additionally, to improve the antimicrobial property of the packaging film, copper (Cu) nanoparticles were incorporated into the PLA/KL composite through a casting process. Cu nanoparticles were produced using the sodium borohydride reduction method, and characterised using UV and Particle size analyser. The anti-bacterial performance of the composite film was evaluated against foodborne bacteria such as Escherichia coli (gram-negative) and Staphylococcus aureus (gram-positive). The proposed work provides significant advances to boost the utilisation of PLA polymer at low costs for various food packaging applications.

Keywords: polylactic acid, lignin, copper nanoparticle, biocomposite, food packaging

Acknowledgement: The authors gratefully acknowledge receiving funding from EU-Horizon 2020–H2020-MSCA-IF-2020 Marie Skłodowska-Curie Individual Fellowship (Grand number: 101031402—PACK-NIN—H2020-MSCA-IF-2020) and the European Commission for funding the InnoRenew project [H2020 WIDESPREAD-2-Teaming grant number 739574]

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Encapsulation of fire retardants in wood modification processes – An overview of recent activities at Luleå University of Technology

Dennis Jones[1,5], Chia-feng Lin[2], Olov Karlsson[3] and Dick Sandberg[4,5]

[1] Wood Science and Engineering, Luleå University of Technology, Forskargatan 1, S-93197 Skellefteå, Sweden [email: dennis.jones@ltu.se]
[2] Wood Science and Engineering, Luleå University of Technology, Forskargatan 1, S-93197 Skellefteå, Sweden [email: chia-feng.lin@ltu.se]
[3] Wood Science and Engineering, Luleå University of Technology, Forskargatan 1, S-93197 Skellefteå, Sweden [email: olov.karlsson@ltu.se]
[4] Wood Science and Engineering, Luleå University of Technology, Forskargatan 1, S-93197 Skellefteå, Sweden [email: dick.sandberg@ltu.se]
[5] Czech University of Life Sciences Prague, Department of Forestry and Biomaterials, 16500 Prague, Suchdol, Czech Republic

Modern construction is moving more towards engineered wood products, such as glulam and cross-laminated timber (CLT). This increase is driven by the aspiration to deliver high-rise buildings with enhanced environmental profiles and human well-being. The desire to use wood in construction is pushing the need for fire treatments capable of meeting a products service life.

Currently, the majority of fire retardants are water soluble, meaning that exposed, uncoated surfaces are prone to suffer leaching of the treatment over time, meaning that many treatments are regarded as not suited for such outdoor use.

In recent years, work at Luleå University of Technology has focused on the combination of wood modification and fire treatment, with an emphasis on encapsulating fire treatment within the modification system, such that they are permanently held within the wood matrix, yet still capable of imparting their fire-retardant properties. This poster will give an overview of the work carried out, primarily with the reagent guanyl urea phosphate (GUP).

Keywords: wood modification, fire retardancy, guanyl urea phosphate, encapsulation.

Biocarbon with tailored properties for the adsorption of indoor volatile organic compounds

Mariem Zouari[1,2], Laetitia Marrot[3], and David Brian DeVallance[4]*

[1] Innorenew CoE, Livade 6A, 6310 Izola, Slovenia, mariem.zouari@innorenew.eu
[2] University of Primorska, Muzejski trg 2, 6000-Koper, Slovenia
[3] ZAG fire laboratory, Obrtna cona Logatec 35, 1370 Logatec, Slovenia; laetitia.marrot@zag.si
[4] College of Science and Technology, Commonwealth University, 401 North Fairview Street, Lock Haven, PA 17745, USA; ddevallanc@lockhaven.edu
* Corresponding author: Mariem Zouari, mariem.zouari@innorenew.eu

Volatile organic compounds (VOC) represent a significant group of airborne pollutants. Given their high toxicity and hazard to human health, VOC occurrence in the indoor environment leads to sickness symptoms such as nausea, headaches, and skin irritation known as sick building syndrome (Burge, 2004), which affects the wellness of occupants. Long-term exposure to VOCs is also linked to chronic diseases like asthma and cancer. Therefore, efforts are being made to reduce indoor VOC levels in offices and residential buildings.

VOC adsorption is a simple yet efficient technology for trapping pollutants from the air into porous support. Carbonaceous materials are suitable for VOC adsorption due to their high porosity and large surface area. For instance, activated carbon and carbon nanotubes and fibers are widely studied for VOC adsorption (Guo et al., 2016; Lee et al., 2010). Nonetheless, the preparation of engineered carbon materials usually requires time and energy besides the utilisation of chemicals. Biocarbon, prepared from organic feedstock, is a cheap and renewable alternative. However, biocarbon has not been well investigated for the purposes of VOC adsorption as it was claimed that the properties of biocarbon, namely surface area and microporosity, require further development to improve the adsorption capacity.

