Aalto University

Controlling the indoor environment using wood

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1. *The material and the indoor environment*
2. *The material and people*

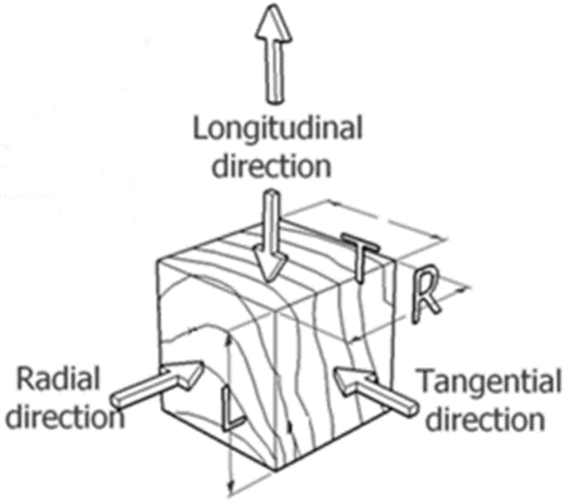
What do we know about wood?

In addition to being a good structural material, wood has:

- Relatively **low thermal conductivity** (it is a good insulator)
- Moderately **high heat capacity** (‘thermal mass’ - can store heat well)
- Has a relatively **low effusivity** (exchanges heat with the environment slowly) and
- Is **hygroscopic** (loves water!)

Also we know that:

- Wood is **very anisotropic** (its properties depend on direction of measurement)

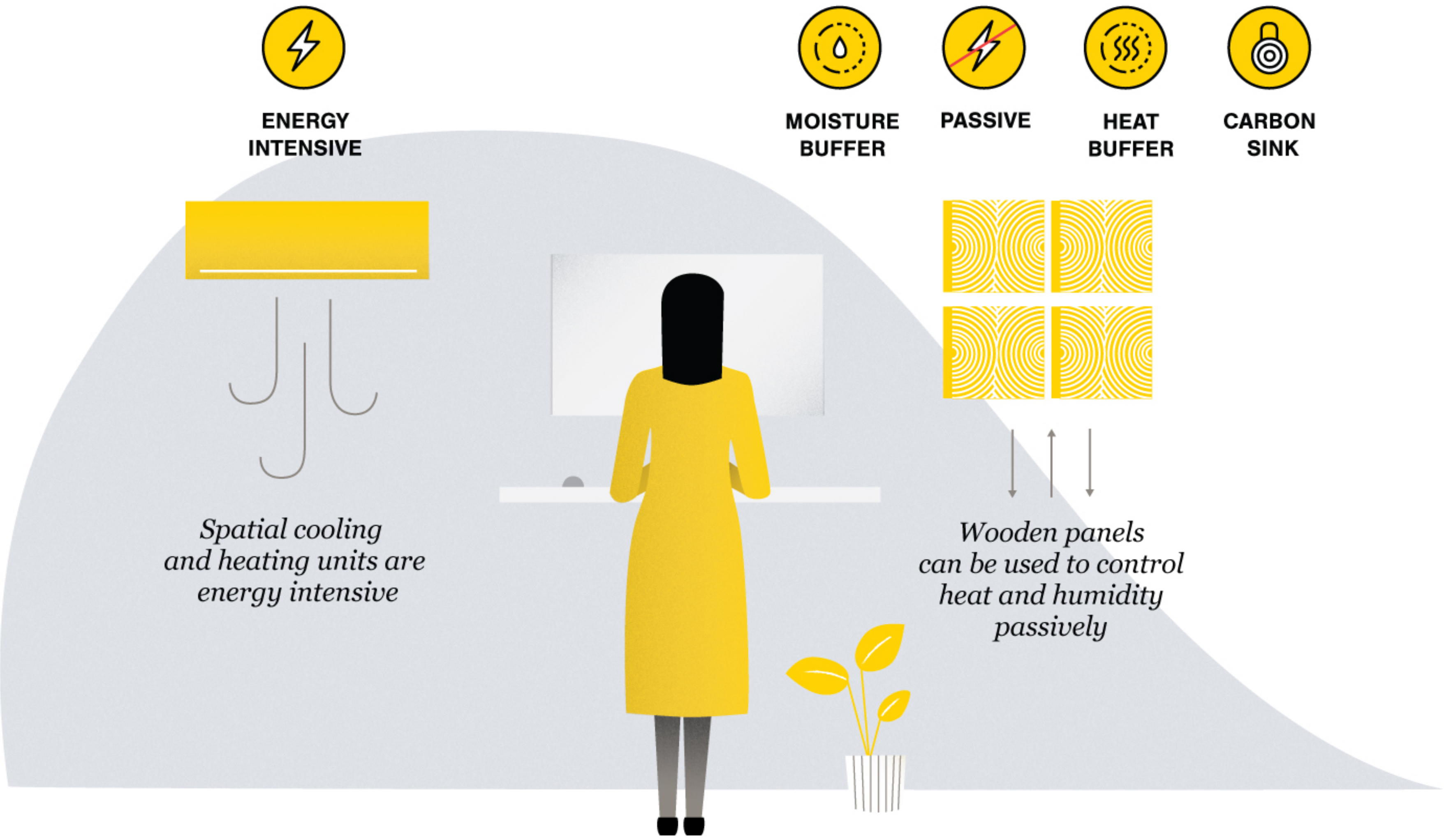


- And it **varies a lot** from species to species

And that….

