Living labs for the built environment

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HYYTIÄLÄ FOREST STATION & LIVING LAB

- Hyytiälä Forest Station in active use for research, teaching and events. Established in 1910.

- New wooden buildings completed in 2023.
  - teaching and accommodation facilities
  - four buildings, construction area 1400 m2
  - walls CLT, floor and ceiling LVL
  - sustainable implementation, target 150 years lifespan

- Building and its users as research subjects
  - living lab: two buildings equipped as a research platform: dining and meeting/teaching facilities, 35 accommodation rooms - 10 equipped with sensors
  - permanent measurement sites, long time series

”KOTO” – Arkkitehdit Rudanko & Kankkunen

HYYTIÄLÄ LIVING LAB FOR SUSTAINABLE WOOD CONSTRUCTION AND HUMAN WELLBEING

PLATFORM FOR RESEARCHERS

REAL LIFE CONTEXT – INCLUDING BUILDING USERS AS RESEARCH SUBJECTS

DATA AND DATA BASED INTERNATIONAL COMPARATIVE RESEARCH AND DEVELOPMENT

HYYTIÄLÄ LIVING LAB

Vision, design, building and testing by pilot research

Multidisciplinary, modern, international research environment:

- Forest sciences, atmospheric sciences, business economics, behavioral and medical sciences, microbiology
- Building and its users a research objects

Topics:

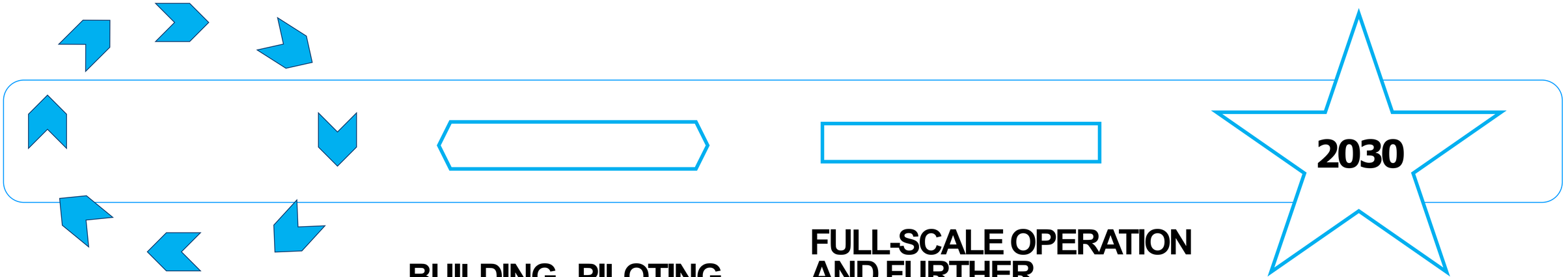
- Wood material, construction, building and usage processes, environment
- Indoor air quality,
- Human behavior, perceived and measured wellbeing
- Learning behavior

How:

- continuous measurements (sensors)
- experimental research with adjustable variables
- long term data series, open data
- solution orientation, innovations

REALIZING THE 2030 VISION

HYYTIÄLÄ LIVING LAB



DESIGN, CONCEPT AND START 2019-2021

Preliminary desk study
Study visits
Broad draft concept for the Living lab –platform

Research themes (broadly)
Research approaches and related data needs

First information to potential collaborators in Finland and abroad

BUILDING , PILOTING AND BROADENING THE USER BASE 2022-2026

Technical and detailed design and pilot building of the measurement environment, testing and analysis of data, creating human research pilot test environments, collectedness tests for various data sets, first research projects for testing the environment. Collaboration models and agreements, and marketing of the environment. Advisory board for research, and Living Lab formal operation and management concepts.

FULL-SCALE OPERATION AND FURTHER DEVELOPMENT IN THEMES AND USERS 2026-

First research projects finalized and degrees produced using the platform.

Research broadens and systematic education starts.

Well-working support and collaboration models available for researchers.

International network and reserach broadens, and has impacts on EU-policies and innovation activities.
Collaboration with business and other societal actors is systematic and the volume is growing.

