Moisture Sorption in Biobased Insulation

Indoor Environmental and Energy Engineering — Christoffer Brødsgaard & Thomas Juul

The Shift to Biobased Insulation

To reduce emissions from the building sector, a key strategy is shifting to regenerative biobased materials. Here side streams from fast-growing crops like grass, straw, and hemp offer great potential for use in insulation materials. [1]

Hempfiber

Woodfiber

Shifting to biobased insulation presents several challenges, with moisture and mould growth being one of them. To assess the risk of mould growth and deterioration it is essential to know the moisture sorption properties of the materials, so that humidity conditions inside constructions can be evaluated accurately. [2]

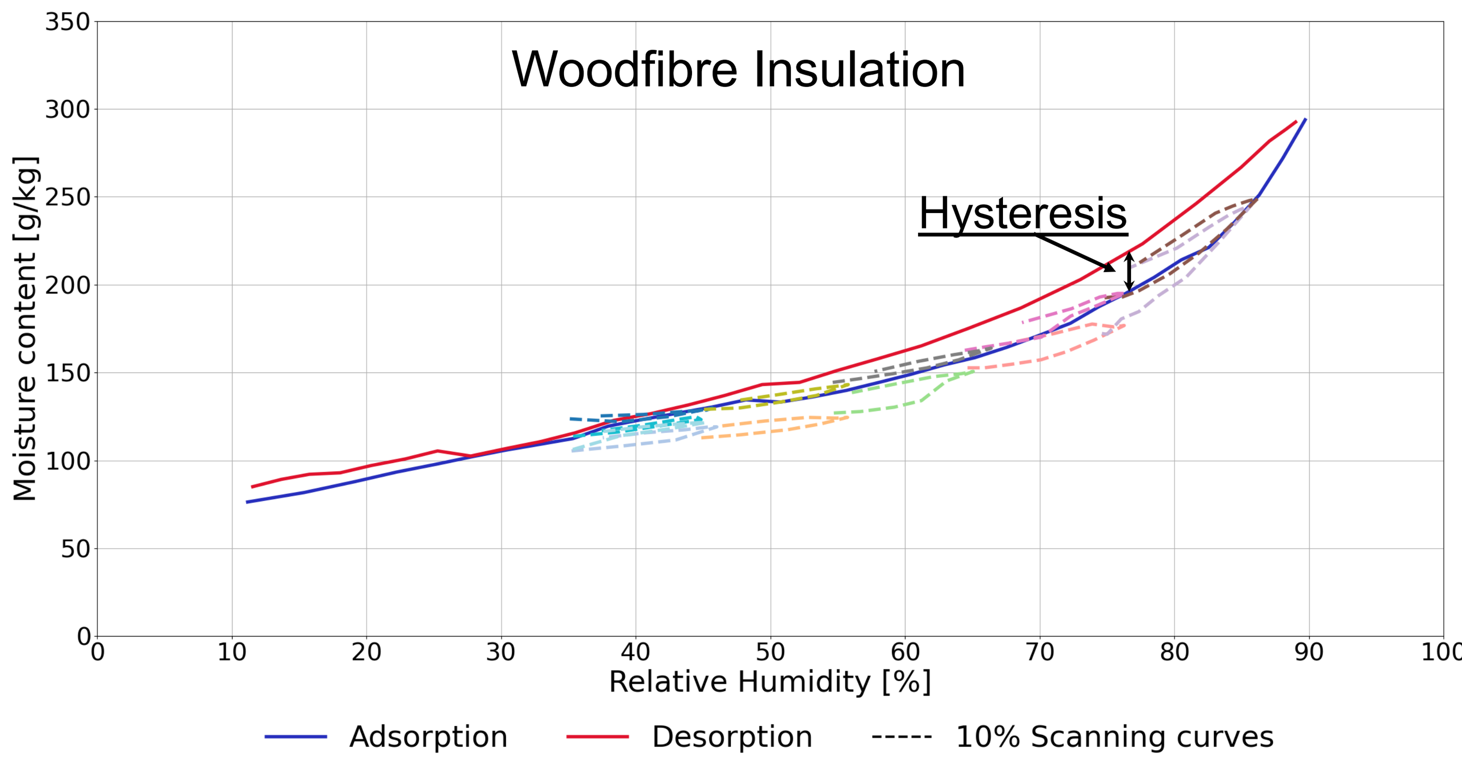
Realistic Humidity Variations

A moisture sorption isotherm describes the equilibrium moisture content in a material at a given relative humidity (RH). They consist of an adsorption and desorption curve, with hygroscopic materials showing hysteresis—a measurable gap between these curves [3]. The curves are time consuming to measure, and is typically measured from 10% to 90% RH, which does not represent reality. Simulation tools often simplify moisture behaviour by using only the adsorption curve, ignoring hysteresis [4].

