AIVC – SINTEF Community – OsloMet
Workshop 'Urban Home Ventilation' | 19th May 2020
Part 3: Moisture Control

Moisture buffering in modern timber constructions

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OSLO METROPOLITAN UNIVERSITY
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Norway: a country with long tradition in timber

Photo: Dagfinn Rasmussen, Riksantikvaren

Photo: Own archive

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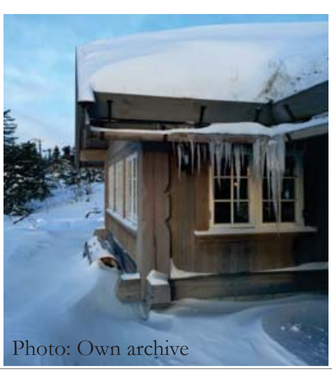

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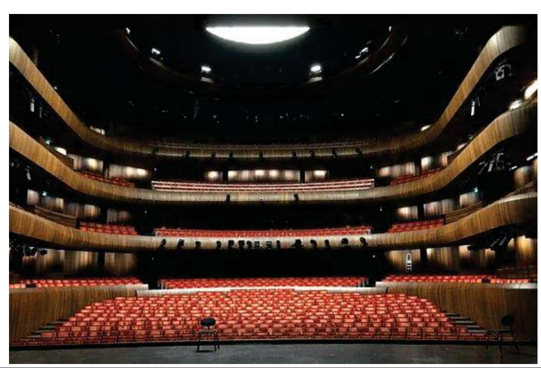
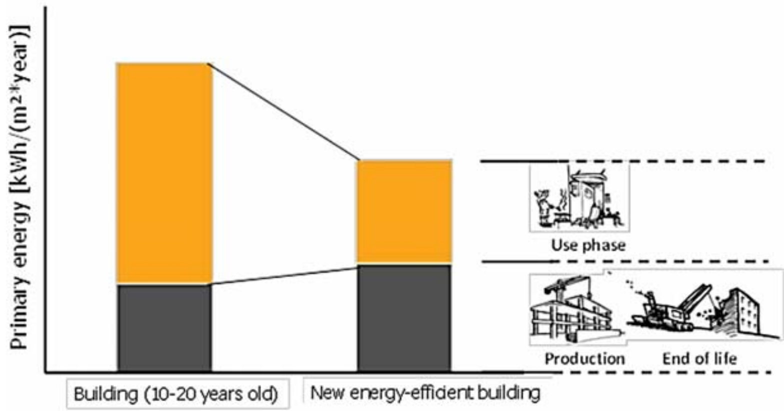
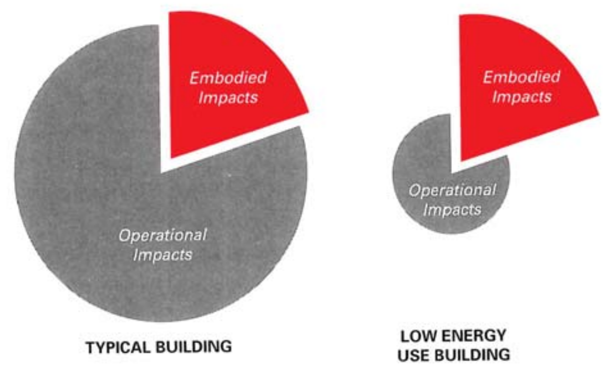


Increased interest in use of engineered timber products

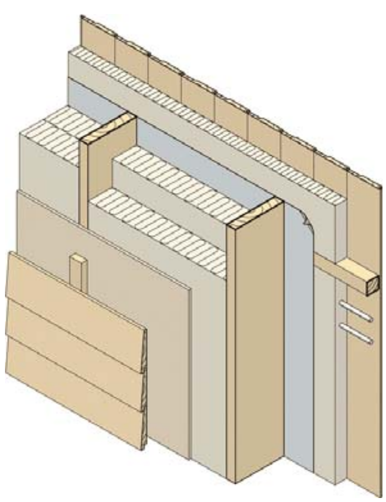
- Tradition is not the only reason
- Norway – Strict national framework for energy use in buildings →
  dramatic reduction of energy use for heating since 1990 (-69%) (NEA, 2018)
- Ensure high indoor environmental quality (IEQ)
- Efforts to decrease the carbon footprint from building materials