In this study biocarbon was prepared from demineralised Arundo Donax and olive stone by-product at variable temperatures (300 °C, 400 °C, 500 °C, 600 °C, 700 °C, and 800 °C). The prepared biocarbon samples were ball-milled to further increase the surface area and pore volume. The samples were characterised by proximate thermogravimetric, scanning electron microscopy, and physisorption analyses and tested for their capacity to adsorb VOCs at ambient conditions. The effect of carbonisation temperature on the efficiency of biocarbon in air remediation was assessed and will be presented.

Keywords: Biocarbon, pyrolysis temperature, volatile organic compounds, adsorption

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Factors of wood substitution and their effects in the construction sector

Theresa Boiger[1], Claudia Mair-Bauernfeind[1], Tobias Stern[1]*

[1] University of Graz, Institute of Systems Sciences, Innovation and Sustainability Research, Merangasse 18/1, 8010 Graz, theresa.boiger@uni-graz.at
* Corresponding author

Impact Assessments of building materials in the construction sector are important to find out how to make the sector more sustainable. Previous studies showed that using wood instead of other materials has the potential of reducing environmental impacts (e.g.: Gustavsson et al., 2021; Eberhardt et al. 2019). However, it is unclear how high the potential for improvements is (considering different impact categories). As the construction sector shares the limited resource wood with other sectors it is important to consider the direct effects of increasing the amount of wood in the sector and indirect effects on other wood-processing sectors, e.g. saw residues leading to side effects in the pulp and paper, or panel industry. Apart from that, it is unknown which measures need to be taken to increase the share of wood in the construction sector. Increasing the use of wood and substituting other materials is a complex issue and there are political, economic, social, and technological factors influencing the decision of the choice of material for buildings, e.g. price elasticity or the acceptance of wood.

Therefore, a system's perspective needs to be taken, where not only the substitution impacts are assessed but where also the effects of these influencing factors are accounted for. We propose a system dynamics model that describes the substitution of wood in the construction sector. The model quantifies the direct and indirect effects of wood substitution for several impact categories. It includes influencing factors of substitution in the construction sector to depict the dynamics of the system and gives the opportunity to estimate the impact of different scenarios. The model will show which factors have a high influence on increasing the use of wood in the construction sector and the environmental impacts connected with the substitution. This will indicate where actions need to be taken to improve the sustainability performance of the construction sector.

Keywords: wood substitution, system dynamics model, substitution factors

Acknowledgment: The authors gratefully acknowledge receiving funding from CARpenTiER. The project CARpenTiER "Modelling, Production and further Processing of Eco-Hybrid Structures and Materials" is funded within the framework of COMET - Competence Centers for Excellent Technologies by BMK, BMDW and the Province of Styria. The COMET program is managed by the FFG.

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Reaction to fire characterisation of densified-processed poplar and beech

Ulises Rojas-Alva[1], Nataša Knez[2], Grunde Jomaas[1,3], Lei Han[3,4], Marica Mikuljan[3,4], Andreja Kutnar[3,4]*

[1] Department for Fire-safe Sustainable Built Environment (FRISSBE), ZAG (Slovenian National Building and Civil Engineering Institute); Obrtna cona Logatec 35, SI-1370 Logatec, Slovenia; ulises.rojas-alva@zag.si, grunde.jomaas@zag.si
[2] Slovenian National Building and Civil Engineering Institute; Dimičeva 12, Ljubljana, Slovenia; natasa.knez@zag.si
[3] Faculty of Mathematics, Natural Sciences and Information Technologies, University of Primorska, Glagoljaška 8, 6000 Koper, Slovenia; lei.han@innorenew.eu, marica.mikuljan@innorenew.eu, andreja.kutnar@innorenew.eu
[4] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia
* Corresponding author

There is a renewed interest in the densification of wood due to the need for utilising lower quality wood species and utilisation of fast-grown woods (Sandberg et al., 2021). The densification process improves the mechanical properties of wood that can then be used for advanced engineering (structures and other applications). However, as with all cellulose products aimed at the built environment, the fire performance of the densified wood products needs to be characterised. Therefore, cone calorimeter experiments, following the ISO 5660-1 standard (ISO, 2015), were carried out for a range of densified samples of Black poplar (Populus spp.) and European beech (Fagus sylvatica L.) to assess the fire characteristics of densified wood. Densification was performed by thermo-hydro-mechanical (THM) treatment in an open system at 170 °C - 200 °C. Time to ignition and the heat release rate (HRR) were measured during the testing campaign. Three groups of poplar were tested: (1) unmodified specimens, (2) THM-densified specimens, (3) low-molecular-weight phenol-formaldehyde resin-impregnated and THM-densified specimens, while the test on beech only included unmodified specimens and THM-densified specimens. For poplar, the time to ignition increased by 5 times with resin impregnation (when exposed to 35 kW/m^2), whereas the influence on time to ignition from densification alone is less clear. The heat release rate (HRR) of poplar was slightly decreased by densification, but the peak HRR increased somewhat by densification. This falls in line with the fact that the mass loss rate of the poplar decreased by densification. More significant results were obtained for beech, as the densification increased substantially by the HRR and mass loss rate. Interesting observations were also made in the analysis of the combustion products. All in all, poplar with resin impregnation and THM treatment is significantly less ignitable than untreated poplar, and densified beech burns at a lower rate than untreated beech.