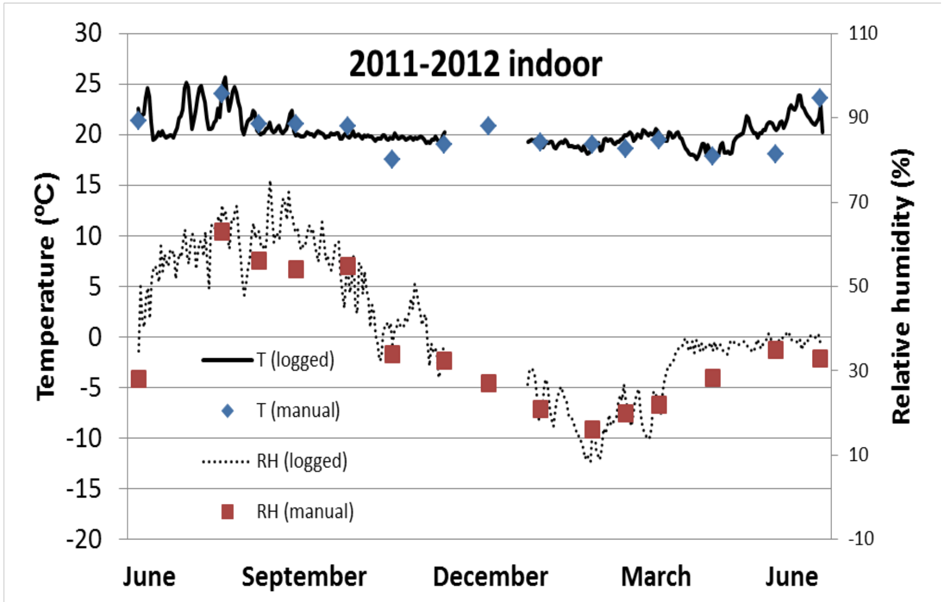
- Wood feels pleasant and warm to the touch and is visually interesting

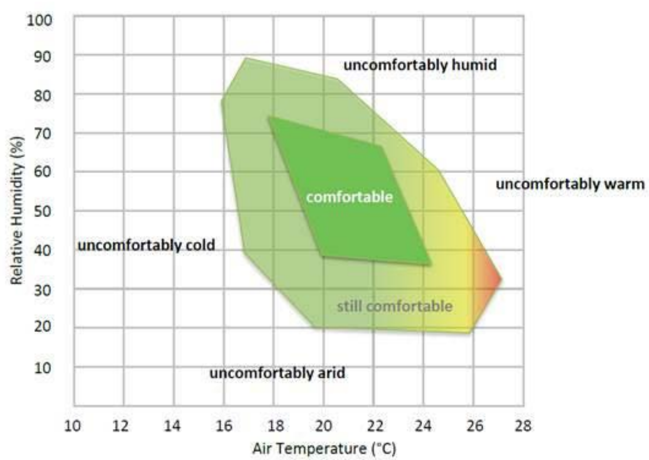
Can we use these characteristics to better effect?

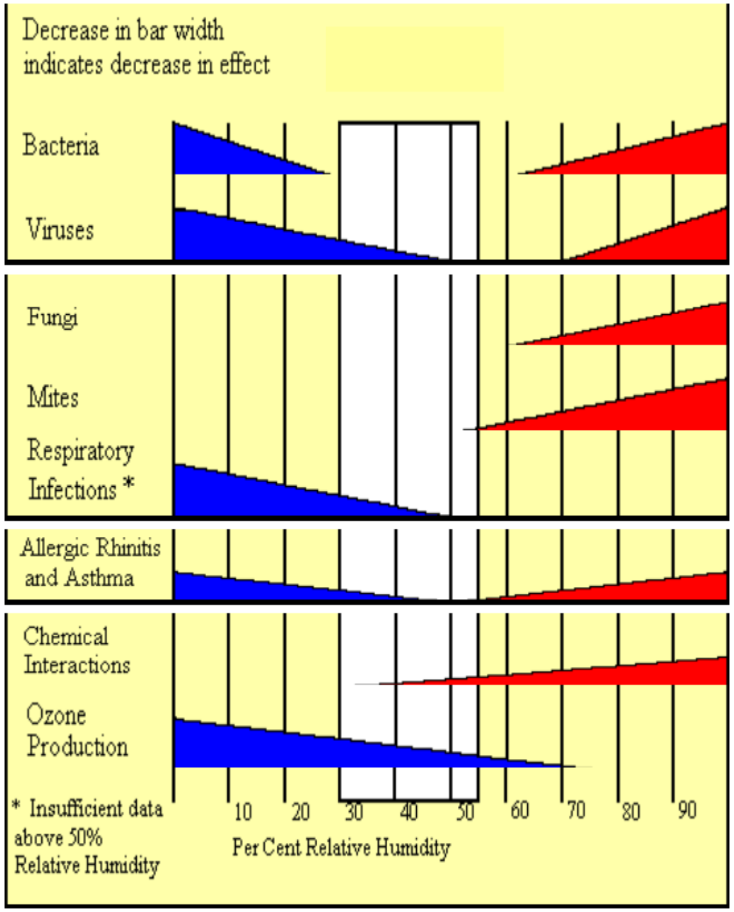


Indoor environment – materials – people

Comfort, health and the indoor environment







(*Source: Simonson, C. J., Salonvaara, M. & Ojanen, T., Improving Indoor Climate and Comfort with Wooden Structures, VTT Publications 431, Technical Research Centre of Finland, Espoo 2001*)

