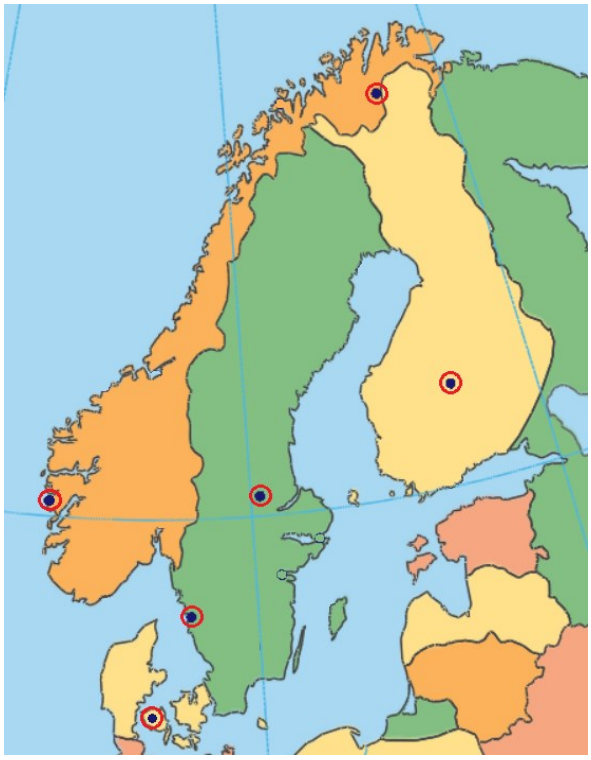
Hygrothermal analysis of the *EcoCocon* wall system in different Scandinavian climatic conditions

(as of 14 February 2023)



Passivhusbyrån Ingo Theoboldt

Tel: +46 (0) 762 874 024

Address: Vasared 301, 523 94 Tvärred, Sweden

E-mail: info@passivhusbyran.se

Content

Background and mission

Passivhusbyrån has been commissioned to produce a hygrothermal analysis of *EcoCocon's* building systems for six different Scandinavian locations (climates) and eleven different wall types. The locations are Borlänge (Sweden), Gothenburg (Sweden), Bergen (Norway), Karasjok (Norway), Jyväskylä (Finland) and Aarslev (Denmark).

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 data, and to examine the performance and long-term moisture safety. In order to get a good overview of the effects under the different Scandinavian climatic conditions, the locations were chosen with a wide spread (see map on the front page).

Reservations

The calculations and simulations for this project are based on the submitted sketches and input data received between 2022-06-09 and 2023-02-03.
Climate data needed for the simulations are obtained from the following sources: the Lund University of Technology (Borlänge and Gothenburg), the Norwegian University of Science and Technology (Bergen and Karasjok), the Finnish Meteorological Institute (Jyväskylä), and the Meteonorm-8 programme for Aarslev.

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] (w-value). If applicable, moisture-dependent thermal conductivity [W/m·K] and water vapour diffusion resistance number are also included. The weatherproofing membrane used in all simulations has a sd-value of 0.05 m, and wall type M has an additional vapour retarder with a sd-value of 6.45 m.

Climate data - these quantities describe the boundary conditions acting on the internal or external surface of the building component: rainfall load on the surface [ltr/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 of wall type A (used in all places except Karasjok):

Materials:

	- Scandinavian spruce transverse direction	0.025 m
	- Air Layer	0.05 m
	- wood fibre board	0.06 m
	- weather resistive barrier (sd=0,05m)	0.00 m
	- EcoCocon straw bales	0.4 m
	- Clay Plaster	0.025 m

Construction of wall type B (used in all places except Karasjok):

Materials:

	- Scandinavian spruce transverse direction	0.025 m
	- Air Layer	0.05 m
	- wood fibre board	0.06 m
	- weather resistive barrier (sd=0,05m)	0.0 m
	- EcoCocon straw bales	0.4 m
	- plasterboard	0.013 m

Construction of wall type C (used in all locations except Karasjok):

Materials:

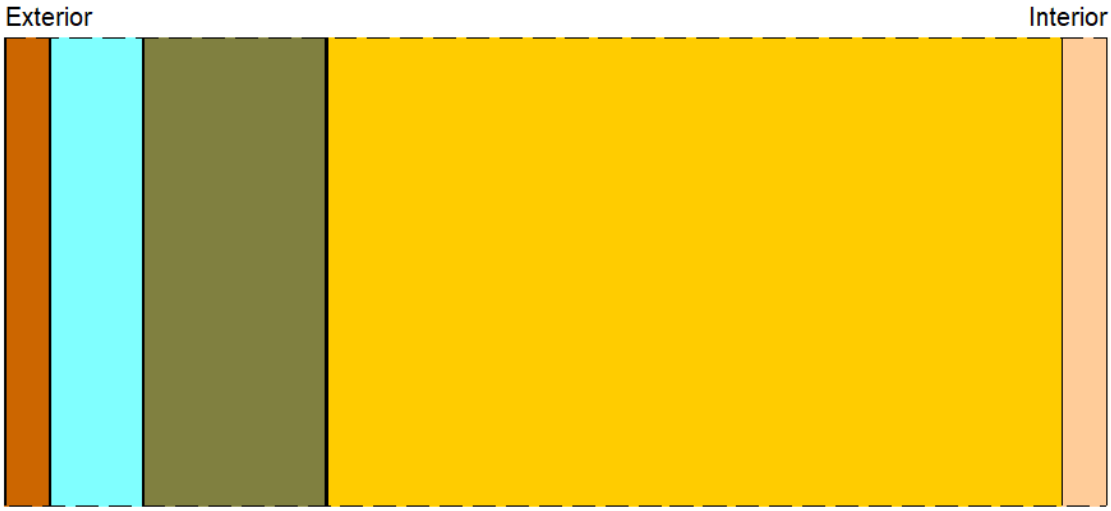
	- Mineral Plaster	0.008 m
	- wood fibre board	0.06 m
	- weather resistive barrier (sd=0,05m)	0.0 m
	- EcoCocon straw bales	0.4 m
	- Clay Plaster	0.025 m

Construction of wall type D (used in all locations except Karasjok):

Materials:

- Mineral Plaster	0.008 m
- wood fibre board 60mm	0.06 m
- weather resistive barrier (sd=0,05m)	0.0 m
- EcoCocon straw bales	0.4 m
- plasterboard	0.013 m

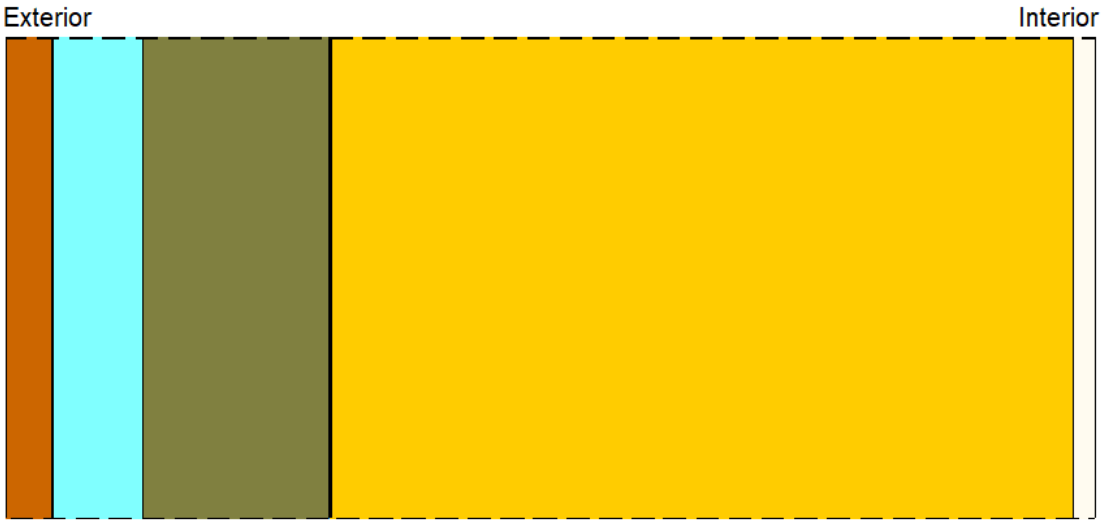
Construction of wall type E (used only in Karasjok calculations):



