Hygrothermal analysis of *EcoCocon* straw panels in the *JDH* wall systems in the Danish climate

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Content

Background and mission

Passivhusbyrån has been commissioned to produce a hygrothermal analysis of *EcoCocon's* straw panel in combination with JDH built walls of six different designs in the Danish climate. The location chosen is Aarslev, as it is in the middle of Denmark. The climatic conditions and the different types of walls are described below (input data). The aim of the analysis is to obtain results, based on the input below, and to examine the performance and moisture resistance in the long term.

Reservations

The calculations and simulations for this project are based on data received between 29th November 2022 and 11th February 2023. The climate data needed for the simulations were produced with the Meteonorm-8 program. For additional stress testing, a 1 % fraction of the rainfall load was included as seeping into the structure, namely into the straw panel directly behind the weather resistive barrier, in accordance with ANSI/ASHRAE Standard 160-2021. In addition, an intentionally high relative humidity of 80 % was assumed for all components at the time of installation and a very low air turnover in the facade ventilation gap.

Hygrothermal analysis

The simulation was done with *WUFI 6.5 Pro*, which allows hourly dynamic simulation for an unlimited number of years. During the process, the following parameters are considered, among others:

Material properties - these quantities describe the hygrothermal behaviour of the materials to be examined: bulk density [kg/m³], porosity [m³/m³], specific heat capacity [J/(kg·K)], dry thermal conductivity [W/(m·K)], dry water vapour diffusion resistance, moisture storage function [kg/m³], and liquid transport coefficient of suction and redistribution [m²/s]. If applicable, moisture-dependent thermal conductivity [W/(m·K)] and water vapour diffusion resistance number are also included. The weatherproofing membrane supplied by EcoCocon with its panels and used in the model has an sd-value of 0.05 m and the vapour retarder 6.45 m.

Climatic data - these quantities describe the boundary conditions acting on the internal and external surface of the building component: rainfall load on the surface [l/(m²·h)], depending on the slope and orientation of the component, shortwave radiant flux density (solar) [W/m²], depending on the slope and orientation of the component, outdoor air temperature [°C], outdoor air relative humidity [0...100 %], indoor air temperature [°C], indoor air relative humidity [0...100 %] and average air pressure [hPa] during the calculation period.

Input data

Construction wall type M (with weather protection membrane and vapour retarder):

Materials:

- Scandinavian spruce transverse direction	0.025 m
- Air Layer	0.052 m
- Weatherboard 365	0.01 m
- OSB	0.012 m
- Weather resistive barrier (sd=0,05m)	0.001 m
- EcoCocon straw panel	0.4 m
- Vapour retarder	0.001 m
- Wood fibre board	0.045 m
- OSB	0.012 m
- Plaster board	0.013 m

Construction wall type N (like wall type M, but without vapour retarder):

Materials:

- Scandinavian spruce transverse direction	0,025 m
- Air Layer	0,052 m
- Weatherboard 365	0,01 m
- OSB	0,012 m
- Weather resistive barrier (sd=0,05m)	0,001 m
- EcoCocon straw panel	0,4 m
- Wood fibre board	0,045 m
- OSB	0,012 m
- Plaster board	0,013 m

Construction wall type O (like wall type M, but without weather resistive barrier):

Materials:

- Scandinavian spruce transverse direction	0.025 m
- Air Layer	0.052 m
- Weatherboard 365	0.01 m
- OSB	0.012 m
- EcoCocon straw panel	0.4 m
- Vapour retarder	0.001 m
- Wood fibre board	0.045 m
- OSB	0.012 m
- Plaster board	0.013 m

Construction wall type P (like wall type N, but with FERMACELL instead of Weatherboard and OSB on the outside):

Materials:

- Scandinavian spruce transverse direction	0,025 m
- Air Layer	0,052 m
- FERMACELL Gypsum-Fibreboard	0,012 m
- weather resistive barrier (sd=0,05m)	0,001 m
- EcoCocon straw panel	0,4 m
- Wood fibre board	0,045 m
- OSB	0,012 m
- Plaster board	0,013 m

Construction wall type Q (like wall type P, but without the wood fibre layer):

Materials:

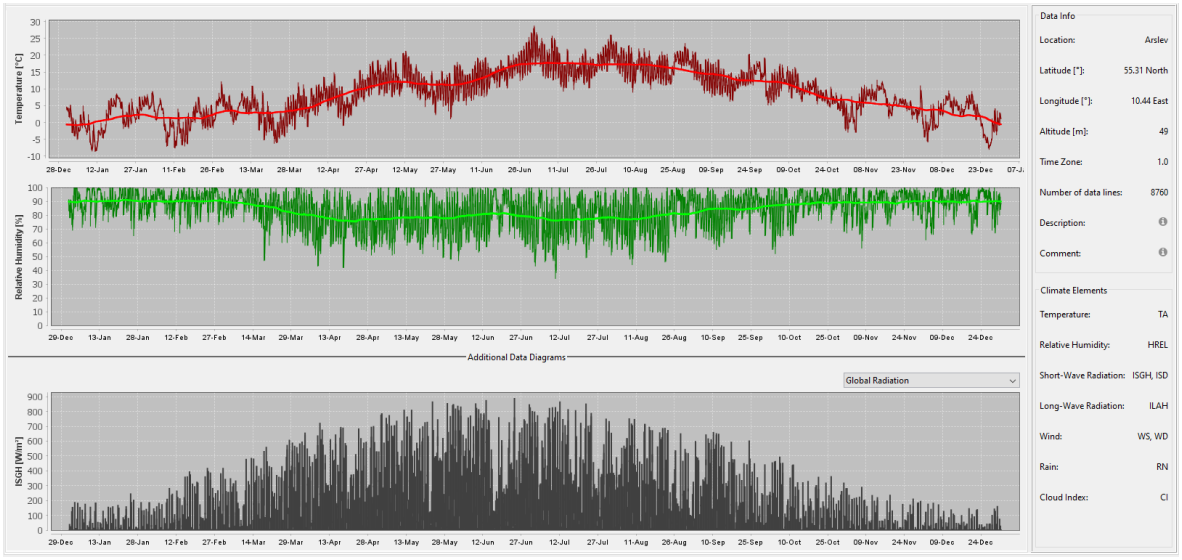
- Scandinavian spruce transverse direction	0,025 m
- Air Layer	0,052 m
- FERMACELL Gypsum-Fibreboard	0,012 m
- weather resistive barrier (sd=0,05m)	0,001 m
- EcoCocon straw panel	0,4 m
- OSB	0,012 m
- Plaster board	0,013 m

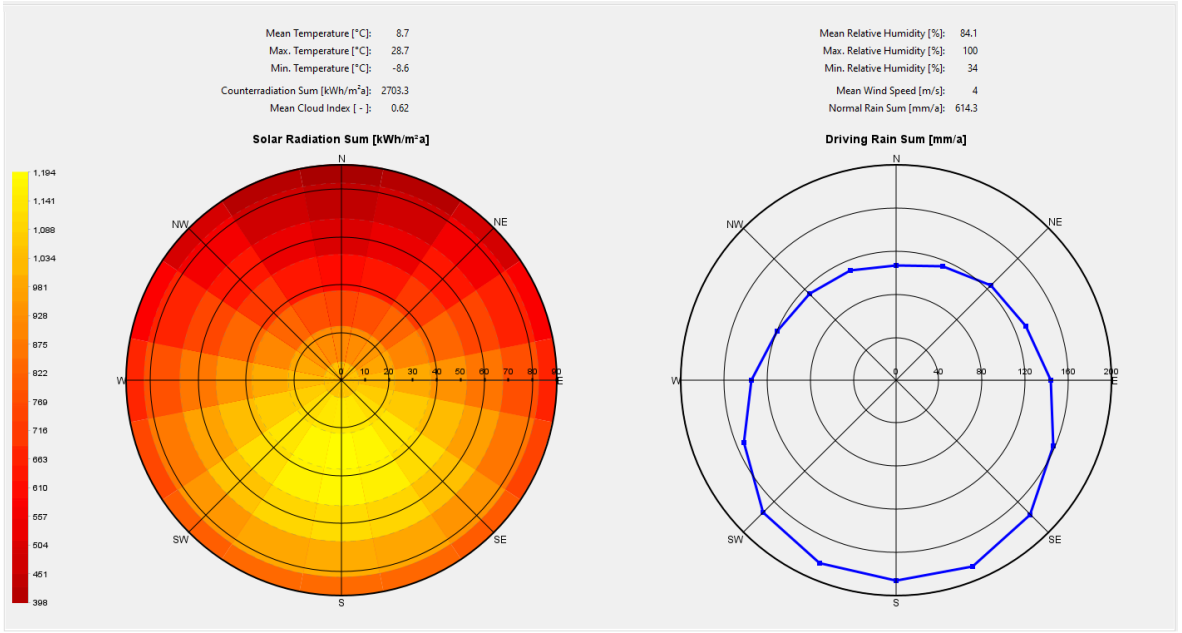
Construction wall type R (like wall type Q, but with interior clay plaster instead of OSB and plasterboard):

Materials:

- Scandinavian spruce transverse direction	0,025 m
- Air Layer	0,052 m
- FERMACELL Gypsum-Fibreboard	0,012 m
- weather resistive barrier (sd=0,05m)	0,001 m
- EcoCocon straw panel	0,4 m
- Clay Plaster	0,025 m

Outdoor climate Aarslev (Denmark)