WORLD LEADING RESEARCH HUB AND PLATFORM FOR SUSTAINABLE WOOD CONSTRUCTION AND HUMAN WELLBEING

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

HYYTIÄLÄ LIVING LAB – RESEARCH OVERVIEW

Building monitoring

- 10 identical test rooms
- Testing different types of sensors

Sensors:
- Moisture behaviour of CLT walls
- Air quality (temp. humidity, Co2 ,TVOCs)
- Light (illuminance, adjustable)
- Acoustics (sound-level, dB)
- Outdoor air quality (SMEAR-II station)

Potential:
- Nature elements & biophilic design
- Test-bed for materials & technologies
- Change in visual aesthetics (e.g. materials, colors)

LCA & Sustainability for wood construction
- Doctoral researcher to study SLCA in wood construction (2024-)

Human wellbeing

Healing interiors pilot study (2023-2025)
- Experienced and measured psychophysiological wellbeing, mix of smart rings, survey data and interviews.
- Forestry students, cross-over trial.

Post-occupancy evaluation study (2024-)
- Effects of built environment to human health, wellbeing and recovery.
- Visitor groups, pilot phase for continuous data collection.

Restorative radiance (2025-2026)
- Replicate the revitalizing effects of forest lights indoors.

Learning environment studies (2026?-)
- How modern wooden buildings function as learning environment and support learning.
- Interdisciplinary approach together with Faculty of Education and Faculty of Science.

Wood construction business

- Drivers and barriers for wood construction (Knock on Wood project 2020-2023)
- Consumer behaviour, attitudes and needs
- Financiers' decision-making
- New business models for sustainable housing

Research groups

- **Wood, Science and Wellbeing**
- **Forest Bioeconomy, Business and Sustainability**
- **Indoor air quality program**
- **Viikki Wood & Forest Innovation Hub**
- **International collaboration**

- Forming the research groups (recruitments, collaboration)
- Establishment of research activities (pilot studies, first scientific publications, development living lab research platform)
- Communication to stakeholders, future research collaboration, new funding opportunities

LIVING LAB Research environment all year round

Building monitoring for continuous data measurement and experimentation

STRUCTURAL PHYSICS, WOOD MOISTURE CONTENT AS AN EXAMPLE OF ONGOING MEASUREMENT ACTIVITIES

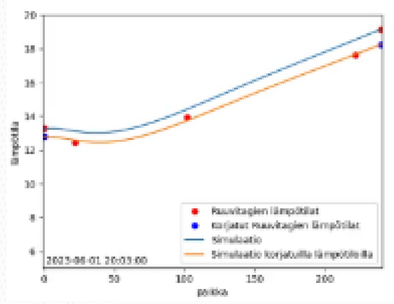
- Started already at the CLT element factory
- Kia Roininen MSc thesis 2024

Measurements

CLT wall moisture measured at 110 points

Methodological development

T calibration and simulation of CLT element internal T

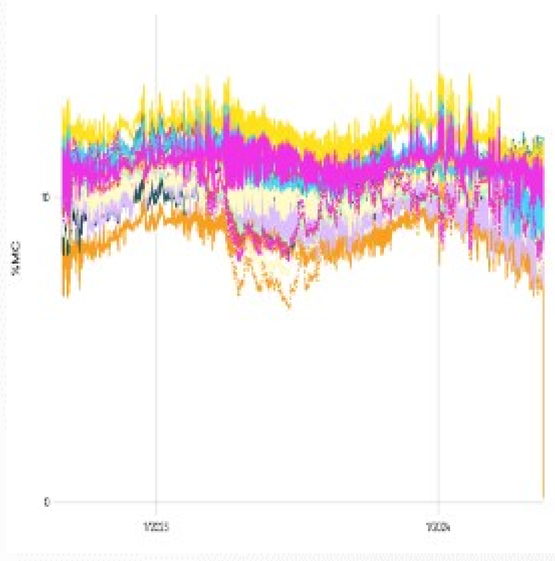


Device development

Electrode cabling developed and tested in collaboration with the sensor manufacturer.