Keywords: wood densification, reaction to fire, heat release rate, Black poplar, European beech

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Upcycling of wood and textile & leather waste into modern building materials

P. Hochmańska-Kaniewska[1], D. Janiszewska[1], A. Noskowiak[1]*

[1] Łukasiewicz Research Network – Poznań Institute of Technology, Center of Wood Technology, Winiarska St. 1, 60-654 Poznan, Poland, patrycja.hochmanska@pit.lukasiewicz.gov.pl, dominika.janiszewska@pit.lukasiewicz.gov.pl, andrzej.noskowiak@pit.lukasiewicz.gov.pl
* Corresponding author

Dynamic urbanization makes the construction industry the most resource- and energy-consuming sector, which has already experienced the effect of raw material exhaustion and rising prices. Fortunately, due to environmental and economic reasons a positive trend has been observed over recent years, attributable to the reuse of secondary raw materials (Tomaszewska, 2020). The demolition, renovation, and modernization of buildings generate a large amount of such waste, which are a valuable source of material resources that can be recycled and reused in construction, including wooden construction. The posibility of reusing secondary raw materials supports their effective maintenance in a circular economy.

The study aims to develop a prototype of multifunctional composites in the form of construction and insulation products, produced from secondary raw materials available on the local market, including demolition wood, textile, and leather waste. Innovative materials are dedicated to the construction facililties in technologies based on prefabrication. Modern building materials should comply with basic requirements, such as: strength, resistance to water, resistance to fire, heat insulation, as well as not have harmful effects on human health.

In addition to the development of modern products with improved properties, the project will deepen the knowledge regarding the suitability of secondary raw materials for building materials' production and contribute to the promotion of circular solutions.

Keywords: building materials, composites, demolition wood waste, reuse, secondary raw materials

Acknowledgment: The authors gratefully acknowledge receiving funding from the President of the Łukasiewicz Center under Grant Agreement No. 1/Ł-ITD/CŁ/2021 (MATRECBUD).

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Modification of wood via biocarbon particles impregnation

Langella T.[1], Mikuljan M.[1], Lei H[1], DeVallance D.[1,2]*

[1] InnoRenew CoE, Livade 6a, Izola, 6310, Slovenia, tania.langella@innorenew.eu, marica.mikuljan@innorenew.eu, lei.han@innorenew.eu, devallance@innorenew.eu
[2] College of Science and Technology, Commonwealth University, 401 North Fairview Street, Lock Haven, PA 17745, United States of America
* Corresponding author

Modification of wood by introducing carbon particles through impregnation under vacuum conditions was studied; water resistance and spring-back behaviour of the wood were evaluated. The wood was subjected to different combinations of impregnation and densification processes. A water solution with 1%, 2.5%, and 5% carbon was used for impregnating the wood. The impregnation and thermal-hydro-mechanical densification treatments (THM) were performed on four types of wood: Populus nigra (Black poplar), Picea abies (Spruce), Abies alba (European fir), and Fagus sylvatica (Beech). The physical and mechanical characteristics were evaluated and compared for all samples in relation to the percentage of carbon. It was shown that the addition of 2.5 and 5% carbon particles positively affected the mechanical behaviour of spruce wood. In the case of other woods, biochar had no effect or at some percentages it had a negative effect. In the densified samples the presence of carbon lowered the set-recovery values. Spruce had the best waterproof surface.

Keywords: wood modification, biochar, moisture resistance, spring-back behaviour

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Emission of VOCs from wood materials and impact on indoor environment

Bakke Ingrid[1]

[1] Norwegian University of Life Sciences, Høgskoleveien 12, 1430 Ås Norway, ingrid.m.bakke@nmbu.no

Wood is known to emit a considerable amount of volatile organic compounds (VOCs) into its surroundings. Many VOCs are associated with Sick-Building-Syndrome (SBS), and up to 10% of the population experience symptoms of SBS (Kishi et al., 2020). However, wood is generally regarded as a suitable material for indoor surfaces, as multiple studies indicate positive psychological effects from exposure to wood. In addition, wood surfaces are beneficial regarding their hygroscopic properties, as wood building materials have the potential to reduce seasonal fluctuations in temperature and relative humidity (Nore et al., 2017). To assess the suitability of wood as an indoor building material it is important to identify the size and profile of VOC emissions from wood. In this study, emission rates of six VOCs were measured during construction of student housing in Fredrikstad, Norway. The main frame of the building was cross-laminated timber (CLT) and air samples were collected from rooms with either ceiling or ceiling and one wall in visible CLT. The sampling was performed during nine weeks of construction, and the air samples were analyzed using TD-GCMS. All emission rates of the VOCs, namely camphene, α-pinene, β-pinene, β-myrcene, 3-carene and hexanal, were below recommended LCI values, indicating no adverse health impact in the indoor environment.