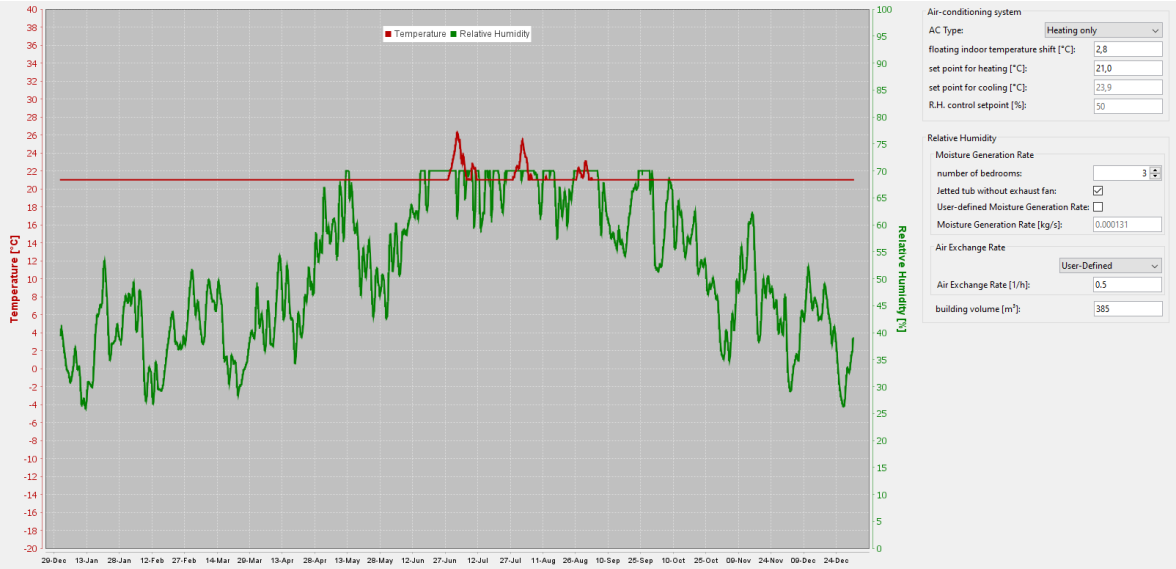
The direction with the most driving rain is straight south. There is also the strongest solar radiation, with high drying capacity. However, for the investigation on ventilated facades, straight north is always the decisive orientation.

Indoor climate Aarslev

The same model building was used for all simulations: a three-bedroom villa with 385 m³ of indoor volume. A whirlpool bathtub without a separate exhaust fan was included for possible additional internal moisture production – for extra stress-testing. An MVHR-unit delivers 0.5 air changes per hour.

Air conditioning is available as heating only, no active cooling. The heating set point is 21 °C (typical value for a single-family house).

The indoor climate model was based on the ASHRAE 160-2021 standard, as it provided the means to represent the above conditions:

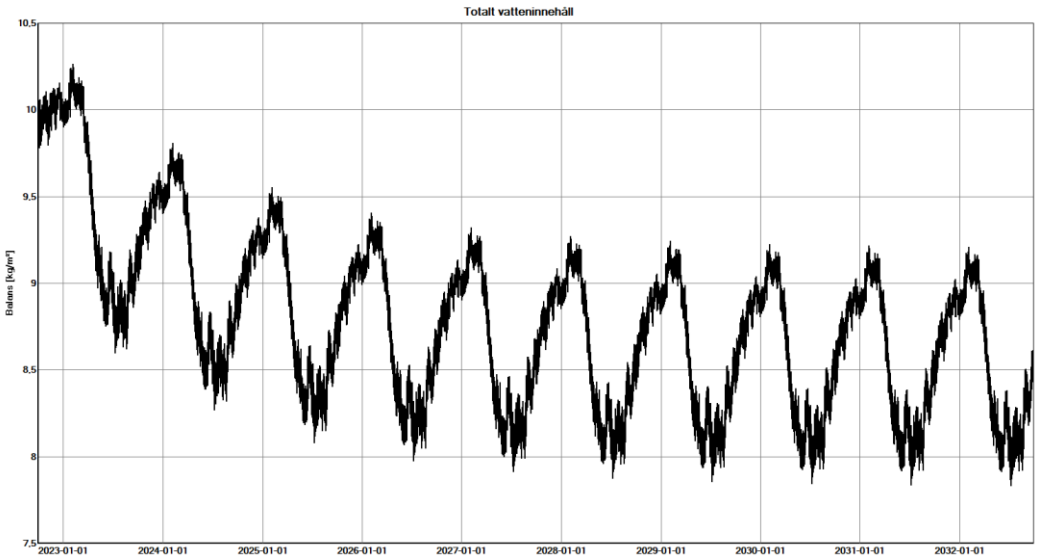


Results

The following diagram shows the water content of the individual layers over 10 years.

Wall type M

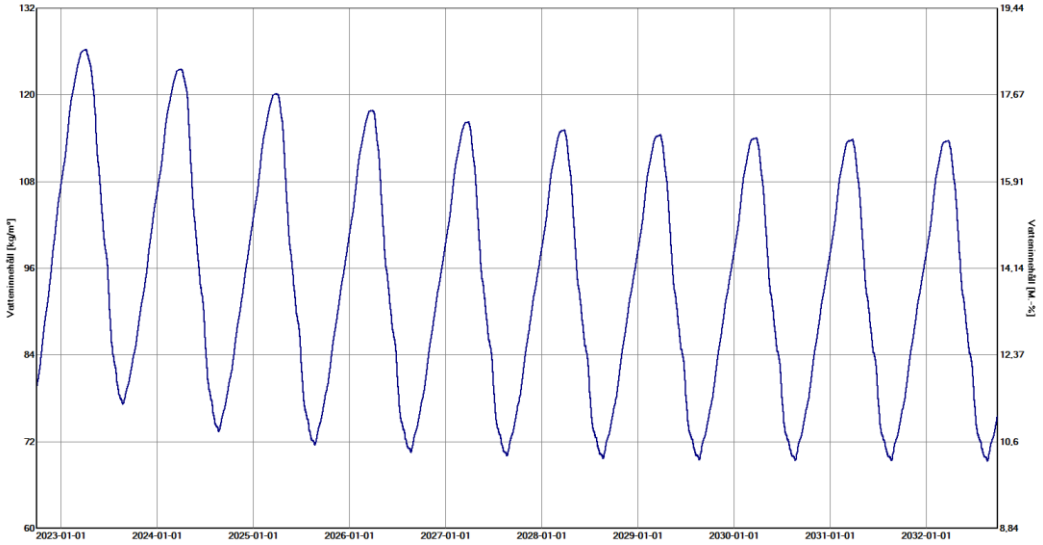
The whole wall



The simulation over 10 years shows that there is no accumulation of moisture over the long term, but it takes a few seasons to release the assumed high level of built-in moisture. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

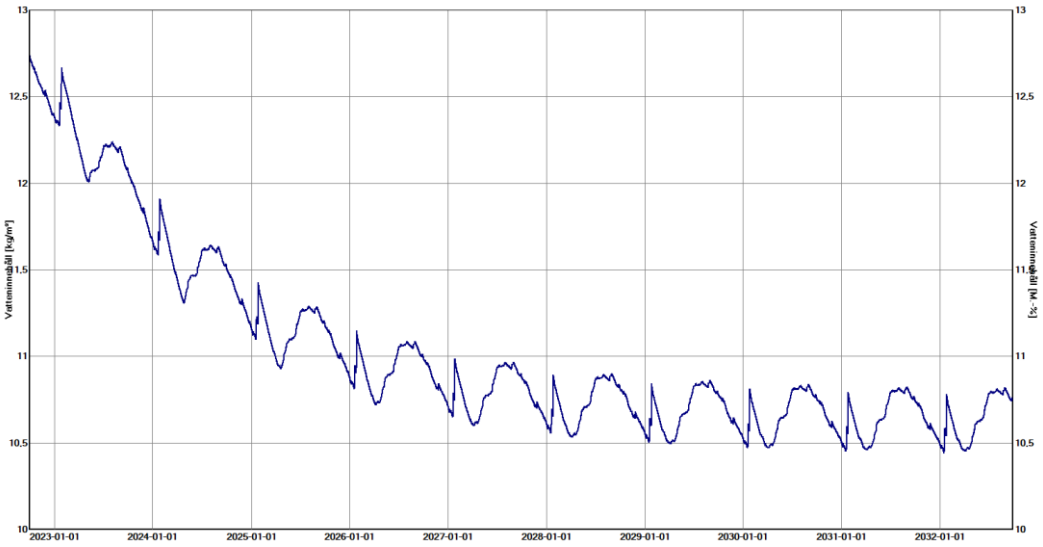
Individual layers

The OSB board towards the outside:



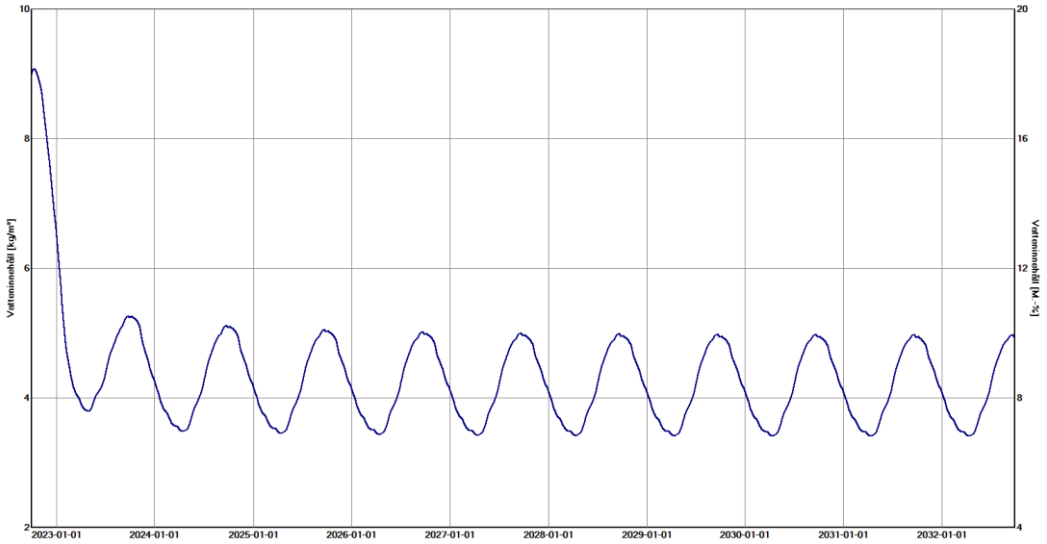
After a few seasons of stagnation, the water content is permanently below 17 M.-%. The use of dry materials at the time of construction will also eliminate the higher moisture content shown at the beginning of the simulation.