Kathrina Simonen, Life Cycle Assessment

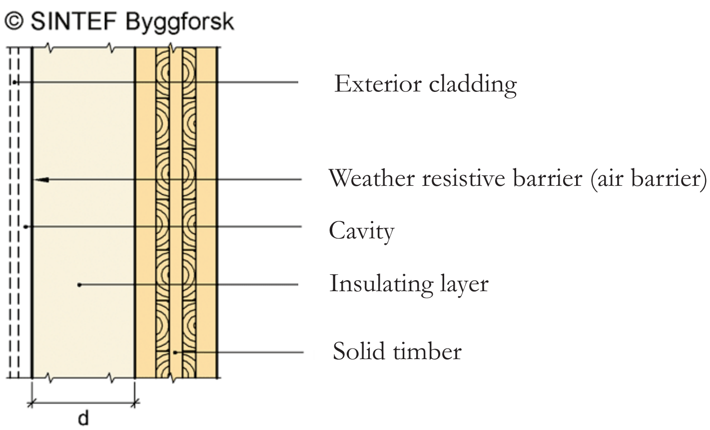
Typical light timber construction



SINTEF Community, Byggforskserien

- Interior wooden cladding (softwood)
- Thin wooden boards, 12 – 14 mm
- Almost always painted

Typical light timber construction



SINTEF Community, Byggforskserien

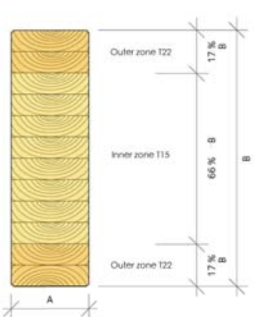
- Solid timber, exposed or covered by gypsum boards
- Thick wooden elements, 60 – 140 mm
- When exposed, treated with diffusion-open Osmo oil

Modern timber constructions

Cross Laminated Timber (CLT)

Leading the 'woodification' of building industry

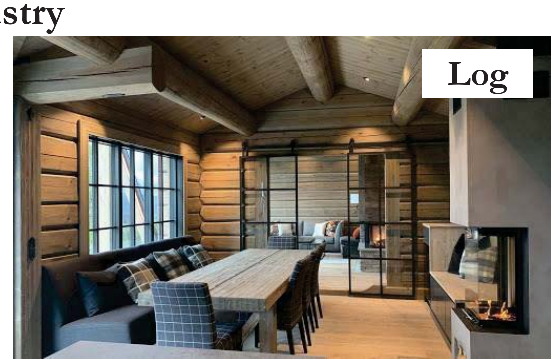
Asplan Viak, 'The new Tøyen Swimming Hall'