Keywords: VOC, indoor air quality, cross-laminated timber, health impact

Acknowledgment: The authors gratefully acknowledge receiving funding from the Norwegian University of Life Sciences and the Student Welfare Organization in Østfold.

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Analysis and implementation of veneer production waste in order to design decorative wall panels

*Domagoj Mamić[1], Marija Krajnović[2], Dina Stober[2], Vlatka Jirouš-Rajković[1], Danijela Domljan[1]**

[1] University of Zagreb, Faculty of Forestry and Wood Technology, Svetošimunska cesta 23, 10000, Zagreb, Croatia, dmamic@sumfak.unizg.hr, vjirous@sumfak.unizg.hr, ddomljan@sumfak.unizg.hr
[2] Faculty of Civil Engineering and Architecture Osijek, Vladimira Preloga 3, 31000 Osijek, Croatia, mkrajnovic@gfos.hr, dstober@gfos.hr
* Corresponding author: Danijela Domljan, ddomljan@sumfak.unizg.hr

Increasing concern for the preservation of the environment aims to reduce natural changes, which ultimately causes greater social changes. As social changes occur, so do changes in the professional approach in the field of technology, production, and design. It is very important nowadays to rethink technology and processes in order to reduce production waste and design better products for a more sustainable future (Fell, 2010).

Based on such an approach, a research and development project is being implemented with the goal of increasing the use of oak logs in the company Spačva Ltd., Vinkovci, Croatia. The aim of this research is to determine what is the residue from the production of oak veneer (Lutz, 1978) and how that residue can be shaped into the design of a new decorative wall panel product.

An example of a possible public application of decorative wall panels, such as school classrooms, was analyzed to define the most common wall dimensions. Ratios of proportions were obtained for the development of the final geometry when designing the wall module.

The results show that with an innovative approach, a large amount of raw material waste can be exploited and processed into a new product such as decorative wall covering. Further research is moving in the direction of confirming the positive impact on the natural environment, built environment (well-being) as well as the overall business of the company.

Keywords: wood waste, wall covering, decorative panels, veneer, product design

Acknowledgment: This paper is written within the framework of a research project Research and development of innovative wooden wall coverings, partitions and load-bearing walls for sustainable construction in the company Spačva Ltd., KK.01.2.1.02.0244, funded by the European Regional Development Fund in Croatia OP Competitiveness and cohesion 2014.-2020., Strengthening the economy by applying research and innovation.

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Communication strategies for waste management in the local community: a case study of Chak Daeng temple, Thailand

Prapassorn Siriwichai[1], Suwattana Thadaniti[2]*

[1] Environment, Development and Sustainability, Graduate School, Chulalongkorn University, Bangkok, Thailand, Email: prapasssiri@gmail.com
[2] Chulalongkorn University Social Research Institute, Bangkok, Thailand, Email: tsuwattana@yahoo.com
* Corresponding author

The annual accumulation of nearly 30 million tons of solid garbage is the main environmental issue in Thailand. Many businesses look for solutions to tackle the waste problem. While garbage separation at the source could play a decisive role, there are no obligatory regulations that require Thai citizens to perform it. However, despite the lack of encouraging programs offered by governmental organizations and authorities, Chak Daeng Temple is an example of attempts to solve this issue at the local level. Alongside advocating Buddhism, this temple has included information on waste separation in an ordinary manner for the locals. In order to attain the ideal for a sustainable society, this study examines the communication methods and tactics that Chak Daeng Temple uses to foster cooperation among stakeholders, including the local community, the private sector, NGOs, and the state sector.

Keywords: communication strategies, waste management, Buddhist temples, Chak Daeng Temple (Wat Chak Daeng), Thailand

Bridging the gap between research and society with education for sustainable development

Črtomir Tavzes[1,2], Vesna Starman[1], Jaka Gašper Pečnik[1,2]*

[1] Innorenew CoE, Livade 6a, Izola, crtomir.tavzes@innorenew.eu, vesna.starman@innorenew.eu, jaka.pecnik@innorenew.eu
[2] University of Primorska, Andrej Marušič Institute, Muzejski trg 2, Koper, info@iam.upr.si
* Corresponding author

Education for sustainable development is primarily about creating a learning environment for transformative experiential learning, which is generally understood as a reciprocal process of transforming oneself and the social environment (Wals and Corcoran 2012). In the learning process, participants themselves create knowledge from experience and then apply it to their own lives. Scardamalia and Bereiter (Visvizi et.al. 2020) call this the theory of collaborative knowledge construction. The theory explains how a community of learners actively creates knowledge and emphasizes the need to educate individuals on how to function in a society where knowledge and innovation are fundamental principles. They add that innovation in education should be understood as ideas that trigger the design of educational modernization, services, and approaches to achieve learning objectives more effectively (Visvizi et.al. 2020).