EcoCocon panel (straw):



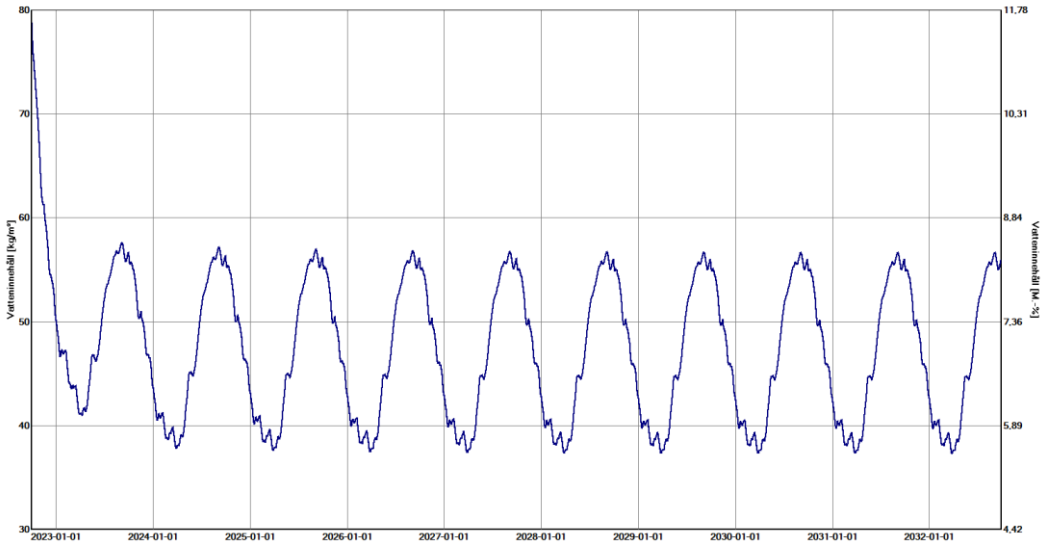
Again, it takes several seasons to stay at a low level, but even after the intentionally high value at the beginning, the water content drops over time and is below 11 M.-% all the time.

The fibreboard:



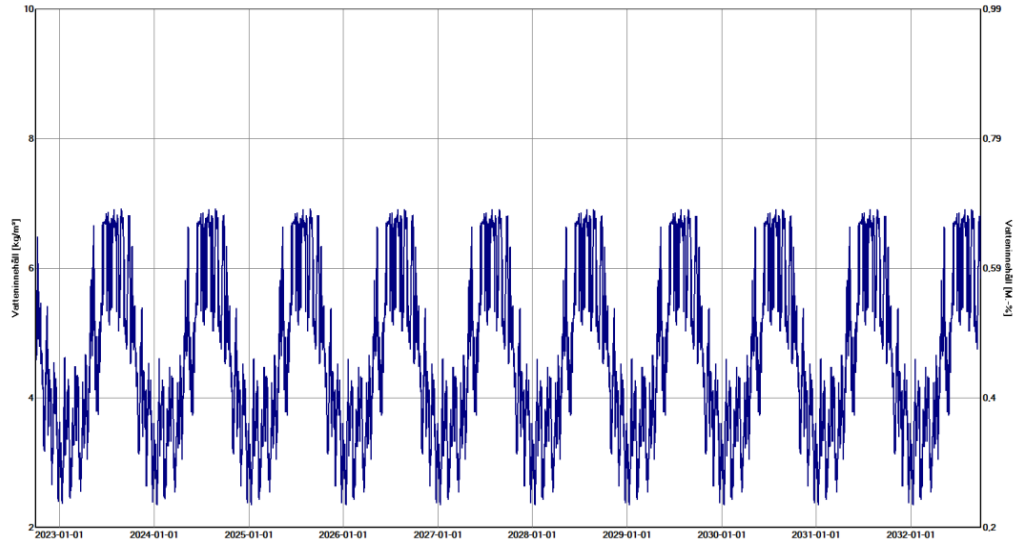
A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 12 M.-%.

The OSB panel towards the inside:



A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 9 M.-%.

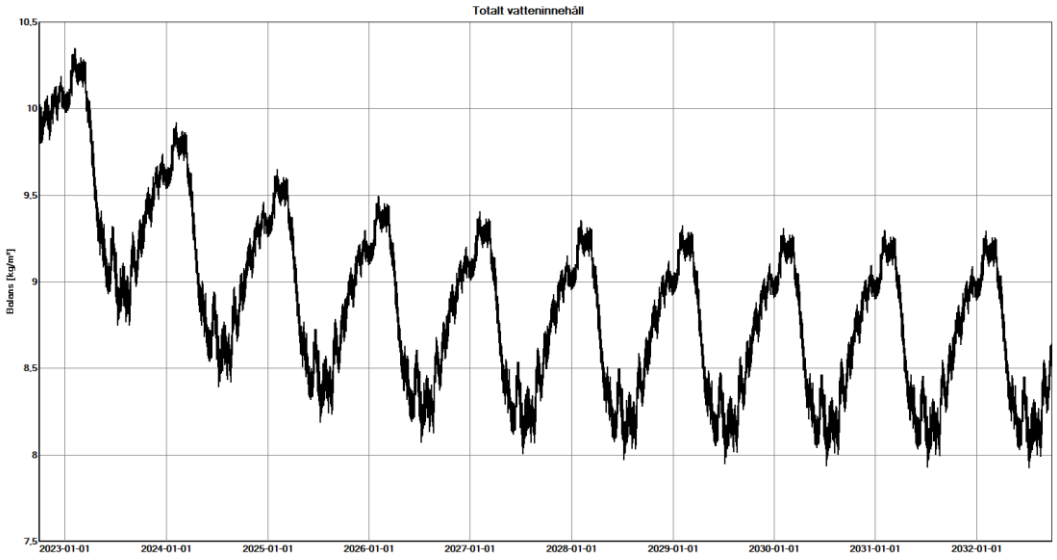
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type N

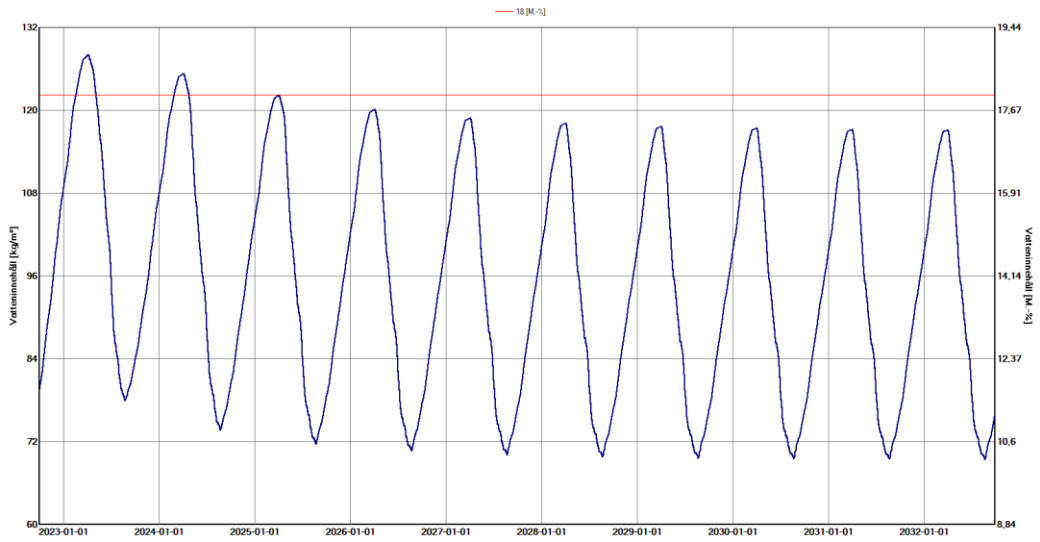
<u>The whole wall</u>



The simulation over 10 years shows that there is no accumulation of moisture over the long term, but it takes a few seasons to release the assumed high level of built-in moisture. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