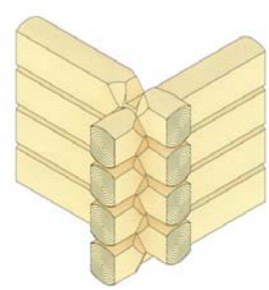
Glulam

Glulam from Swedish wood

Photo: Own archive



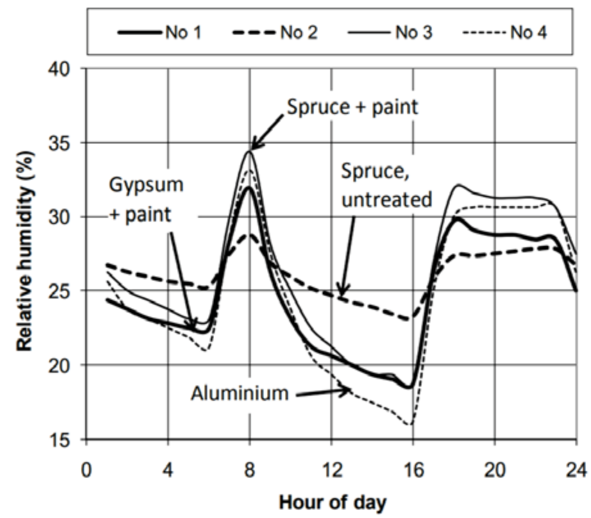
Laftekompaniet AS



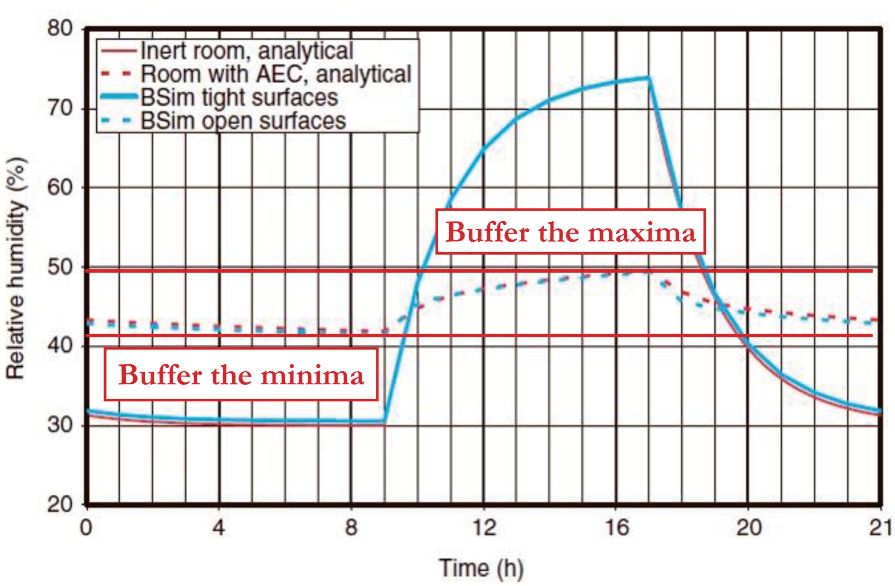
SINTEF Community, Byggforskserien

Controlling the RH indoors

- DCV - Moisture control, e.g. max at 50%
- Humidification / Dehumidification
- Adjusting respectively the air temperature indoors
- **Moisture buffering** in hygroscopic surfaces indoors, building materials, furnitures etc.



Moisture buffering – What is it?



NordTest project

- Technical University of Denmark (DTU)
- Norwegian Building Research Institute (earlier NBI, nowadays SINTEF Community);
- Technical Research Centre of Finland (VTT);
- Lund University, Sweden (LTH);

Moisture buffering of building materials, Rode, Carsten; Peuhkuri, Ruut Hannele; Mortensen, Lone Hedegaard; Hansen, Kurt Kielsgaard; Time, Berit; Gustavsen, Arild; Ojanen, Tuomo; Ahonen, Jarkko; Svennberg, Kaisa; Arfvidsson, Jesper
https://backend.orbit.dtu.dk/ws/portalfiles/portal/2415500/byg-r126.pdf

Moisture Buffer Value (MBV)

Moisture buffering of building materials, Rode, Carsten; Peuhkuri, Ruut Hannele; Mortensen, Lone Hedegaard; Hansen, Kurt Kielsgaard; Time, Berit; Gustavsen, Arild; Ojanen, Tuomo; Ahonen, Jarkko; Svennberg, Kaisa; Arfvidsson, Jesper
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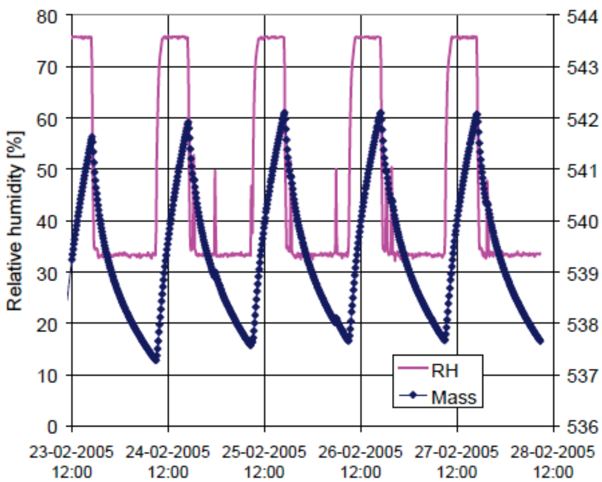
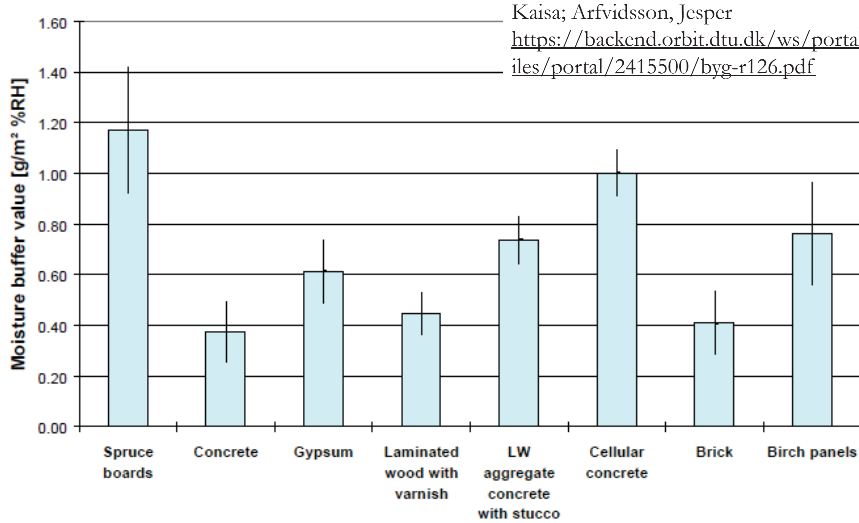