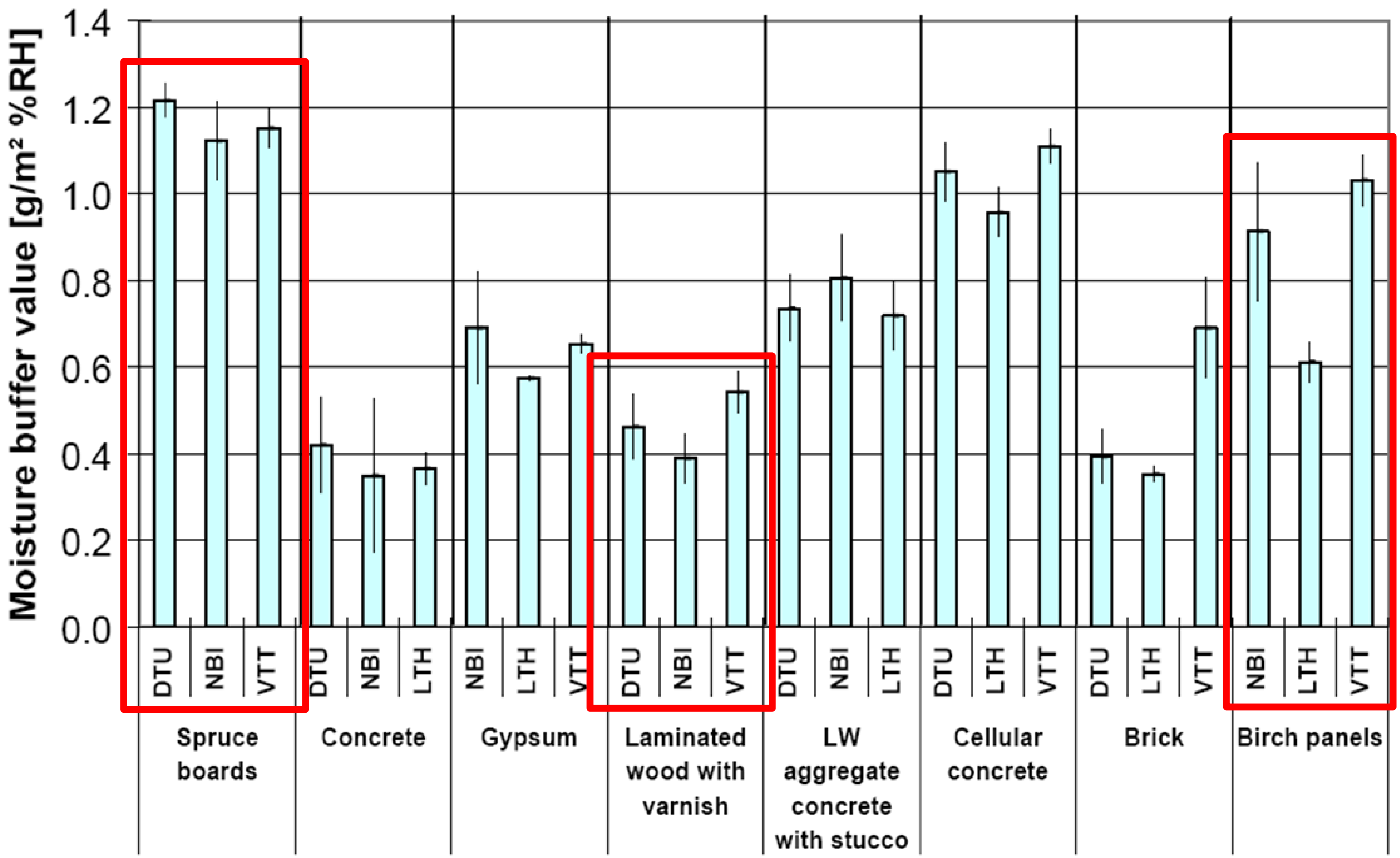
The material and the indoor environment

(How do the material properties affect the indoor environment)

Several ways in which we can utilize wood, including:

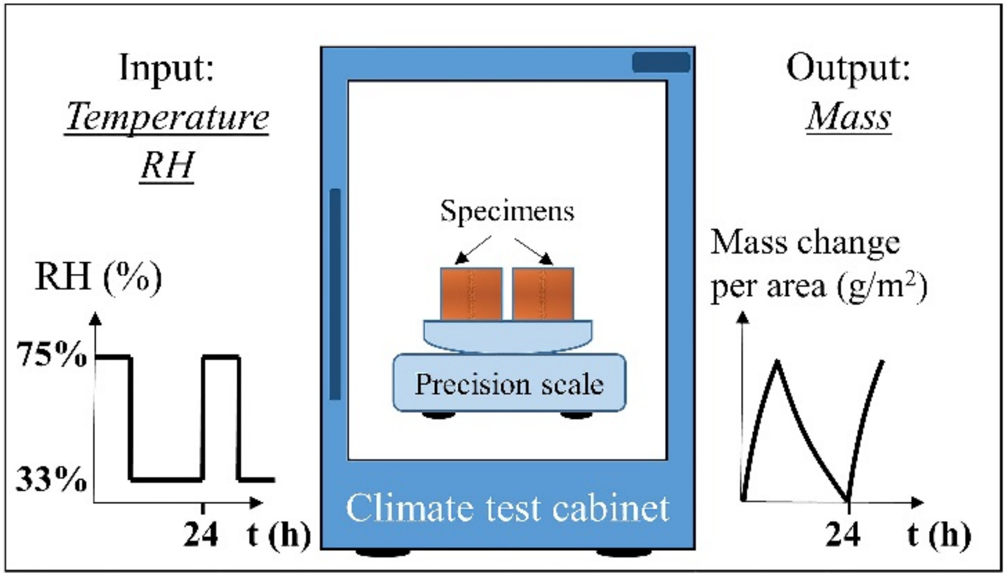
- Harnessing its ability to buffer internal relative humidity (relying its hygroscopic properties)
- Making use of the enthalpy changes arising from sorption ('heat of sorption'), coupled with its thermal buffering ability

Moisture buffering of building materials



(**Source:** *Simonson, C. J., Salonvaara, M. & Ojanen, T., Improving Indoor Climate and Comfort with Wooden Structures, VTT Publications 431, Technical Research Centre of Finland, Espoo 2001)*

Measuring moisture buffering ability



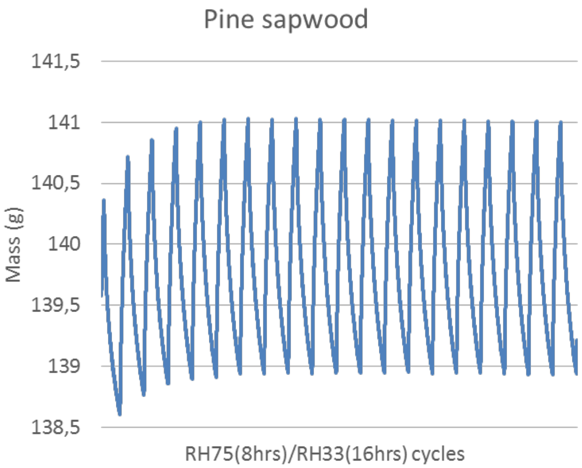
$$MBV_{practical} = \Delta m / S \cdot \Delta RH$$

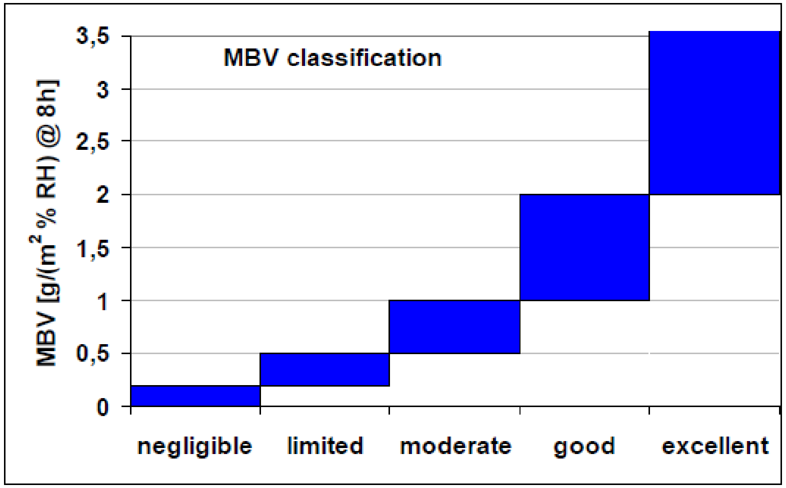
Δm – moisture exchange
S – open surface area
ΔRH – change in relative humidity

Calculations and measurements were done in accordance with NORDTEST method

- How do different species buffer relative humidity?
- Is the buffering ability anisotropic?