In this paper we will present a pilot project Loose Cells - Innovation at the Crossroads of Art and Science, which was carried out by representatives of different educational institutions, exploring different innovative approaches in the development of art and science to promote sustainable development in education.

After the pilot project, we conducted a case study involving data collection through semi-structured interviews with participating students. Based on the data collected, we found that the interdisciplinary approach contributed to the complexity of sustainable development understanding, while encouraging participants to develop creative and innovative visual solutions. The research, therefore, helped to foster the attitude towards education for sustainable development.

Keywords: education for sustainable development, interdisciplinary approach, STEAM, creative and innovative visual solutions

Acknowledgement: Authors gratefully acknowledge the European Commission for funding the InnoRenew project [Grant Agreement # 739574] under the Horizon2020 Widespread-Teaming program, the Republic of Slovenia (investment funding of the Republic of Slovenia and the European Union European Regional Development Fund).

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Implementation of spectral sensors and chemometric modelling for development and support of smart supply chain in the agri-food sector

Albert Kravos[1], Jakub Sandak[1,2], Anna Sandak[1,3],*

[1] InnoRenew CoE, Livade 6A, 6310 Izola, Slovenia, albert.kravos@innorenew.eu; jakub.sandak@innorenew.eu; anna.sandak@innorenew.eu
[2] University of Primorska, Andrej Marušič Institute, Muzejski trg 2, 6000 Koper, Slovenia jakub.sandak@upr.si
[3] University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies, Glagoljaška 8, 6000 Koper, Slovenia, anna.sandak@famnit.upr.si
* Corresponding author

Circular bioeconomy and bio-based product production are becoming essential in the current transition from a fossil-based economy to a new sustainable green economy. In this context, the possibility to give new life to underexploited bio-based side streams and residues has enormous benefits. High quality olive leaves represent a potentially lucrative feedstock for various biorefinery routes; however, the chemical concentration of the extractives varies considerably between feedstock provenance defining the leaf's industrial value.

There is limited availability of analytical technologies suitable for in-field assessment of the chemical-physical properties of biomass. However, intensive progress in smart, portable, and relatively low-cost sensors suitable for the characterisation of materials is occurring. The real challenge is the development of the spectra post-processing routines, especially chemometric models linking the light absorbance spectrum with specific biomass characteristics. Implementation of an approach directly at the site of collection of the leaves will avoid biorefining of poor-quality biomass and allow the highest concentration of extractives to be processed.

The desired solution will identify high-quality leaves that feature high concentrations of oleuropein, apigenin-like polyphenols, luteolin-like polyphenols, total polyphenols, oleanolic acid, total triterpenes, essential oil, lignin, cellulose, and hemicellulose. In concomitance with the OLEAF4VALUE project optimal portable spectrometers will be investigated. The required chemometric models will be built without advanced data mining; however, implementation of deep learning for achieving all our goals is not excluded.

Keywords: chemometrics, spectroscopy, circular economy, chemical-physical modelling biomass

Acknowledgement: Authors acknowledge the European Commission for funding the InnoRenew project (grant agreement #739574 under the Horizon2020 Widespread-2-Teaming program), and the Republic of Slovenia (investment funding from the Republic of Slovenia and the European Regional Development Fund). The project OLEAF4VALUE has received funding from the Bio Based Industries Joint Undertaking (JU) under grant agreement No 101023256. The JU receives support from the European Union's Horizon 2020 research and innovation program and the Bio Based Industries Consortium.

Communication of sustainable construction topics through social media

Lea Primožič[1], Andreja Kutnar[1,2]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, lea.primozic@innorenew.eu, andreja.kutnar@innorenew.eu
[2] University of Primorska, Titov trg 4, 6000 Koper, Slovenia, andreja.kutnar@upr.si
* Corresponding author

Marketing and communication strategies are an important tool for reaching the general public and creating legitimacy and acceptability of the topic you are communicating about. The developments in communication technologies have led to the rise of digital platforms and social media. By sharing messages on social media, a wider audience can be reached and a platform for engagement can be created. However, it is important to know what kind of messages to share, and to understand the differences between the various social media channels. In this study we investigated what kind of messages should be shared on institutional social media channels (Facebook, Twitter and LinkedIn) about topics related to sustainable construction (Engineered wood composites with enhanced impact sound insulation performance to improve human well-being), in order to further engage the audience (e.g. general public) and consequently influence a change in behaviour. Weekly posts (from May 2022 until August 2022) were shared and the created engagement was monitored and recorded. We created three types of content that varied weekly: a) text-based information related to the research field of wood composites, sound insulation, building acoustics, human well-being, and modelling of the floating floor and project research activities, b) displaying images related to the project research activities and research equipment used, with a short text caption of the image, c) photographs of researchers working on the project research activities and using research equipment, with a short text caption of the image. Preliminary results of the study showed which type of messages shared on social media channels created more engagement of the general public, and possible differences in engagement among the three social media channels. Results can help communication practitioners and researchers to improve their communication and dissemination activities on social media and to more effectively promote their research project activities related to new concepts of sustainable construction.