$$\textbf{Moisture Buffer Value: MBV} = \frac{\textit{moisture uptake}\ [g]}{\textit{change in RH}\ [\%] * \textit{hygroscopic surface}[m^2]}$$

Internal humidity loads according to ISO 13788

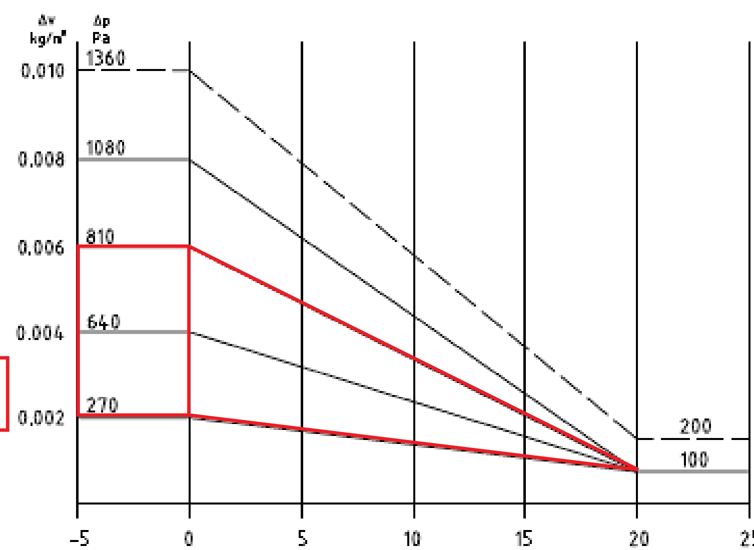
$v_i = v_e + \Delta v$

$\Delta v = G/V'$

G: moisture production indoors [g/h]

V': ventilation rate [m^3/h]

Humidity class	Building
1	Unoccupied buildings, storage of dry goods
2	Offices, dwellings with normal occupancy and ventilation
3	Buildings with unknown occupancy
4	Sports halls, kitchens, canteens
5	Special buildings, e.g. laundry, brewery, swimming pool



max Δv = 4 or 6 g/m^3

Moisture sources indoors

Branz.co.nz

Moisture buffering and ventilation strategies

Photo: inhabitat.com

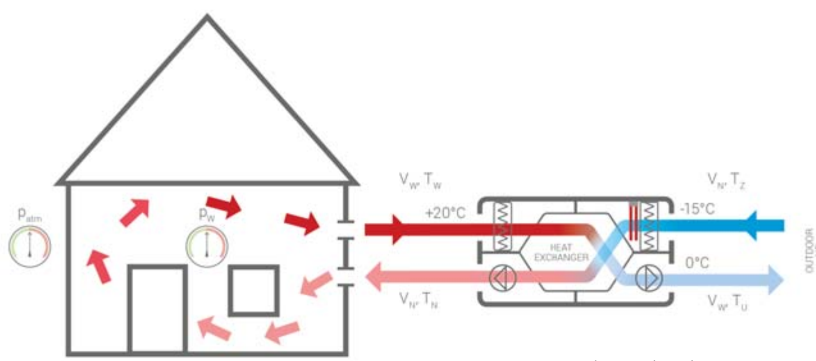


Photo: thesslagreen.com

Case study 1/4 - Field

Photo: Rumi Baumann
Design: Tron Meyer

What's the behaviour of CLT under extreme moisture load?