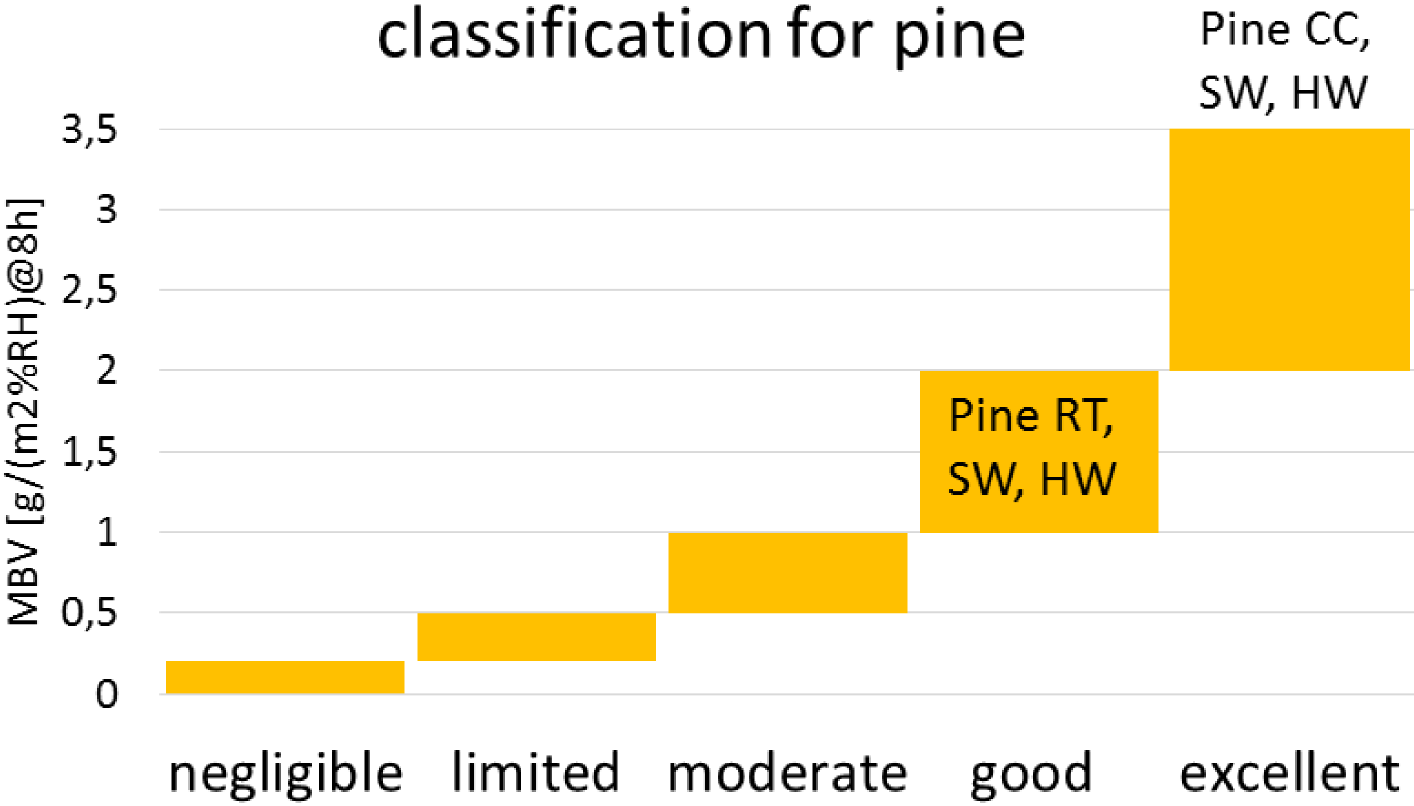
Practical Moisture Buffering Value, $MBV_{practical}$





Practical Moisture Buffer Value classes according to the Nordtest method

Moisture buffering value (MBV) classification for pine

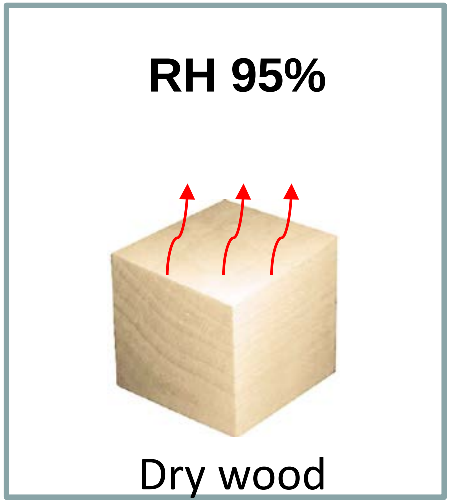


Moisture buffering in practice

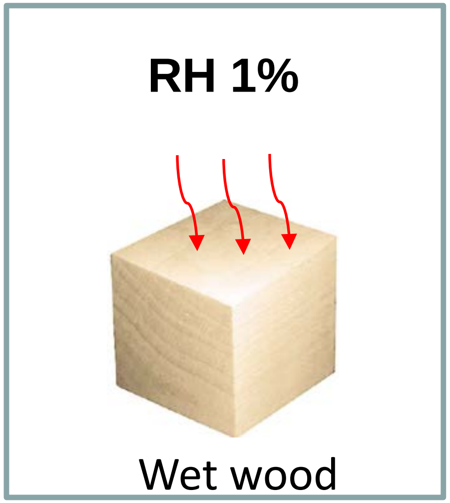
- Buffering found to be about 4 x greater axially than transversely
- Distinct species effects: greater buffering capacity in softwood species
- Heartwood less effective than sapwood (in pine)

Right: Concept moisture buffering panel created by students of the Aalto University Integrated Interior Wooden Surfaces course