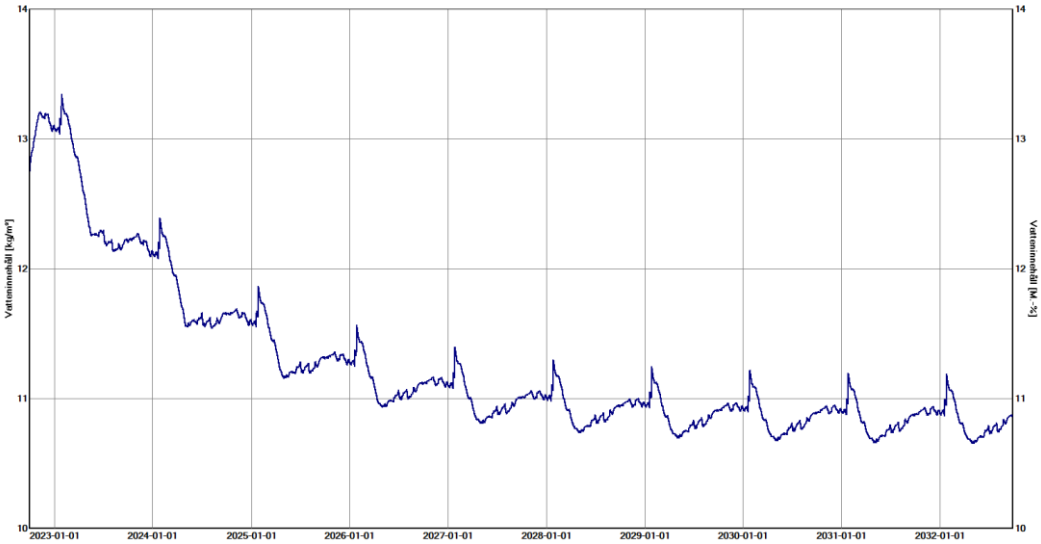
Individual layers

The OSB board towards the outside:



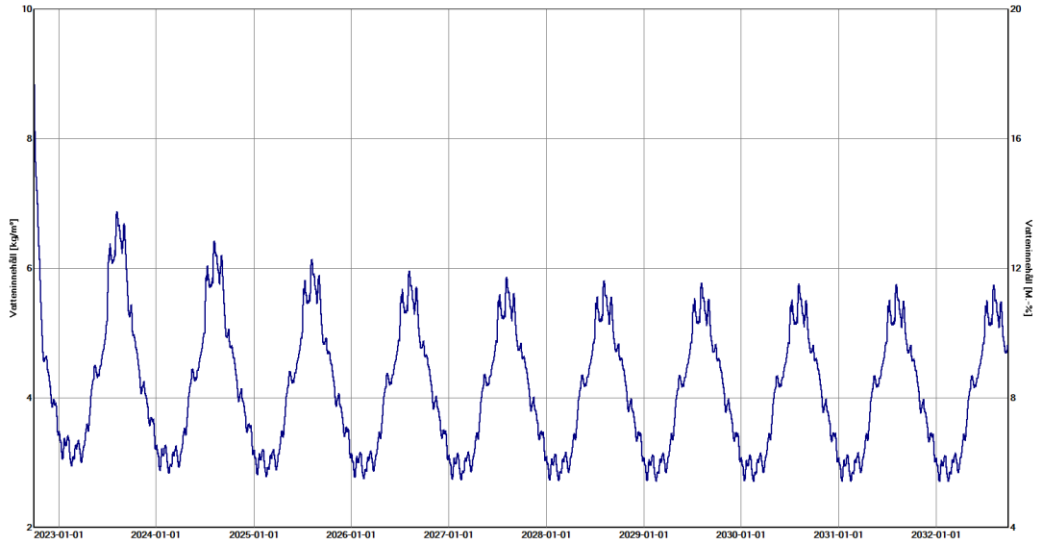
After a few seasons of stagnation, the water content is permanently below 18 M.-%.

EcoCocon panel (straw):



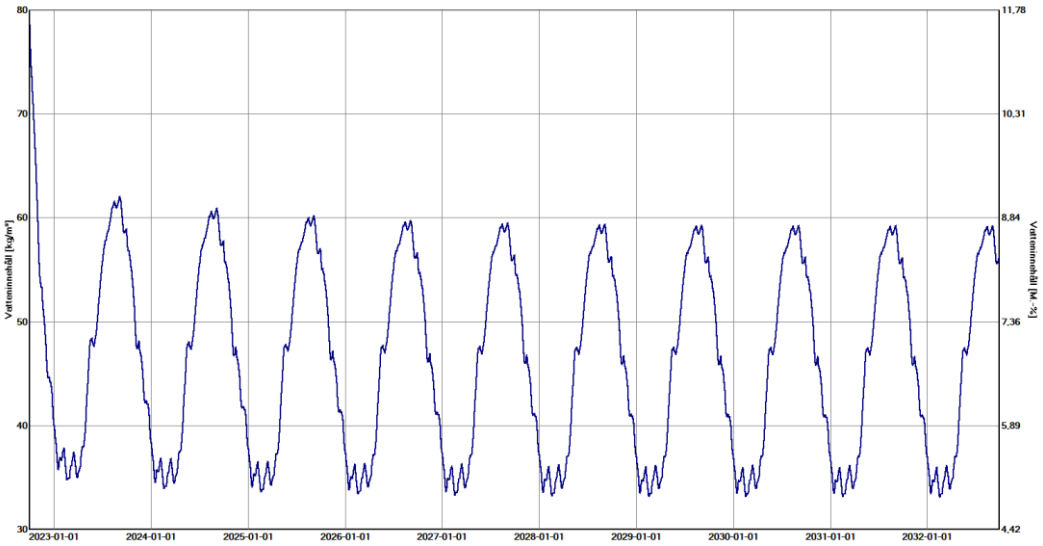
Again, it takes several seasons to stay at a low level, but even after the intentionally high value at the beginning, the water content drops over time and is below 12 M.-% all the time.

The fibreboard:



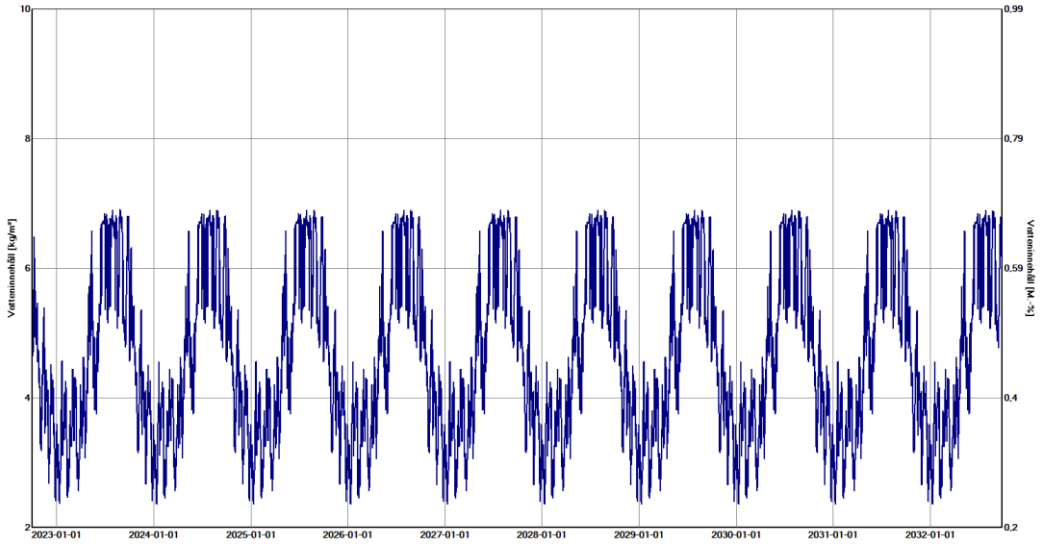
A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 12 M.-%.

The OSB panel towards the inside:



A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 9 M.-%.

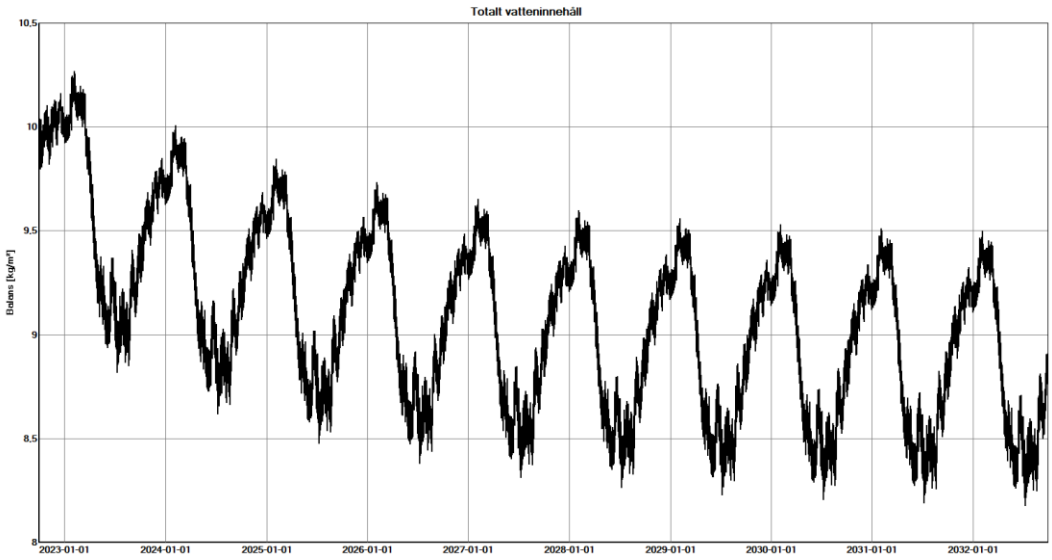
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type O