Field test of moisture buffering capacity in CLT modules

BioKlim field, Ås, NMBU

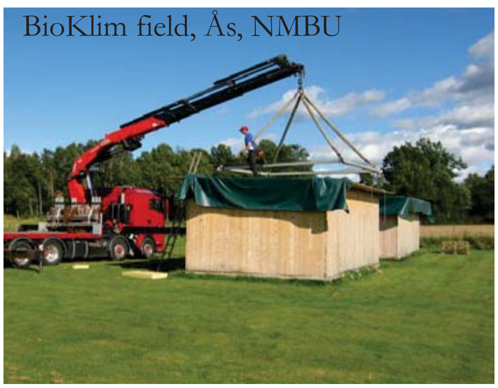
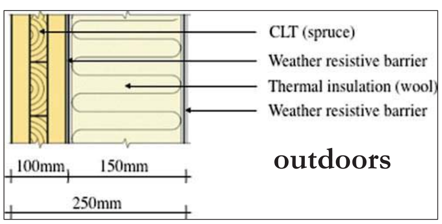


Photo: Tormod Aurlien, NMBU



WEEE project - Wood, Energy, Emissions, Experience

- Norwegian Institute of Wood Technology
- OsloMet (earlier HiOA)
- NMBU
- Norwegian Institute of Air Research

Test modules:

- Volume V = 57 m^3
- Exhaust ventilation V' = 0.5 ACH
- Moisture load G = 0.62 kg/h (in total 5.8 kg)

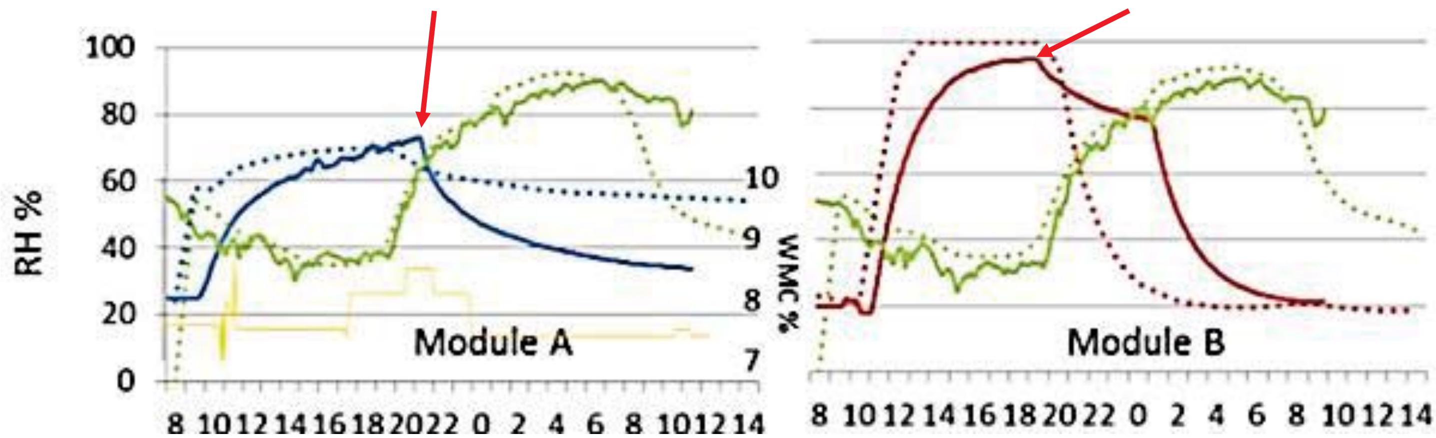
  Very high load! ($\Delta v > 20$ g/m^3)