Heat of sorption



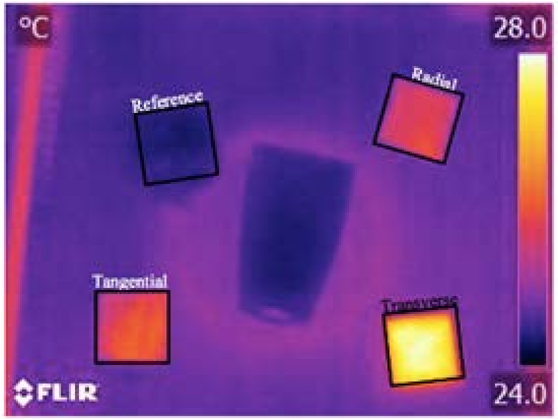
Heat of adsorption



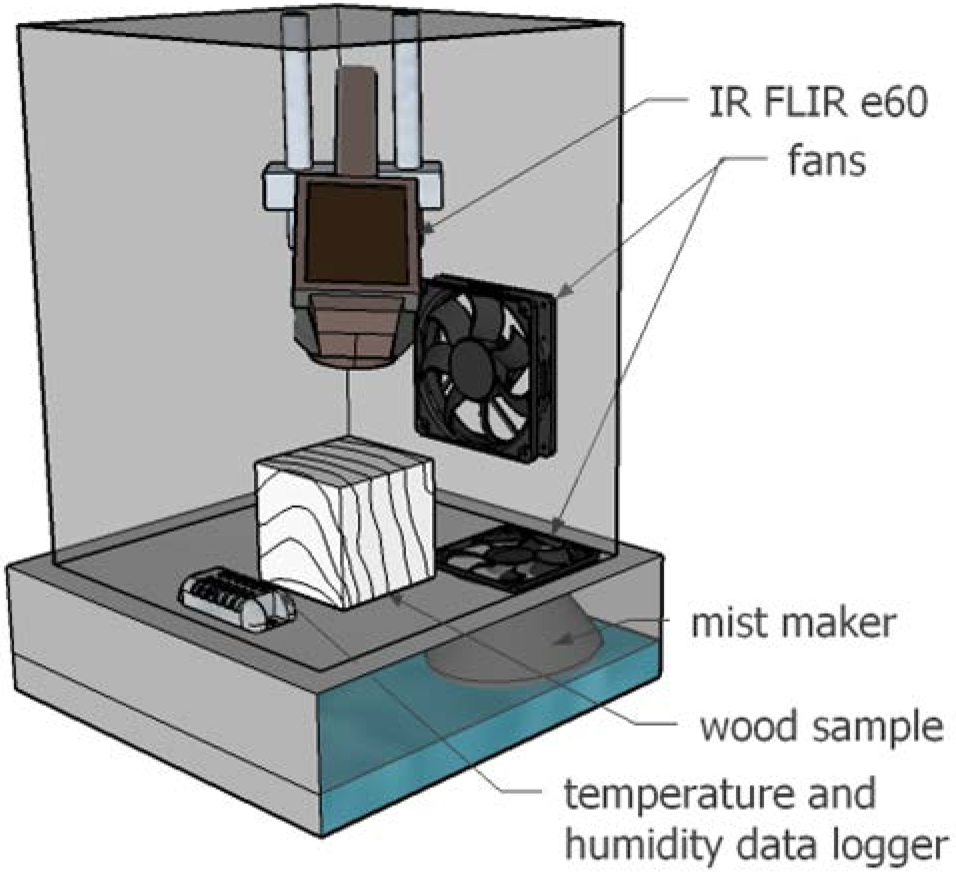
Heat of desorption

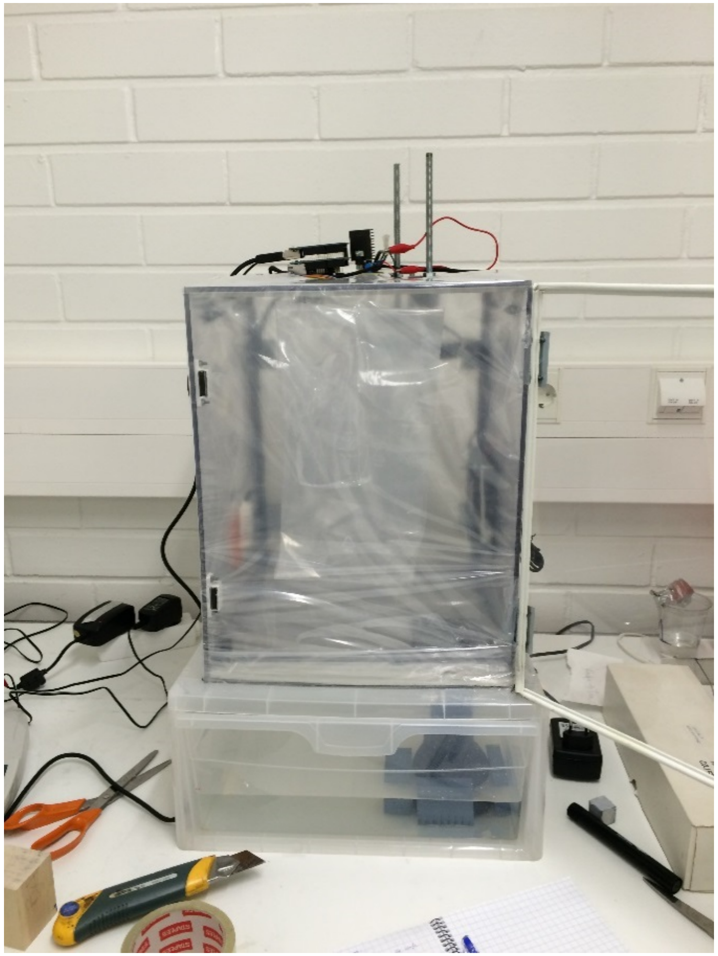
- As dry wood adsorbs moisture heat is generated and as wet wood dries, heat is required