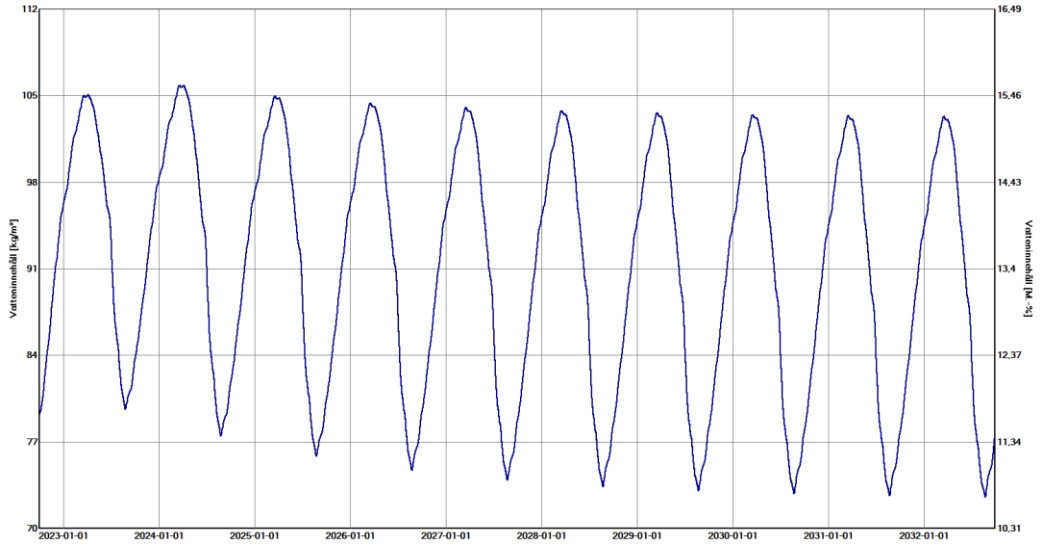
<u>The whole wall</u>



The simulation over 10 years shows that there is no accumulation of moisture over the long term, but it takes a few seasons to release the assumed high level of built-in moisture. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

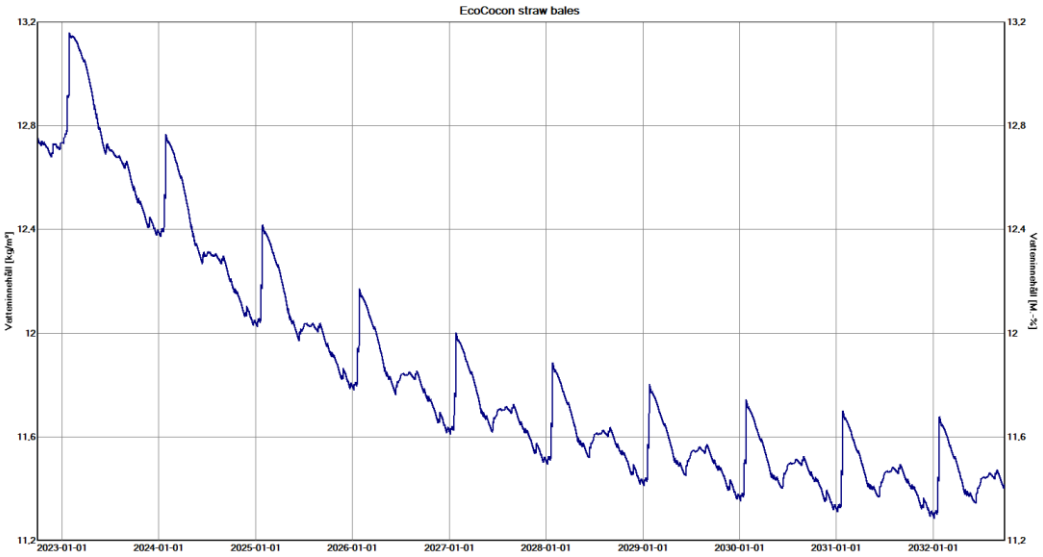
Individual layers

The OSB board towards the outside:



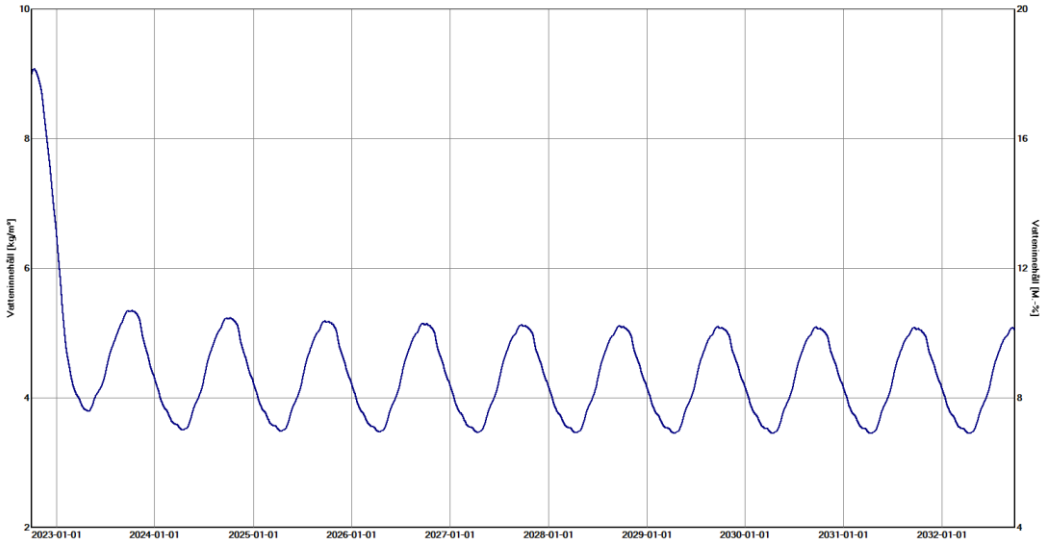
The water content is permanently below 16 M.-%.

EcoCocon panel (straw):



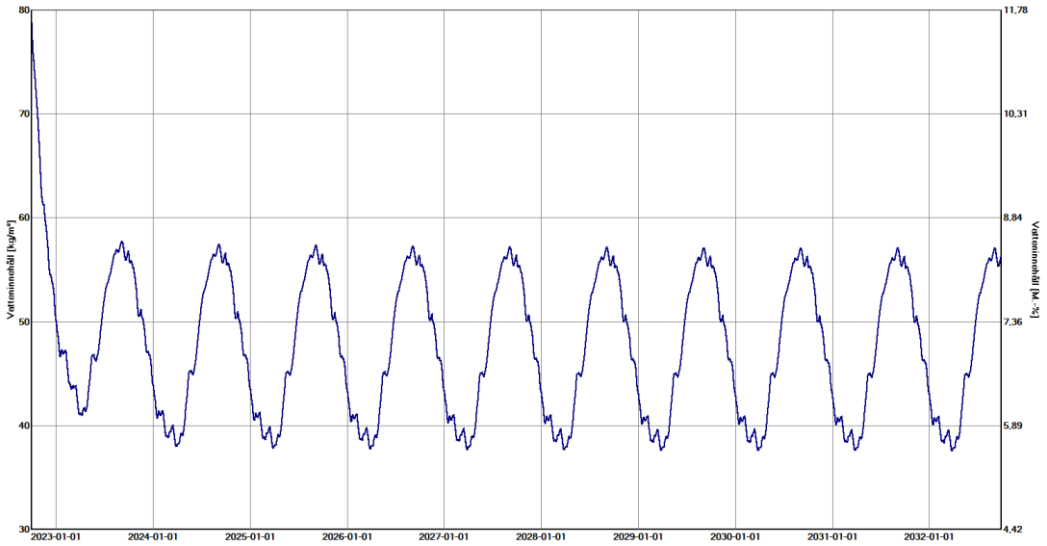
Again, it takes several seasons to stay at a low level, but even after the intentionally high value at the beginning, the water content drops over time and is below 13 M.-% all the time.

The fibreboard:



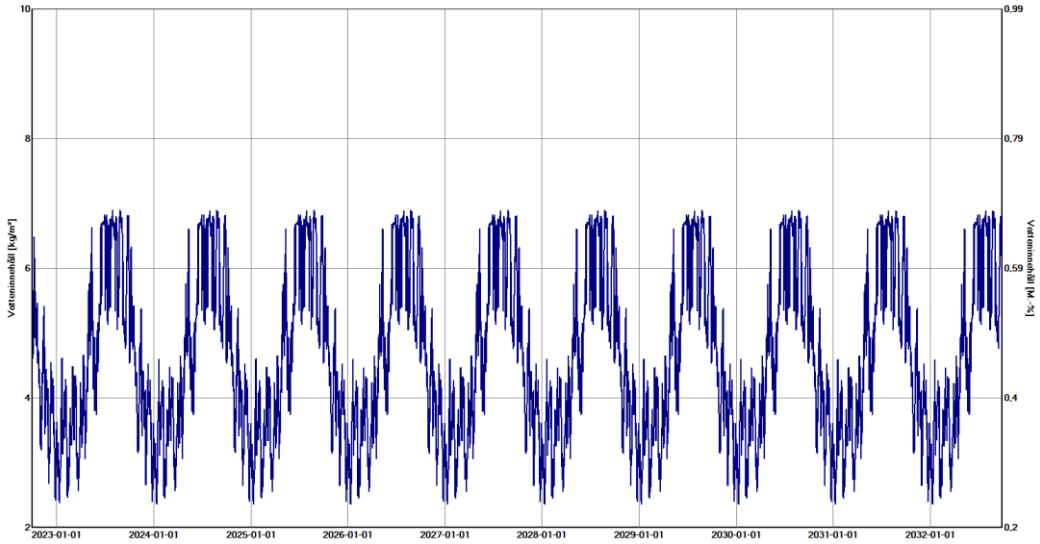
A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 12 M.-%.

The OSB panel towards the inside:



A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 9 M.-%.