Keywords: sustainable construction, communication strategies, digital platforms, type of content

Acknowledgement: Authors gratefully acknowledge the European Commission for funding the InnoRenew CoE project (Grant Agreement #739574) under the Horizon2020 Widespread-Teaming program and the Republic of Slovenia (Investment funding of the Republic of Slovenia and the European Union of the European regional Development Fund), and the Slovenian Research Agency for funding the project J4-3087.

Carbon storage in harvested wood products in Europe – State of the Art analysis and research outlook

Daša Majcen PhD[1], Erwin M. Schau PhD[1], prof. Andreja Kutnar PhD[1,2]*

[1] IInnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, dasa.majcen@innorenew.eu, erwin.schau@innorenew.eu, andreja.kutnar@innorenew.eu
[2] University of Primorska, Titov trg 3, 6000 Koper, Slovenia and InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, andreja.kutnar@innorenew.eu
* Corresponding author

Carbon storage of harvested wood products (HWPs) is a realistic opportunity for climate change mitigation; however, accounting for it depends strongly on the method used. Around the world, several methods for carbon accounting of HWPs exist. Globally used IPCC 2016 method for carbon accounting for national inventory reports takes into account the carbon stored in HWPs. However, it uses simplified assumptions about categories and lifespans , failing to provide an accurate account of the carbon stored in all HWPs. Other more detailed methods such as Life Cycle Assessment (LCA), by default consider the neutrality of biogenic carbon, and do not account for timing of uptake and release of CO2. Furthermore, LCA does not consider delayed emissions of carbon over time. The advantage of LCA is nevertheless its standardisation, availability and accessible data, and the capacity to demonstrate impacts of material substitution.

The above mentioned and other methodologies for carbon accounting in HWPs should be advanced in order to include environmental impact throughout the forest-based industry, encompassing its manufacturing emissions, end-of-life treatments of wood, and wood substitution.

As the basis for methodology development, the present study shows an overview of existing data on carbon storage for selected European countries in HWPs, obtained with various methods (Dias et al., 2012, Pilli et al., 2015, Aleinikovas et al. 2018, Johnston at al. 2017), including LCA (Hoxha et al., 2020, Wiloso et al., 2016), dynamic system models (Braun et al. 2017), and others. Based on the results of the statistical analysis, inputs from experts as well as findings from literature, best practices, and guidance for method improvement and development will be provided. The improved method should be robust and sufficiently detailed to inform a transition towards greener, carbon neutral forest-based industry. Furthermore, cascade utilisation of wood will be included to emphasise the reuse of HWPs in multiple cycles.

Keywords: harvested wood products, forest-based value chain, life cycle analysis, carbon footprint, carbon mitigation

Acknowledgement: The author gratefully acknowledges receiving funding from European Commission under the H2020-MSCA-IF-2020 program, Grant Agreement #101024687 and the European Commission for funding the InnoRenew project (Grant Agreement #739574) under the Horizon 2020 Widespread-Teaming program and the Republic of Slovenia (investment funding of the Republic of Slovenia and the European Regional Development Fund). The authors are also grateful for the support of the Slovenian National Research Agency (ARRS) and the Ministry of Economic Development and Technology (MGRT) through grant V4-2124.

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Climate change adaptation and mitigation activities of Austrian and Slovenian enterprises in the wood-value chain

Ana Slavec[1], Annechien D. Hoeben[2], Miguel M. Torres[2], Lea Primožič[1], Tobias Stern[2]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, ana.slavec@innorenew.eu, lea.primozic@innorenew.eu
[2] Institute for Systems Sciences, Innovation and Sustainability Research, University of Graz, Merangasse 18/I, 8010 Graz, Austria, annechien.hoeben@uni-graz.at, miguel.moreno-torres@uni-graz.at, tobias.stern@uni-graz.at
* Corresponding author

Climate change is one of the key challenges addressed by the forest-based bioeconomy. On one hand, climate change poses a growing threat to European forests as evidenced by the increasing frequency and severity of heat waves, extended periods of drought, storms, and other natural disturbances over an increasingly larger scale (Seidl et al., 2017). On the other hand, forests mitigate climate change by storing carbon, regulating extreme weather events, and halting land degradation. In addition, forest-related economic activities play an important role in climate change mitigation and adaptation strategies, as innovation and promotion of new forest-based materials and products to replace fossil-based counterparts can have potentially significant environmental benefits (Hurmekoski et al., 2021). Along these lines, we conducted a study to understand the impact climate change has on enterprises in the forest-based and related sectors, their attitudes and motivations that lead them to act regarding climate change and how that is related to innovation strategies and activities. In this study, we present the results of a survey of 293 Slovenian and Austrian companies in the forest-timber sector, which took place in mid-2021. We found that most companies are at least somewhat concerned about climate change, and few have developed related innovations. Their level of concern and analogous activities can to some extent be explained based on the theory of planned behavior (Ajzen, 2011). Based on the results and keeping in mind the theory of planned behavior, we make recommendations on what measures and communication strategies can be used to encourage companies to innovate and consequently contribute to climate change mitigation.