Data handling

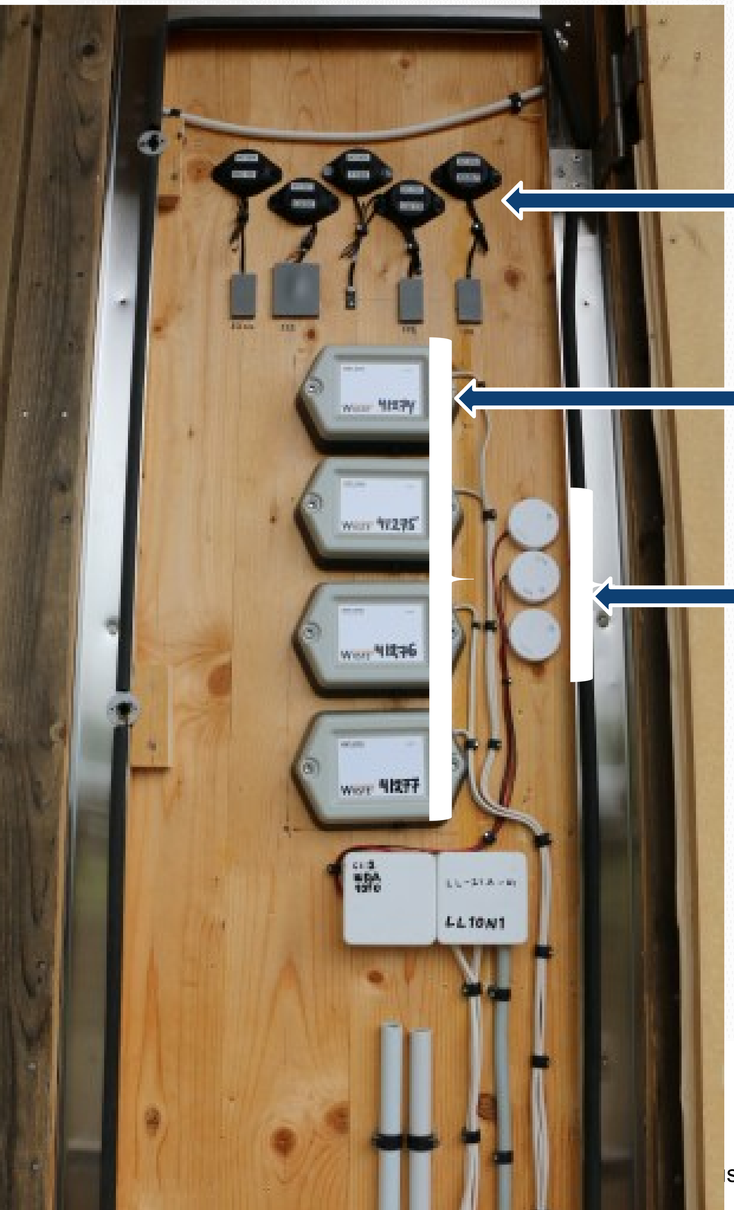
- Storage system UH on the server in test mode
- New visualisation service provided by the sensor manufacturer



Group: Laura Alakukku, Pekka Kaitaniemi, Juuso Unnaslahti, Szabi Galambosi, Juho Aalto

STRUCTURAL HEALTH MONITORING

Long-term monitoring of novel wooden building materials



VARIABLES MONITORED WITH SENSORS

Temperature sensors

Daily moisture content of wood material at several depths

Temperature, Pressure, Relative Humidity

Moisture content (MC) of cross laminated timber (CLT) elements during the construction phase

Mariapaola Riggio, Jan Vcelak, Pekka Kaitaniemi, Andre R. Barbosa, Niki Hrovatin, Anna Sandak, Jakub Sandak, Michael Mrissa, Miklos Kresz, Anssi Yli-Jyrä, Ritva Toivonen, Laura Alakukku. 2023. Federated use of hygrothermal monitoring data in mass timber buildings: opportunities and challenges. World Conference of Timber Engineering Oslo 2023. https://doi.org/10.52202/069179-0507