Moisture buffering, energy potential, and volatile organic compound emissions of wood exposed to indoor environments
K. Nore, A.Q. Nyrud, D. Kraniotis, K.R. Skulberg, F. Englund, T. Aurlien
https://www.tandfonline.com/doi/abs/10.1080/23744731.2017.1288503

Field test of moisture buffering in CLT modules

Exposed CLT
max $RH_i \approx 70\%$

non-hygroscopic
max $RH_i \approx 95\%$



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Case study 2/4 - Lab

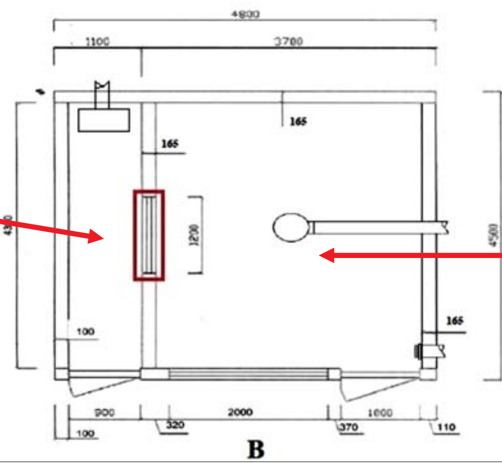
What is the moisture buffering performance of CLT under controlled operational conditions in the lab?

Moisture buffering capacity of a CLT element

- **Step 1**: determination of **MBV = 1.1 g/(%RH*m²)** – almost the same as reported in NordTest for wooden sample (softwood)

- **Step 2**: investigation of moisture buffering capacity under 'operational conditions'
  - $V = 37\ m^3$ | $V' = 57.5\ m^3/h$ (= 1.55 ACH = $3.82\ m^3/h*m^2$)

'outdoors'
$\theta e \approx -8.5$ °C
$RH_e \approx 70\%$
$v_e = 1.7\ g/m^3$



'indoors'
$\theta e \approx 21.5$ °C
$RH_{i,initial} \approx 20\%$
$V_{i,\ initial} = 3.5\ g/m^3$

Moisture buffering capacity of a CLT element

Three different scenarios of moisture load:

1. Moisture $load_{,8h}$ = **268.75 g/h**
   → **expected** increase of humidity indoors = 268.75/57.5 = **4.7 g/m³** ($RH_i \approx 45\%$)
   → **actual** increase of humidity indoors = **3.54 g/m³** ($RH_i \approx 40\%$)
   → corresponding **'ventilative' effect** of moisture buffering = **18.4 m³/h (total: 75.9 m³/h)**

2. Moisture $load_{,8h}$ = **312.5 g/h**
   → **expected** increase of humidity indoors = 312.5/57.5 = **5.4 g/m³** ($RH_i \approx 50\%$)
   → **actual** increase of humidity indoors = **3.7 g/m³** ($RH_i \approx 41\%$)
   → corresponding **'ventilative' effect** of moisture buffering = **27 m³/h (total: 84.5 m³/h)**

3. Moisture $load_{,8h}$ = **343.75 g/h**
   → **expected** increase of humidity indoors = 343.75/57.5 = **6 g/m³** ($RH_i \approx 60\%$)
   → **actual** increase of humidity indoors = **3.8 g/m³** ($RH_i \approx 45\%$)
   → corresponding **'ventilative' effect** of moisture buffering = **33 m³/h (total: 90.5 m³/h)**

Case study 3/4 - Field


Photo: Rumi Baumann
Design: Tron Meyer

What is the moisture buffering performance of CLT under fully operational conditions in-situ?