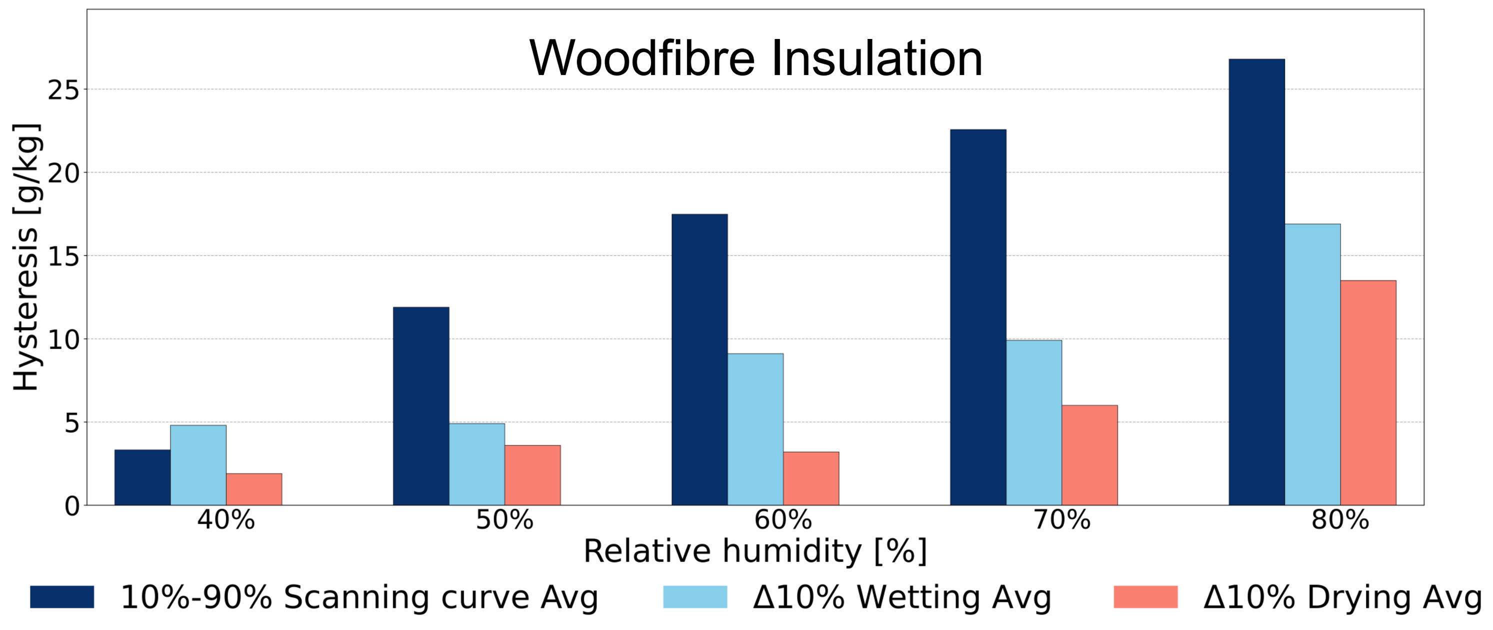
Using data from [5], our analysis of 2000 WUFI simulations on walls, documents that the RH typically varies ±10% within the range of 40–80%RH inside the wall. In reality materials will follow scanning curves, that are in between the adsorption and desorption curve.
We investigated these scanning curves under realistic RH-variations and looked into the actual scale of hysteresis. This knowledge can improve modelling accuracy.

Hysteresis in Biobased Insulation

Using the Dynamic Dewpoint Isotherm method (DDI) [6], scanning curves are measured at 10%RH variations, both wetting and drying between 40 to 80%RH. The figure below is for Woodfibre Insulation (WFI) and show the smaller scanning curves, and the large 10-90% curves. Measurements is also done on Hempfiber insulation and Aerated Autoclaved Concrete.



Even at small RH-variations, hysteresis is present. The smaller variations also show a lower slope, compared to the large curves, indicating a lower moisture buffering capacity. Hysteresis is quantified below, to compare the smaller scanning curves with the large.



From this, it can be concluded that using the 10-90% sorption curves might overestimate the actual hysteresis. The next step is to implement this into a biobased hysteresis model.

Dynamic Wall-Scale Measurement Setup

A major part of this thesis involves designing and creating a measurement setup that supports an exploratory approach, enabling the testing of various wall assemblies — featuring different assembly principles, biobased insulation materials, and vapour or wind barriers. A wall-scale experiment under dynamic weather conditions, makes it possible to investigate the complex dynamic interactions and calibrate simulation tools. A chamber setup was successfully established, providing a well-mixed and stable indoor environment within ±1 °C and ±3% RH.

Using calibrated, high-precision sensors embedded in the wall construction, temperature and relative humidity were measured in seven wall elements installed within the setup. Only one month of data was collected, which was insufficient to draw clear conclusions.
Using measured boundary conditions, a WUFI model was developed to enable comparison between measurements and simulation results. WUFI is a state-of-the-art hygrothermal simulation tool. The model showed good agreement in temperature; however, discrepancies were observed in relative humidity, with measured values being higher. Simulations indicate that at least four months are required for the conditions to stabilize, allowing for meaningful comparison across elements. This highlights the discrepancies between reality and modelling.

References

[1] VIA University College et al. “Fra Marken til Byggeri”. (2024).
[2] Torben V. Rasmussen et al. “Biogene materialers anvendelse i byggeriet”. BUILD, Aalborg Universitet. (2022).
[3] Carsten R. Pedersen. “Koblet fugt- og varmetransport i bygningskonstruktioner: Fugtfysik”. (1989).
[4] Michele Libralato et al. “Damage risk assessment of building materials with moisture hysteresis”. (2021). ISSN: 1742-6588.
[5] Marie E. Ø Jensen and Amalie S. Flou. “Hygrotermiske egenskaber og deres indvirkings på skimmelvækst i ydervægge”. (2025).
[6] Emmanuel Arthur et al. “Evaluation of a Fully Automated Analyzer for Rapid Measurement of Water Vapor Sorption Isotherms for Applications in Soil Science”. (2014). ISSN: 0361-5995.