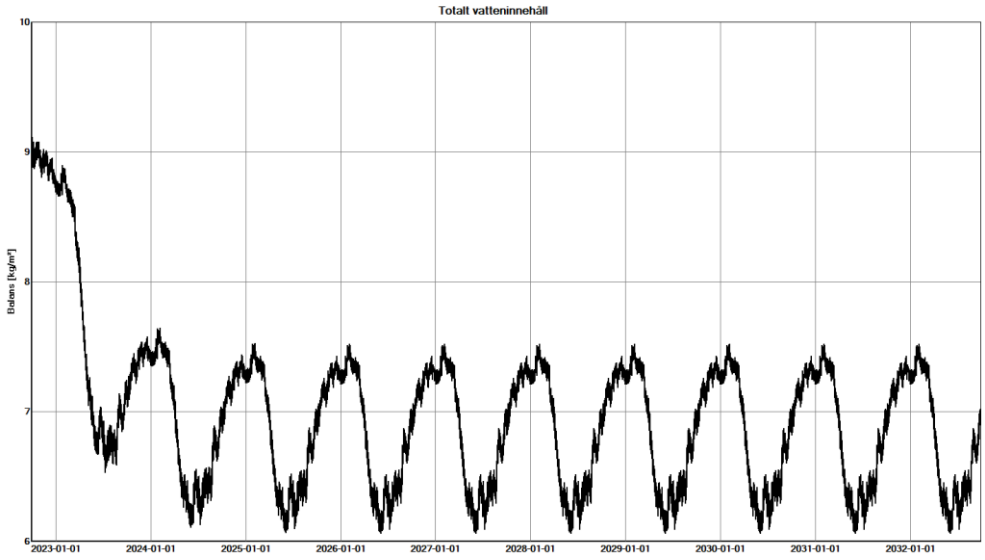
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type P

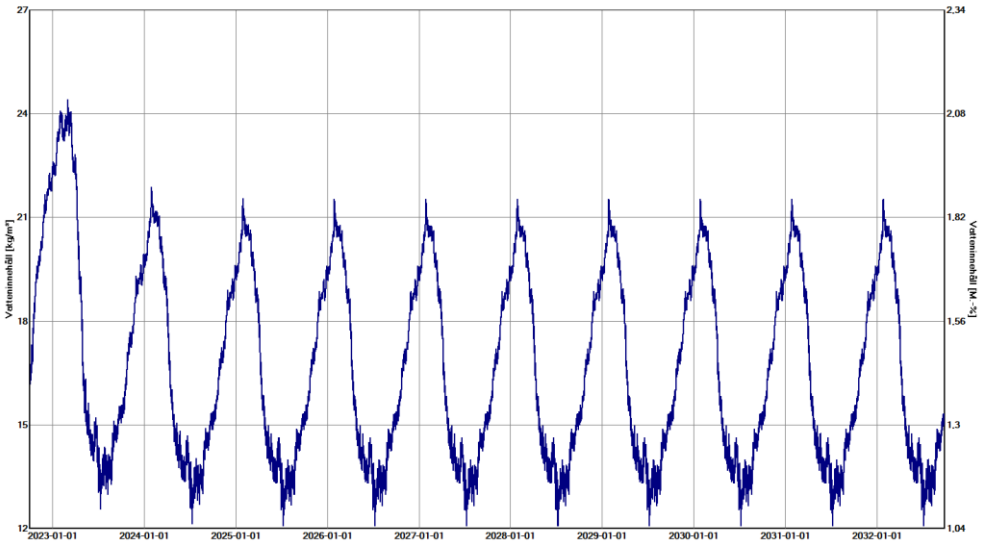
<u>The whole wall</u>



The simulation over 10 years shows that there is no accumulation of moisture over the long term, but it takes one season to release the assumed high level of built-in moisture. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

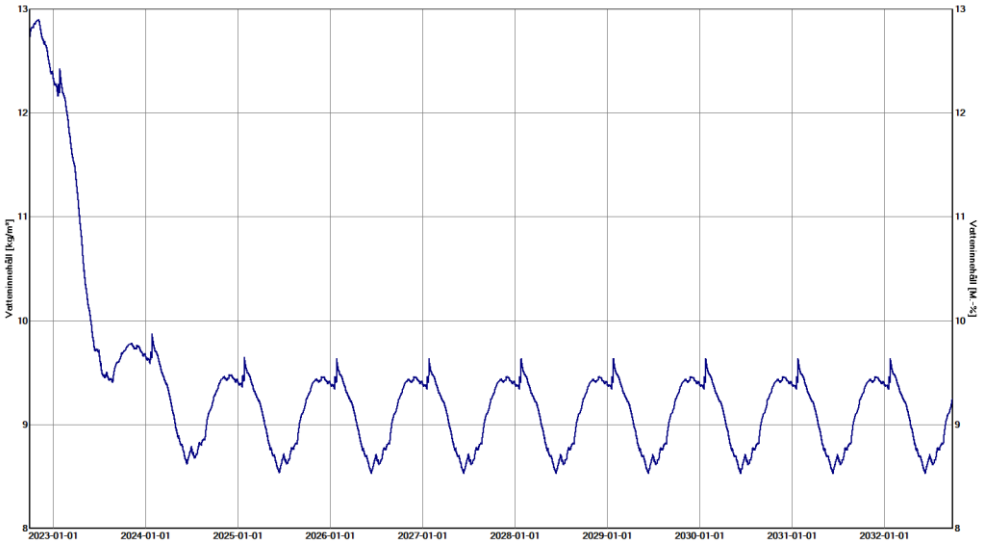
Individual layers

Fermacell board:



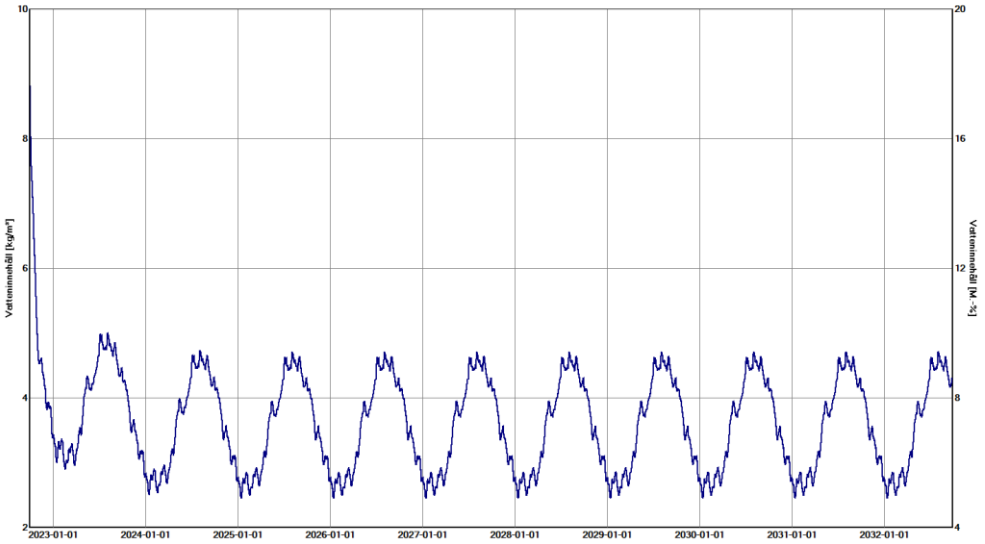
The disc will maintain a low moisture level at all times.

EcoCocon panel (straw):



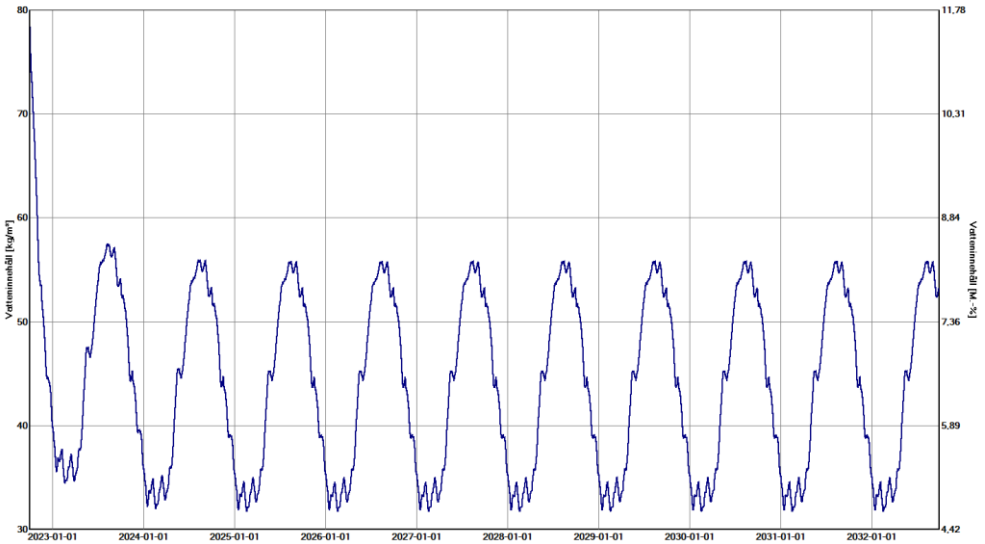
It takes one to two seasons to stay at a low level, but even after the deliberately high value at the beginning, the water content drops below 10 M.-% and stays there all the time.