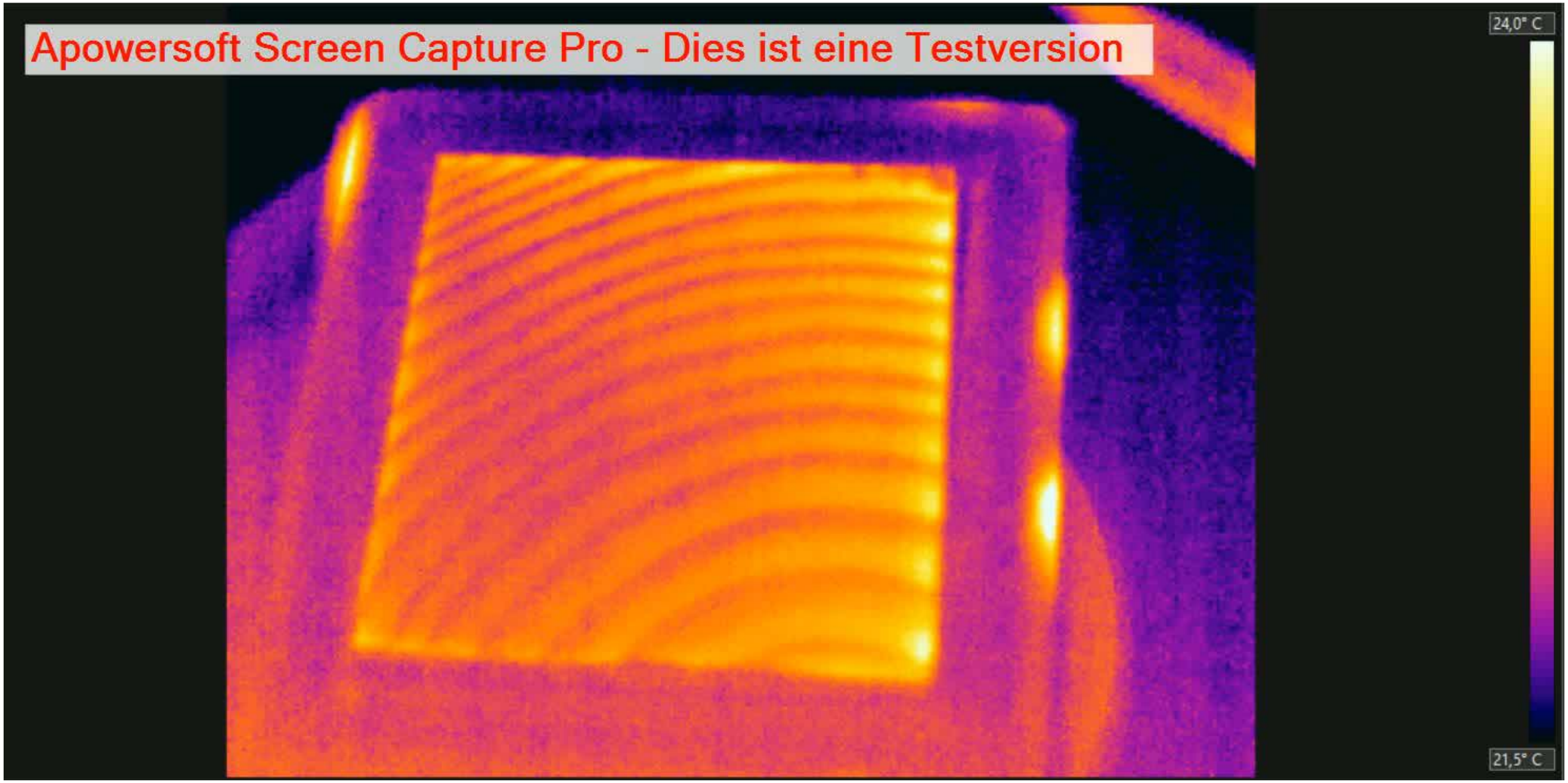
Measuring surface temperature changes in wood due to sorption



Experimental



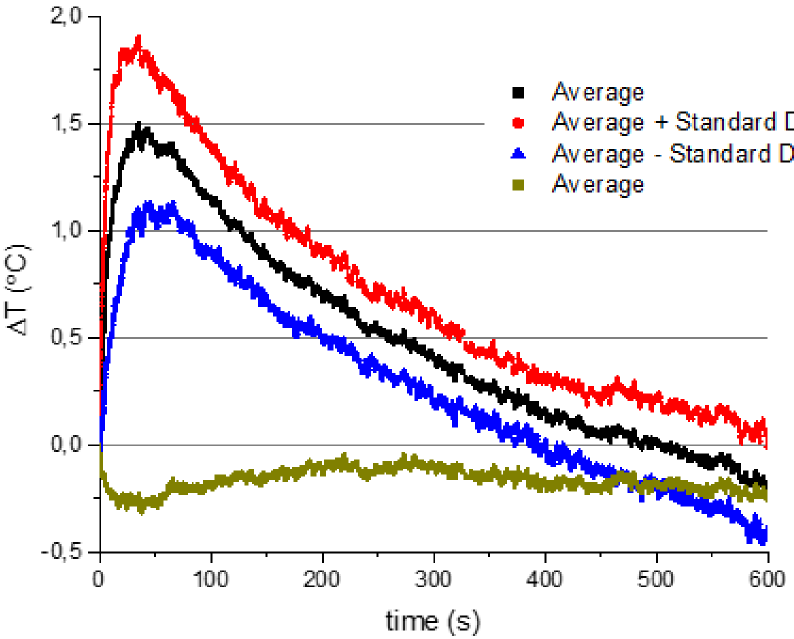




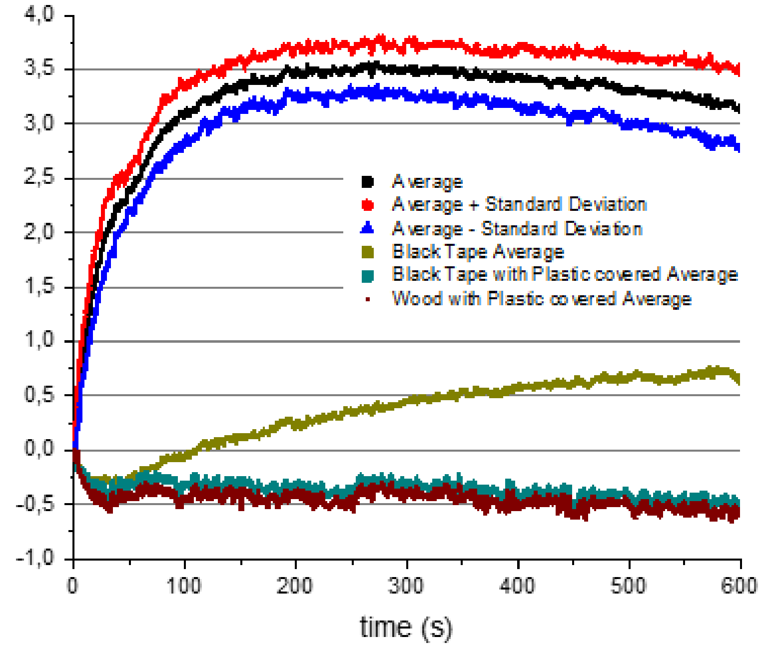
- Temperature rise on the transverse surface of a pine wood block during adsorption