Keywords: innovation, survey, wood-value chain

Acknowledgement: The authors acknowledge receiving funding from the Slovenian Research Agency for the project Innovation of Austrian and Slovenian companies in the wood-value chain [BI-AT/20-21-006] and from the European Cooperation in Science and Technology for the InnoRenew project [grant agreement #739574] under the H2020 Spreading Excellence and Widening Participation Horizon2020 Widespread-Teaming program.

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Wood material and its positive impact in the context of preschool educational programs

Jakub Hanták[1], Danica Končeková[2], Mojca Gregorski[3]*

[1] Slovak University of Technology in Bratislava, Faculty of Architecture and Design, Institute of Architecture of Public Buildings, Námestie slobody 2911/19, 812 45, Bratislava, Slovakia, jakub.hantak@stuba.sk
[2] Slovak University of Technology in Bratislava, Faculty of Architecture and Design, Institute of Architecture of Public Buildings, Námestie slobody 2911/19, 812 45, Bratislava, Slovakia, danica.koncekova@stuba.sk
[3] University of Ljubljana, Faculty of Architecture, Department of Architecture, Zoisova cesta 12, 1000 Ljubljana, Slovenia, mojca.gregorski@fa.uni-lj.si
* Corresponding author

Previous research on the color of the interior surfaces of kindergartens says that the traditional types of interiors of existing kindergartens can increase the feeling of anxiety from an unknown environment, cause confusion and chaos, and unnecessarily overwhelm children of any age with stress. In our research, we believe that the interiors of kindergartens, which involve natural wooden materials containing natural patterns, natural colors, can provide the child with a sense of well-being, security, harmony, and peace. This article aims to expand current scientific knowledge about the positive influence of wood material and its impact on educational processes in the architectural environment of kindergartens. Research and discussion opens the topic of using wood material and seeks its application in the context of preschool educational programs such as Montessori, Waldorf, Reggio Emilia, HigScope, Bank Street, Emergent, Ascend, Parent Co-ops and Religious. The article touches on the topic of biophilic design and restorative environmental design. The authors examine the benefits of using solid wood, the design of which is authentic, with or without a fine surface finish, which does not degrade its visual-haptic-olfactory qualities. The topic discusses the architecture and design of the physical environment of the interiors and exteriors of realized kindergartens and examines the interaction of wooden material and the child.

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The impact of built environment on movement behaviours: a brief overview of the systematic reviews

Kaja Kastelic[1,2], Nastja Podrekar Loredan[2,3], Dean Lipovac[1,2], Mateja Erce[2], Michael D. Burnard[1,2], Nejc Šarabon[2,3]*

[1] Univerza na Primorskem, Andrej Marušič Institute, Muzejski trg 2, 6000 Koper, Slovenia
[2] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia kaja.kastelic@innorenew.eu, nastja.podrekar@innorenew.eu, dean.lipovac@innorenew.eu, mateja.erce@innorenew.eu, mike.burnard@innorenew.eu, nejc.sarabon@innorenew.eu
[3] Univerza na Primorskem, Fakulteta za vede o zdravju, Polje 42, 6310 Izola, Slovenia
* Corresponding author

Background: Movement behaviours (i.e. physical activity, sedentary behaviour, and sleep) collectively impact health and wellbeing. Nowadays, we face a high prevalence of unhealthy movement behaviours, including a lack of physical activity and sleep, which emerged in our industrialisation and urbanisation periods. To develop evidence-based interventions for population-level behavioural change, underlying factors that affect movement behaviours need to be identified. The aim of this study was to examine existing systematic reviews to identify the characteristics of the built environment that affect physical activity, sedentary behaviour, or sleep.

Methods: A literature search was conducted in May 2022. We searched PubMed/MEDLINE, using a search query that included keywords "environment", "movement behaviours", and "review". Only systematic reviews, published in English, reporting a relationship between physical activity, sedentary behaviour, or sleep with characteristics of the built environment were included.

Results: After screening titles and abstracts for eligibility, we found 75 systematic reviews that reported associations with physical activity, 19 for sedentary behaviour, and 8 for sleep. The reviews (n = 81) reported associations between movement behaviours and numerous characteristics of macro-level environments, including neighbourhood walkability, mixed land-use, proximity of services, housing density, recreational facilities, green spaces, street connectivity, traffic safety, ambient air pollution, and noise pollution. Some reviews (n = 9) also reported associations between movement behaviours and micro-level environments, including aesthetic stairs, flexible office design, sit-to-stand desks, presence of screen technology, and prompting (e.g., to use stairs).