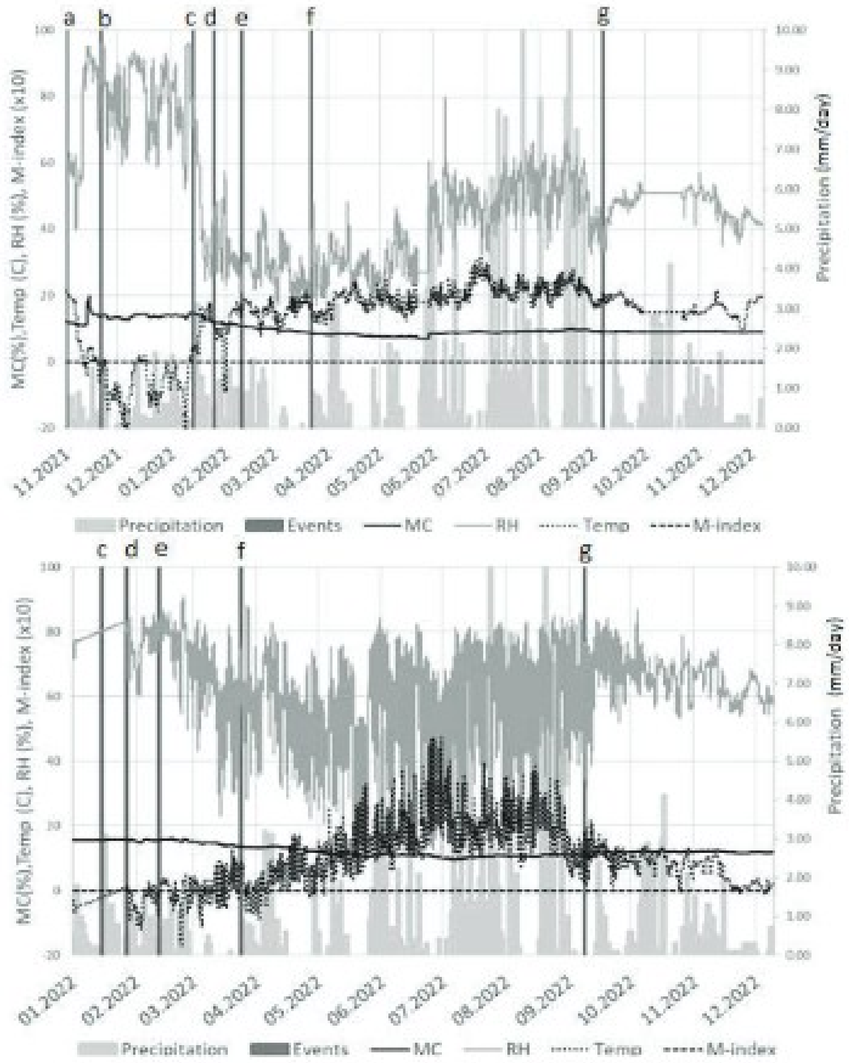


Figure 7. *Hyytiälä. MC, RH, Temperature, Precipitation data, M-index. Vertical lines: (a) installation of the sensors at the CLT facility, (b) wall erection complete, (c) removal of the temporary canopy, (d) installation of windows, (e) indoor heating started, (f) enclosure complete, (g) floor heating turned on.*

INDOOR ENVIRONMENT MONITORING

Long-term monitoring of novel wooden building materials

Air monitoring and measurement in the test rooms

VARIABLES MONITORED IN THE TEST ROOMS

- Daily data of air temperature, air humidity, CO_2, NO_2, VOCs, air-flow and mixing
- Daily readings of lighting qualities
- Daily acoustic and vibration readings

VARIABLES CONTROLLED REMOTELY

- Electric lights and sound
- Air-flow mixing rates via remote controlled HVAC unit

HUMAN WELLBEING

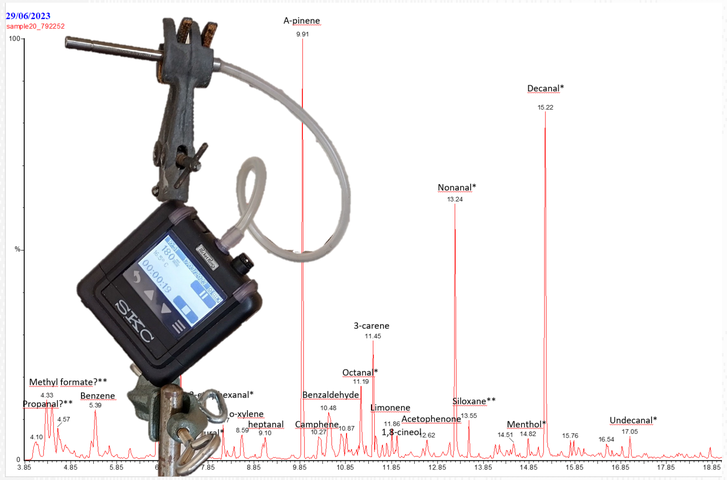
- Surveys to visitors & occupants
- Wearable technology: Oura rings, Polar smartwatches, VR glasses