Surface temperature rise due to heat of adsorption

Bone dry wood ⟶ 90% RH



Tangential surface



Transverse surface

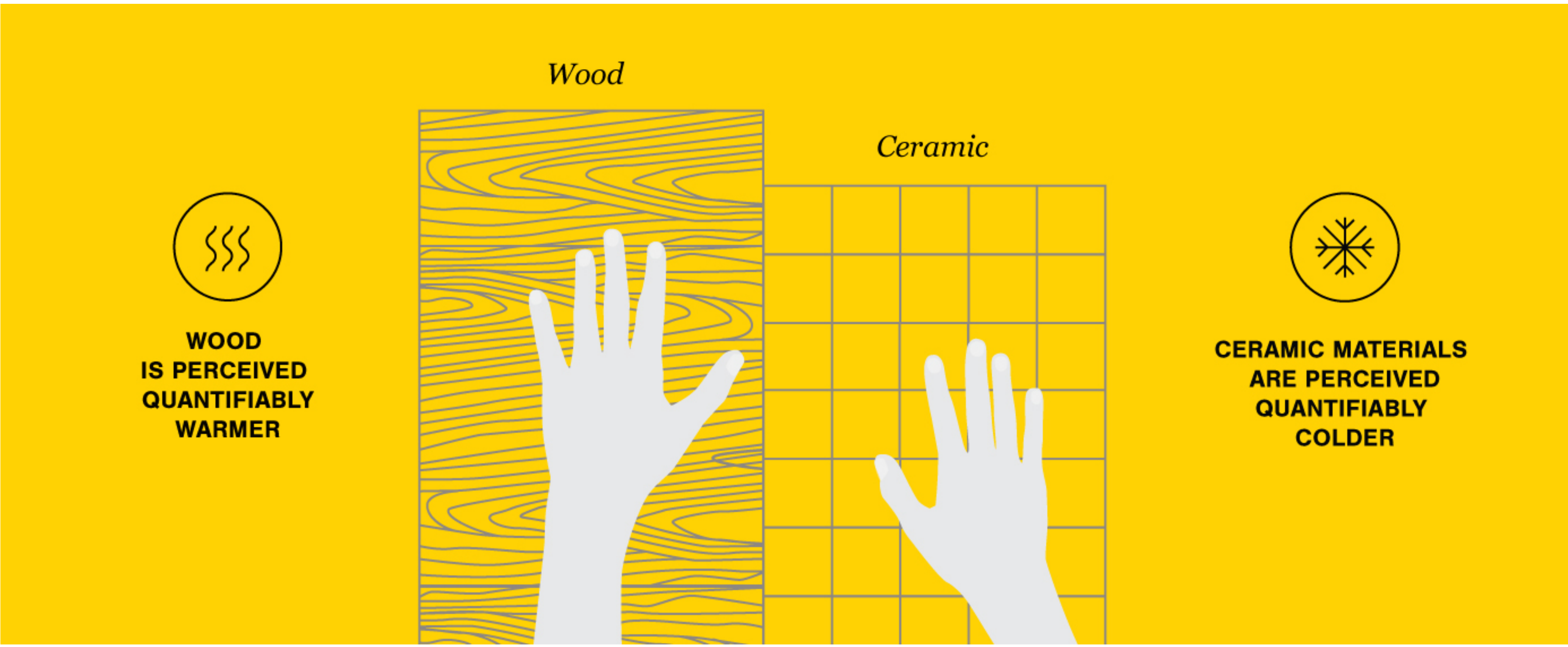
Dupleix, A., Van Nguyen, T., Vahtikari, K. et al. Wood Sci Technol (2017). https://doi.org/10.1007/s00226-017-0968-8

The material and people

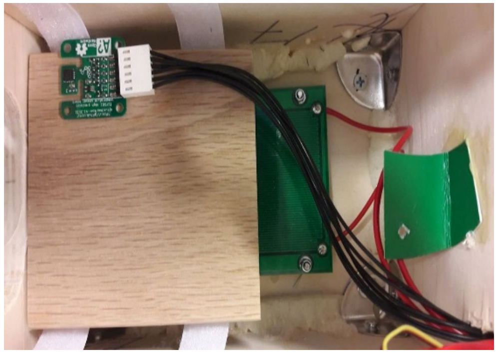
(How do humans interact with wood?)

(https://poolpiscina.com/en/benefits-of-sauna/)