Conclusions: A substantial body of literature reports on the impact of the outdoor built environment on physical activity, while few reviews focused on indoor built environment. The findings suggest a great opportunity to support an active lifestyle through urban design. Given that people spend a considerable proportion of time indoors, studies should further explore the opportunities to promote healthy movement behaviours through indoor design as well.

Keywords: environmental design, active design, physical activity, sedentary behaviour, sleep

Acknowledgment: The authors gratefully acknowledge the European Commission for funding the InnoRenew CoE project (Grant Agreement #739574) under the Horizon2020 Widespread-Teaming program and the Republic of Slovenia (Investment funding of the Republic of Slovenia and the European Union of the European regional Development Fund).

Addressing older adults' needs with built environment features – Systematic literature review

Mateja Erce[1], Dean Lipovac[1,2], Michael D. Burnard[1,2]*

[1] InnoRenew CoE, Livade 6a, 6310 Izola, Slovenia, mateja.erce@innorenew.eu
[2] Andrej Marušič Institute, University of Primorska, Muzejski trg 2, 6000 Koper, Slovenia, dean.lipovac@innorenew.eu, mike.burnard@innorenew.eu
* Corresponding author

Background: Older adults, a fast growing and vulnerable group, face physical and psychosocial challenges, while losing resources to satisfy their own needs despite little change in their needs (ten Bruggencate et al., 2019). Because older adults interact with the built environment constantly, it is a promising way to support them as they face these challenges. However, built environments are more associated with satisfying basic needs while neglecting higher needs (Altomonte et al., 2020). To address these gaps, we assessed scientific literature to identify characteristics of the built environment that may address older adults' basic, psychological, and spiritual needs.

Methods: A systematic literature review was conducted following the PRISMA guidelines in November and December 2021 using Scopus, PubMed, Web of Knowledge, and Google Scholar. The search queries included keywords related to "older adults", "built environment", and "needs" or "well-being". Articles were included if they involved people aged 65 years or more and were written in English. Needs were assessed within Maslow's hierarchy of needs and the Social production function – Successful ageing model (Lindenberg, 1996; Maslow, 1943).

Results: 13,533 articles were identified, 72 met inclusion criteria, and additional 5 articles were identified through other sources. The review revealed that older adults' basic needs are mainly addressed by lighting, paths, sound, and mobility support, psychological with natural environment, views, seats, and sounds, while spiritual needs are addressed with natural environments.

Conclusions: The knowledge gained can be used to help designers, investors, and other practitioners to shape the built environment to improve the well-being of older adults by supporting them in meeting their needs.

Keywords: older adults, built environment, needs, systematic literature review

Acknowledgment: The authors gratefully acknowledge the European Commission for funding the Pilots for Healthy and Active Ageing (GA# 857188) and InnoRenew CoE (GA# 739574) H2020 projects.

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The influence of the position of noise sources in lecture halls and its impact on the subjectively evaluated speech intelligibility

Rok Prislan[1], Denis Pirnat[2], Mateja Dovjak[2]*

[1] InnoRenew CoE, Livade 6a, SI-6310 Izola, Slovenia, rok.prislan@innorenew.eu
[2] Univerza v Ljubljani, Fakulteta za Gradbeništvo in Geodezijo, Jamova 2, 1000 Ljubljana, Slovenija, mateja.dovjak@fgg.uni-lj.si
* Corresponding author

The increasing number of technical equipment and machinery in modern buildings leads to a higher background noise level to which the users are exposed. It is well known that noise levels can affect speech intelligibility, which is critical in lecture rooms where information must be conveyed accurately and easily. In this regard, building regulations include requirements for acceptable background noise levels. However, there are no guidelines for choosing the position of noise sources in the room, which is the subject of this study. Using an artificial speaker as the source, the generated sound was recorded in a representative university lecture room. In addition, background noise was added, and its position and level were varied. Measured speech transmission index (STI) and perceived speech intelligibility were analysed at two listening positions. The latter was determined by binaural listening tests (N=80). The results show that while the position of the noise source has no significant influence on the STI, it can significantly influence the perceived intelligibility. The results are important because they show that background noise is not a sufficient criterion for the inclusion of noise sources in the built environment and that the position of noise sources can be optimised in the design phase.

Keywords: equipment noise, speech intelligibility, noise source position

Acknowledgment: The author gratefully acknowledges the European Commission for funding the InnoRenew project (grant agreement #739574) under the Horizon2020 Widespread-Teaming program and the Republic of Slovenia (investment funding from the Republic of Slovenia and the European Union from the European Regional Development Fund). The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0158, Structural engineering and building physics).