The fibreboard:



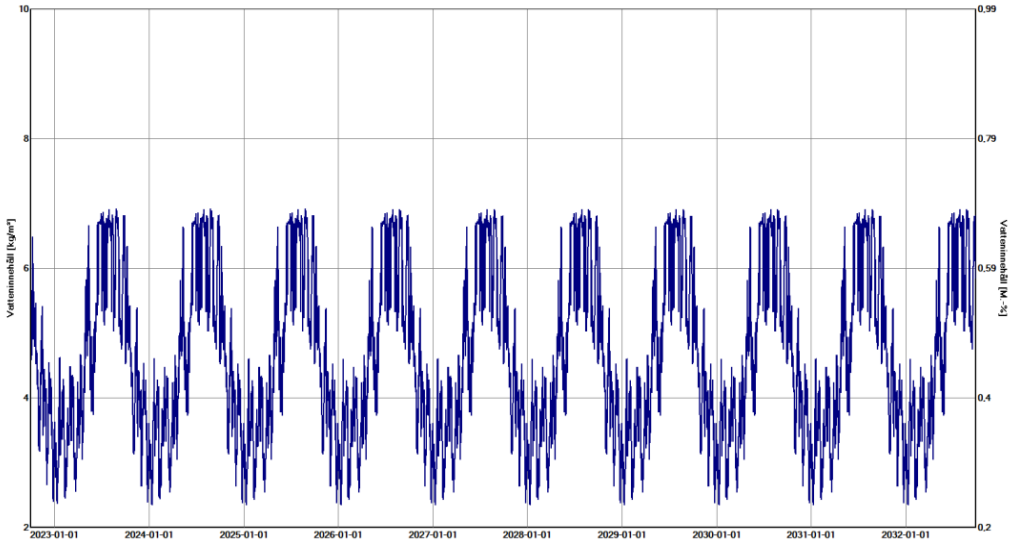
The layer dries out quickly and a low moisture level is reached already after a few months - which stays below 10 M.-%.

OSB board:



A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 9 M.-%.

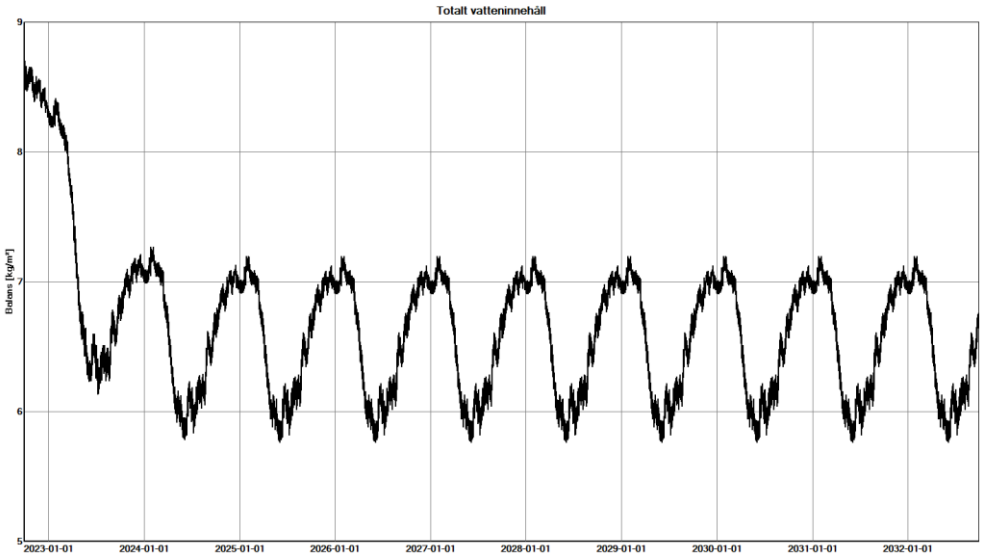
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type Q

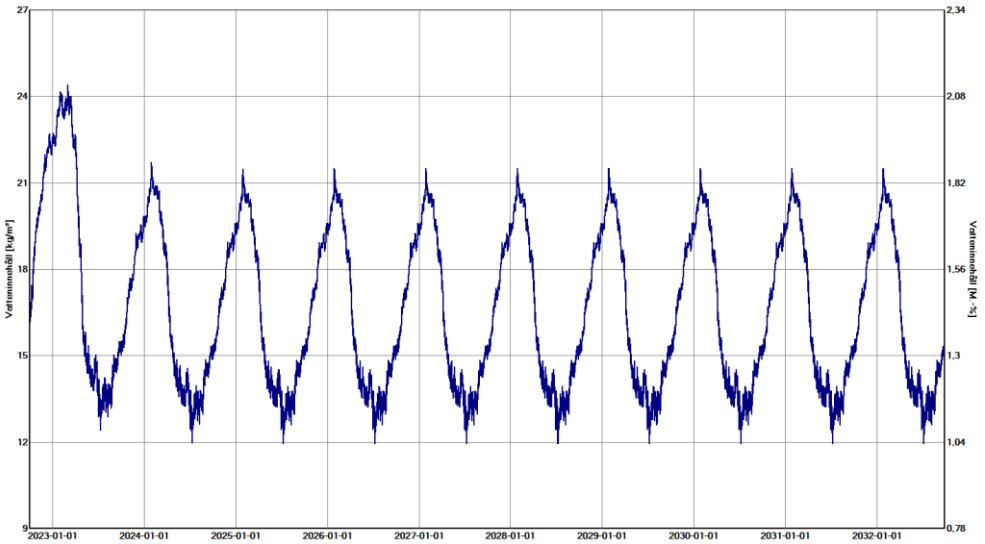
<u>The whole wall</u>



The simulation over 10 years shows that there is no accumulation of moisture over the long term and it takes only one season to release the assumed high level of built-in moisture. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

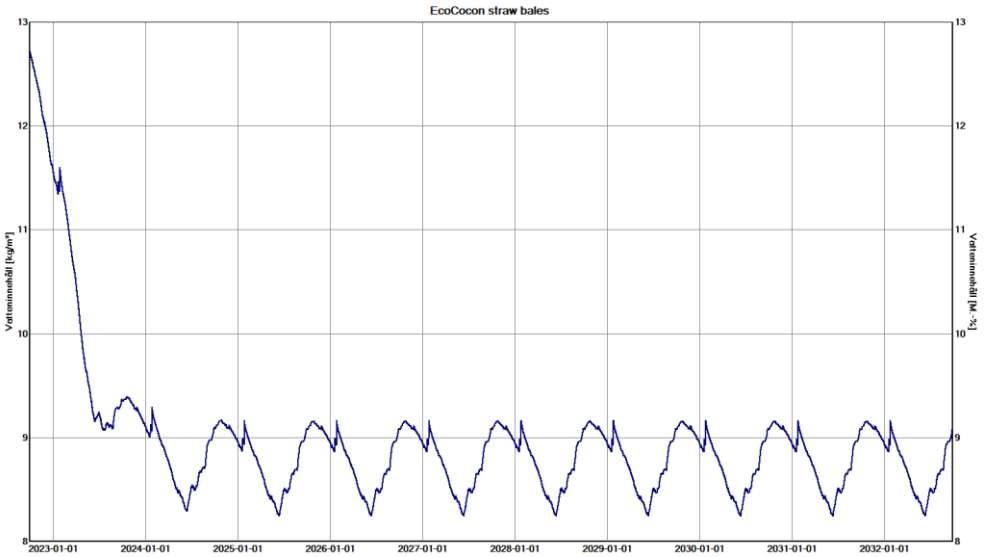
Individual layers

Fermacell board:



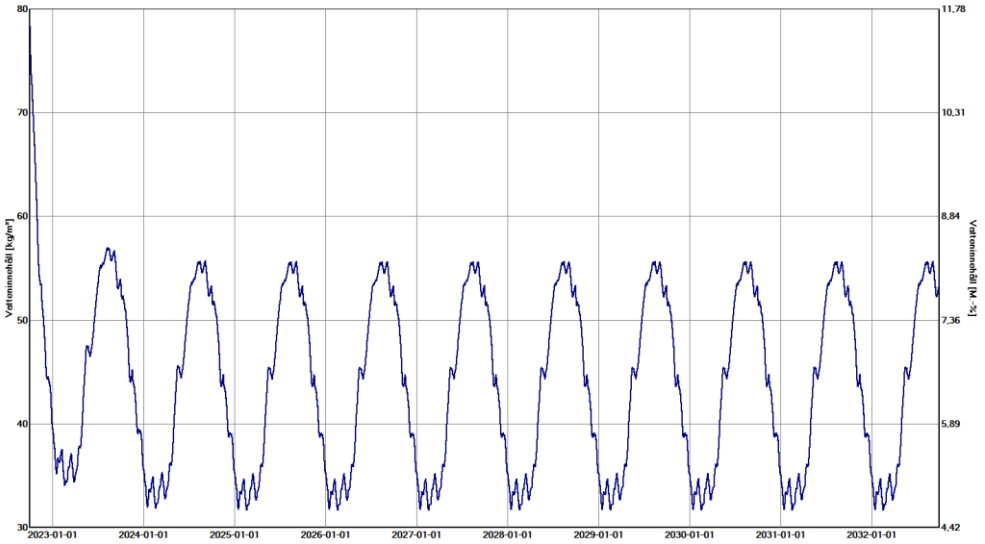
The disc will maintain a low moisture level at all times.

EcoCocon panel (straw):



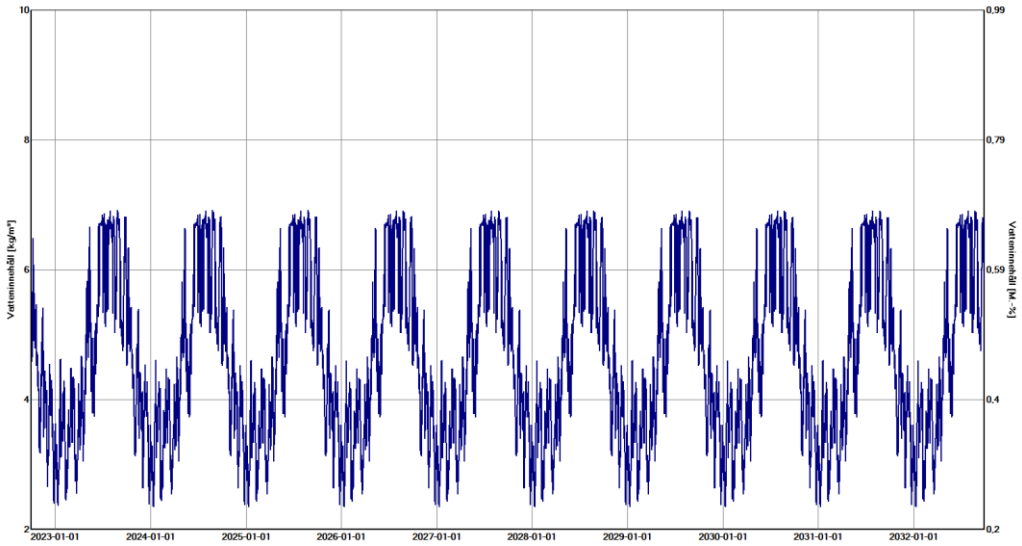
It takes one to two seasons to stay at a low level, but even after the deliberately high value at the beginning, the water content drops to below 9.5 M.-% and stays there all the time.