VOC-MEASUREMENTS

Methods

kuva:
www.markes.com

- The room air is sucked in through a pipe-like ATD collector (so-called Tenax tube)
- VOCs accumulate in the pipe adsorbent inside the tube
- VOCs in the collectors are analysed in a laboratory (FMI)



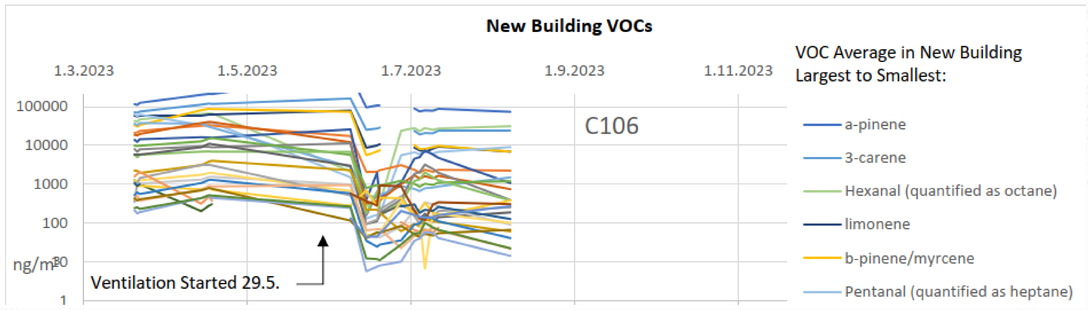
What is measured?

VOC = volatile organic compounds

- BVOCs of natural origin
- AVOC anthropogenic
- OVOC oxidized
- 30 different compounds are analysed, of which the most common in Hyytiälä has been a-pinene

Sampling & analyses

Number of air samples gathered and analysed 134 by 5/24



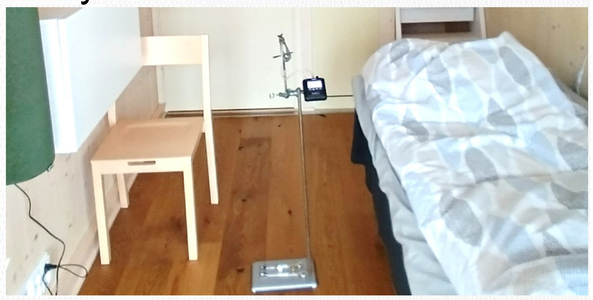
Campaigns

Spring 2023

- Accommodation before occupation of the buildings
- Before and after ventilation start-up

Spring 2024

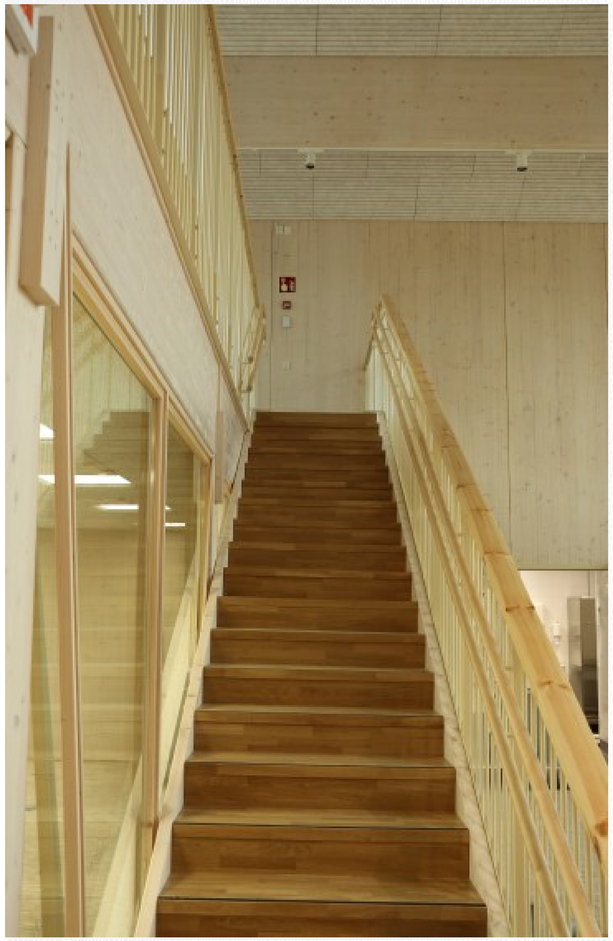
- Accomodation for about after one year use