Ulsholtveien 31, housing units in exposed CLT


Photo: Are Carlsen
Design: Haugen/Zohar Arkitekter (HZA)

Norwegian Architecture Prize 2017
Wooden project of the year 2017

Ulsholtveien 31, housing units in exposed CLT

- Floor area of the tested appartment, **A = 56 m^2**
- Volume, **V = 148 m^3**
- Decentralised ventilation, **V' = 38 m^3/h**, in each of the three rooms (2 units in the kitchen/living room (34.4 m^2) and 1 unit in each of the two bedrooms (7.3 m^2 and 9.7 m^2)
- Exhaust ventilation in the bathroom, **V' = 50 m^3/h** when $RH_{i,bath}$ > 50% or for 15 minutes every 2 hours

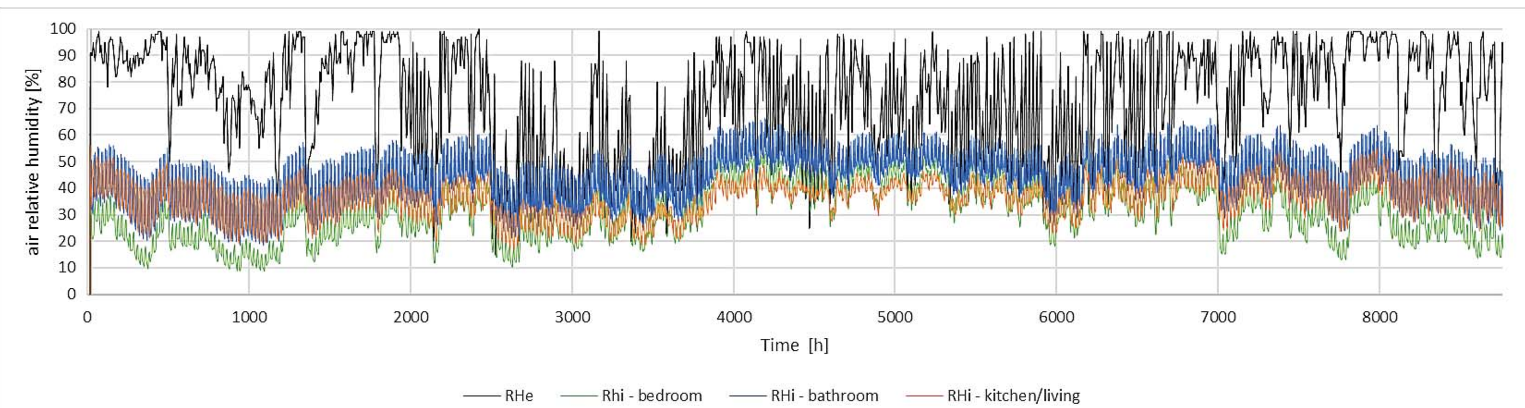
Photo: own archive

Photo: own archive

Interior finishing: exposed CLT, treated with diffusion open Osmo oil

Interior finishing: cement board at the shower

Ulsholtveien 31, housing units in exposed CLT



Bedroom: 9% < RH_i < 54% (too high air temperature, i.e. $\theta_{i,bed}$ = 29 °C)

Bathroom: 18% < RH_i < 66% | water content in wood u = 8.1% - 11.7% < 15.4%

Kitchen/living room: 17% < RH_i < 55% | [CO_2]: usually below 1150 ppm, max = 1550 ppm

Case study 4/4 – Simulation

What is the RH indoors in case CLT is replaced by gypsum boards and tiles (bathroom)?

Numerical comparison between gypsum/tiles and CLT

	Bedroom CLT	Bedroom Gypsum board	Bathroom CLT + cement board	Bathroom Tiles	Kitchen/living room CLT	Kitchen/living room Gypsum board
RHi, min	9%	6% (-3%)	18%	9% (-9%)	17%	13% (-4%)
RHi, max	53%	58% (+5%)	66%	98% (+32%)	55%	63% (+8%)

Synopsis

- Under normal moisture loads, the **corresponding ventilation effect (maxima** of RH**)** of exposed wooden surfaces in residential buildings can be expected **between 20% and 35%** (lab investigation)**.**
- In these conditions, the moisture content in CLT is **not critical for mould growth,** even when CLT exposed in bathrooms (affected by water vapour but not water) and being supported by low-level moisture control (field investigation).
- CLT manages contributes to keep **maxima of RH indoors within accepted limits**, i.e. < 60% (Category II) (field investigation).
- **Overheating** has **negative** consequences not only for the thermal environment but for **moisture buffering capacity** (**minima** of RH indoors) as well (field investigation).
- An equivalent apartment in **gypsum boards and tiles**, instead of CLT, would result to **both lower and higher values of RH indoors** (field investigation and simulation).