OSB board:



A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 9 M.-%.

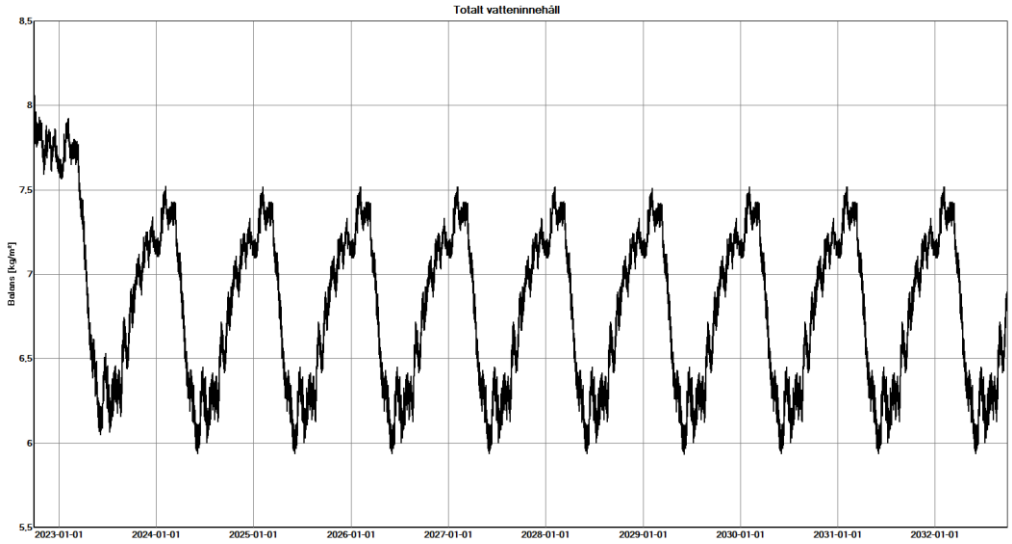
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type R (like wall type **Q**, but with internal plaster)

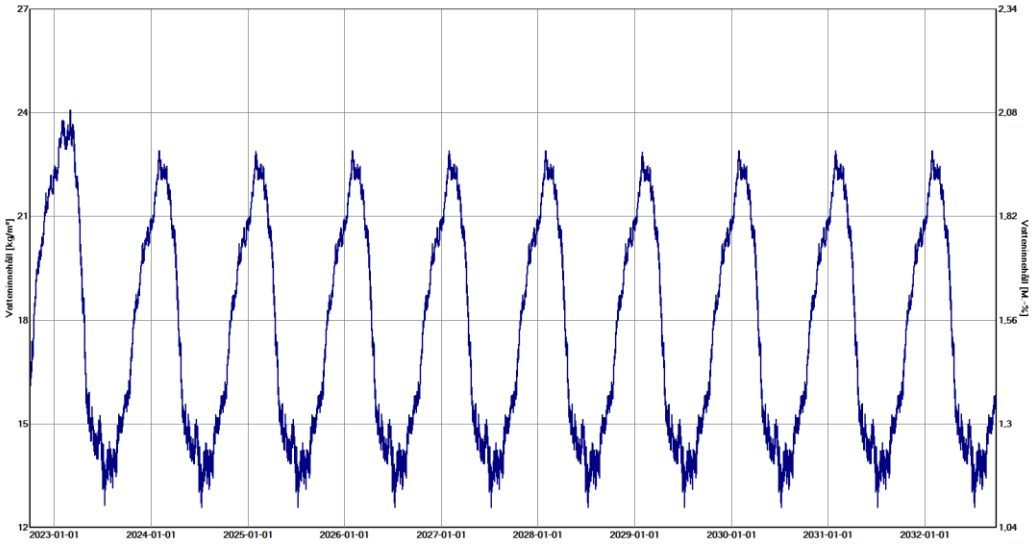
The whole wall



The simulation over 10 years shows that there is no accumulation of moisture over the long term and it takes only one season to release the assumed high level of built-in moisture. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

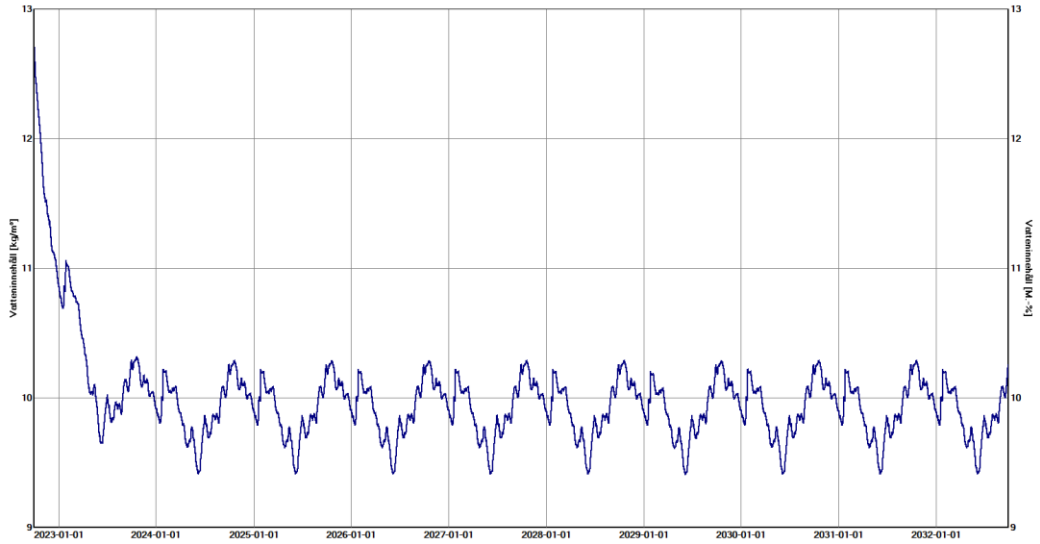
Individual layers

Fermacell board:



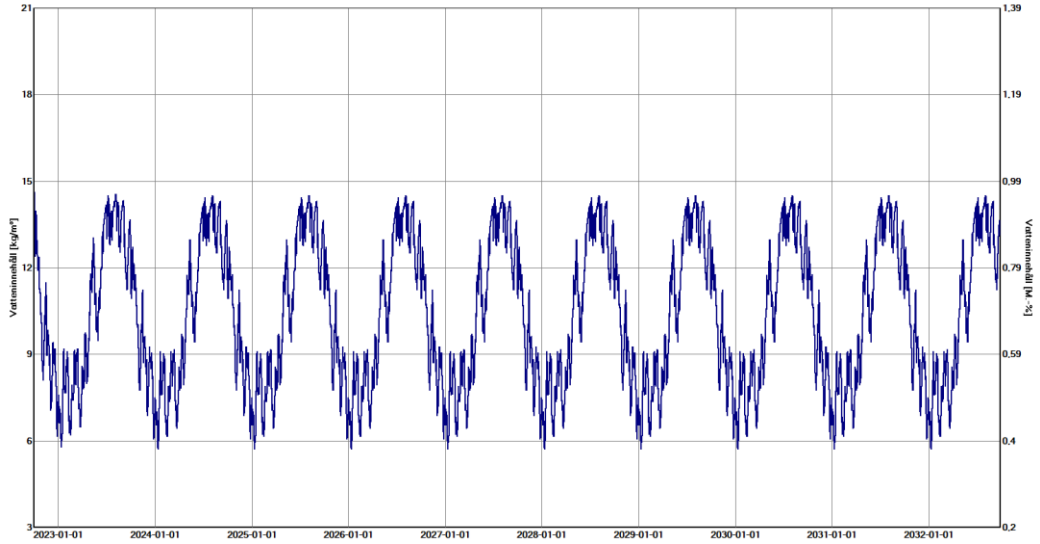
The disc will maintain a low moisture level at all times.

EcoCocon panel (straw):



It takes a season to stay at a low level, but even after the deliberately high value at the beginning, the water content drops below 10.5 M.-% and stays there all the time.

Interior plaster:



The moisture content does not take any harmful forms here.

Summary

The simulation shows that all investigated wall types with an intentionally high moisture content at the construction stage dry out. Of course, there is a periodic accumulation and reduction of moisture in the individual layers, but this never reaches alarming proportions.

A simulation is only as good as its input data, including boundary conditions. The calculation was made with extra safety margins, but each case and situation are special. Therefore, when applying the results in the report, certain aspects have to be taken into account:

1. The calculations are only related to the defined and specified boundary conditions and the named object and substructures and cannot be transferred without further verification, even if the design is the same or similar.
2. For the calculation to be representative, accurate production is required and the contractor is responsible for ensuring that the specifications are consistently maintained.
3. Airtightness and, if possible, airtightness testing, are a prerequisite.
4. The specified moisture contents for the materials, specific to wood or wood-based products, must not be exceeded. Careful, clean and dry storage must be ensured.

Tvärred, 23rd March 2023

Ingo Theoboldt

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