Collaboration: Prof. Markku Kulmala, prof. Tuukka Petäjä

LIVING WITH WOOD

Long-term monitoring of buildings interior environmental characteristics for studying occupants' well-being



- How does living in a novel wood building impact occupant satisfaction and well-being?
- How nature-based materials and human activities interact to shape the quality of learning and living?
- How do indoor and outdoor conditions affect the sense of wellbeing and comfort?
- What is the role of sustainability or comfort and wellbeing to occupants' housing preferences?
- How objective and perceived occupant wellbeing are connected in wooden buildings?

These questions can be studied by controlling and monitoring the indoor environment of 10 identical rooms while monitoring occupant well-being.

HEALING INTERIORS – PILOT STUDY ON HUMAN-WOOD INTERACTIONS

Tuula Jyske, Emilia Rosenborg, Mari Keskiivari, Jaakko Jussila, Timo Hurme, Jutta Kauppi

Objectives:

1. Understanding long-term impacts of wooden materials on psychophysiological well-being, grounded in biophilia hypothesis
2. Can wooden housing materials alleviate mental and physiological burdens?
3. Testing monitoring of long-term mental wellbeing using biometrics from Oura smart rings together with perceived well-being

Target group: Forestry students accommodated in Hyytiälä Forest Station during their field courses.

- 3 different accommodation buildings: brick /concrete, historical log building and novel CLT

Data: Cross-over trial over three years. 79 Participants in 5 intervals during June 2023 – August 2025.

- Smart ring data, weekly surveys, focus group interviews

Results:

- Data analysis under way – first manuscript expected during 2026.
- Master's thesis in 2024 (Rosenborg): Results indicated better sleep quality, reduced stress levels and better overall wellbeing for the occupants accommodating in the wooden buildings as compared to the concrete buildings.

POST-OCCUPANCY EVALUATION STUDY

Jaakko Jussila, Mike Burnard, Ritva Toivonen

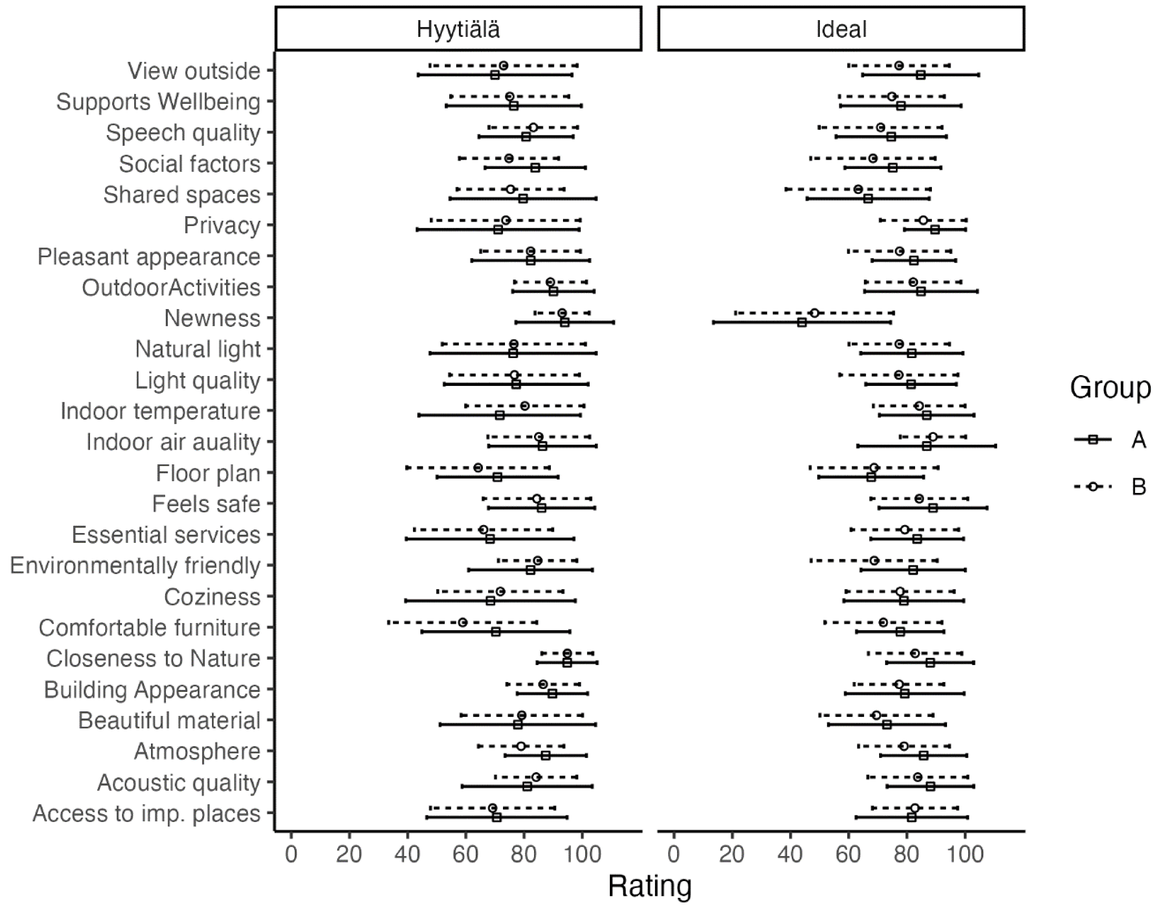
Objectives:

1) How accommodation indoor quality and accommodation neighborhood quality affect occupant perceptions of wellbeing and satisfaction
2) Do occupants' expectations about their ideal accommodation vs current accommodation impact their perceptions of wellbeing and satisfaction?

Data: Visitors staying overnight in living lab accommodation rooms in Hyytiälä.

Post-occupancy survey: 11 visitor groups: 296 visitors and total of 81 respondents during 4-11/2024.

Results: Indoor comfort and eco-friendliness strongly Inked to occupant satisfaction andstress.



HYYTIÄLÄ LIVING LAB

Open for external academic and practice-oriented users worldwide

- Hyytiälä provides an environment where it is possible
  - to study forests, wooden buildings, human experiences, and responses to climate change in multiple combinations.
  - experimental research related to development of new forest related productized eco-system services
  - test and innovation lab.
  - facilities for conferences, businesses for innovation development, testing etc.

LIVING LAB'S INTERNATIONAL NETWORK

FOR SUSTAINABLE WOOD CONSTRUCTIONS

Oregon State University, USA (2020)

InnoRenew CoE, Slovenia (2021)

University of Helsinki, Finland (2023)

Forest Science and Technology Centre of Catalonia, Spain (2025)

WHAT NEXT?

- New wood construction living labs arising in Europe – research and networking seems still siloed.
  - Forest Partnership aims to establish Forest Living Lab network
- Living labs networks – exchange of knowledge, comparable data and fostering collaboration.
- Innovations - network of living labs to accelerate development and validation of innovations – a testbed for biobased products.
- Platform for collaboration: scientific community – businesses –policy actors – consumers.
- Multidisciplinary research and global problems require international collaboration and research teams.
- Quantifying qualitative values – transofrming the life quality into economic value to better understand business opportunities.


PURSUIT OF HAPPINESS
- GREETINGS FROM FINLAND
Finland has been the happiest country in the World for 8 consecutive years*
*UN Happiness report

THE WORLD HAPPINESS REPORT

- annual publication that ranks global well-being of more than 140 countries, based on citizens' responses (Galllup World Poll) United Nations and the University of Oxford.
- The data measures six specific variables:
  - 1) social support, 2) GDP per capita, 3) life expectancy, 4) freedom to make individual life choices, 5) generosity of the country's general population, 6) perceptions of corruption
- a combination of these factors contribute to the well-being and satisfaction of a country's citizens.
- "Key reasons for Finland's high happiness ranking is its robust social-support system."
- "Other factors that are believed to contribute to Finland's high quality of life include its **clean environment**, low crime rates, and a strong emphasis on work-life balance. In addition, **the country's natural beauty, with its vast forests and numerous lakes, provides ample opportunities for outdoor activities and relaxation."**

WELCOME TO HYYTIÄLÄ!
- WE’RE OPEN FOR COLLABORATION

RESEARCH FUNDING

MARJATTA JA EINO KOLLIN SÄÄTIÖ

Metsä

SUOMEN METSÄSÄÄTIÖ

Ympäristöministeriö
Miljöministeriet
Ministry of the Environment

PIRKANMAA
COUNCIL OF TAMPERE REGION