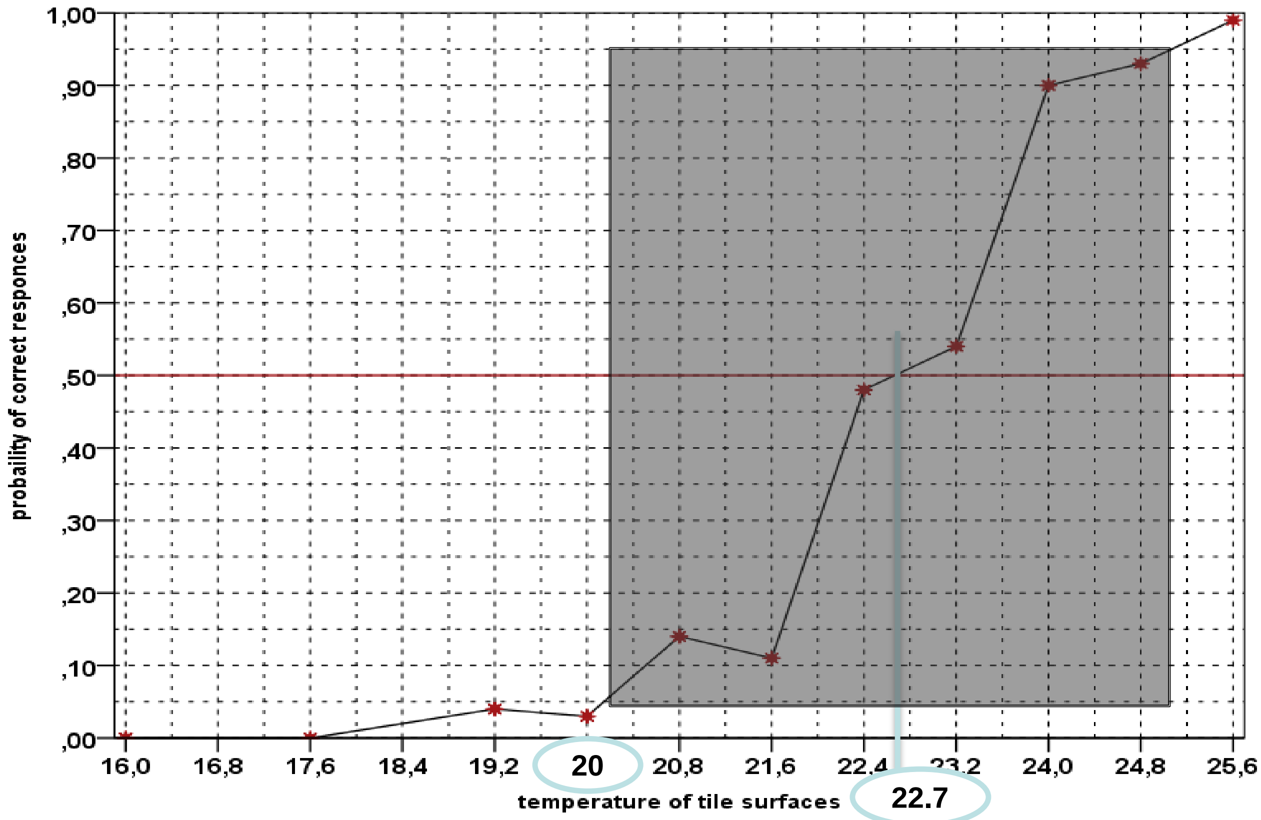
(http://gizmodo.com/how-your-tongue-actually-can-stick-to-cold-metal-1677719843)


WOOD
IS PERCEIVED
QUANTIFIABLY
WARMER
Wood
Ceramic
CERAMIC MATERIALS
ARE PERCEIVED
QUANTIFIABLY
COLDER

How much colder is ‘colder’?



Ceramic tile vs pine

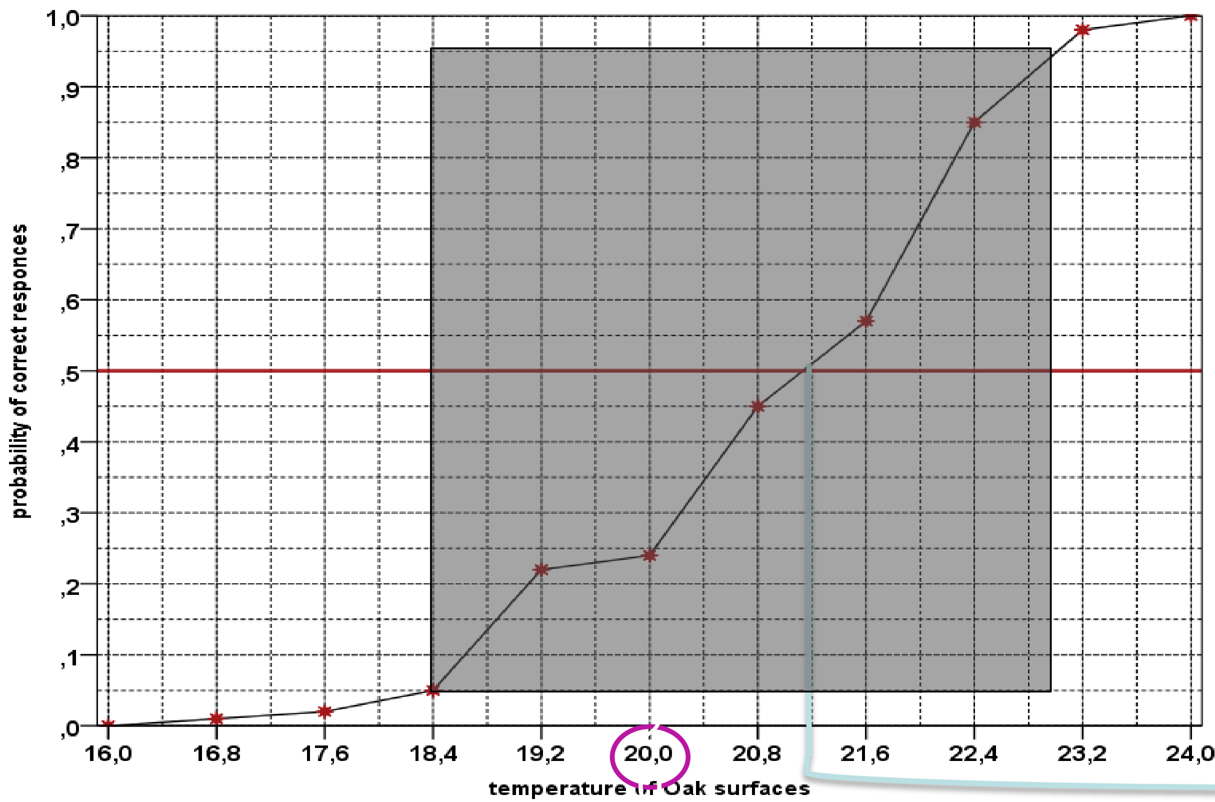


Point of Subjective Equality:

Pine = Tile
20 = 22.7

Pine surface temperature = 20 ^{o}C

Oak vs pine



21.2

Pine surface temperature = 20 ^{o}C

Point of Subjective Equality:

Pine = Oak
20 = 21.2

General conclusions

- The **properties** of wood can be used to **passively** influence or control in the interior environment of a building, which can then have an effect on comfort and health
- The **amount of wood**, the **orientation** of the exposed surface, the **species** and whether it is **coated** or not all play an important role in determining the magnitude of the effect
- The **warmer** or **cooler** ‘**feeling**’ elicited by wood can be used as a means of indirectly affecting the indoor environment