Material:

- Scandinavian spruce, tranverse direction	0.025 m
- Air layer	0.05 m
- Wood fibre board	0.1 m
- Weather resistive barrier (sd = 0.05 m)	0.001 m
- EcoCocon straw panel	0.4 m
- Clay plaster	0.025 m

Construction of wall type F (used only in Karasjok calculations):



Material:

- Scandinavian spruce, tranverse direction	0.025 m
- Air layer	0.05 m
- Wood fibre board	0.1 m
- Weather resistive barrier (sd = 0.05 m)	0.001 m
- EcoCocon straw panel	0.4 m
- Plaster board	0.013 m

Construction of wall type G (used only in Karasjok calculations):

Materials:

	- Mineral Plaster	0.008 m
	- wood fibre board	0.1 m
	- weather resistive barrier (sd=0,05m)	0.0 m
	- EcoCocon straw bales	0.4 m
	- Clay Plaster	0.025 m

Construction of wall type H (used only for Karasjok calculations):

Materials:

	- Mineral Plaster	0,008 m
	- wood fibre board	0,1 m
	- weather resistive barrier (sd=0,05m)	0,0 m
	- EcoCocon straw bales	0,4 m
	- plasterboard	0,013 m

Construction of wall type J (only used in Aarslev's calculations):

Materials:

- Scandinavian spruce transverse direction	0.025 m
- Air Layer	0.05 m
- wood fibre board	0.025 m
- weather resistive barrier (sd=0,05m)	0.00 m
- EcoCocon straw bales	0.4 m
- Clay Plaster	0.025 m

Construction of wall type K (only used in Aarslev's calculations):

Materials:

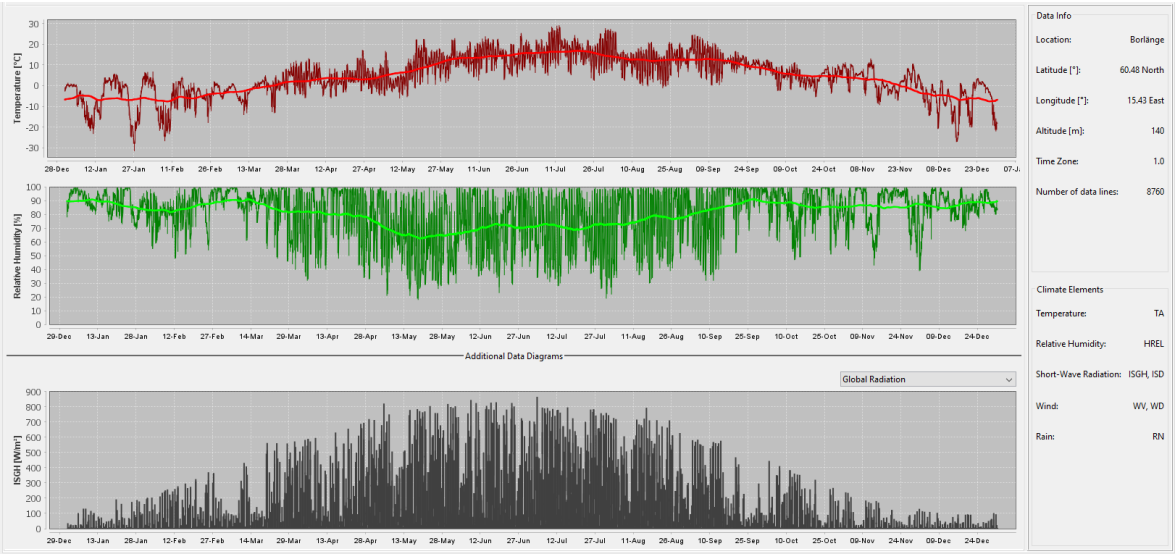
- Scandinavian spruce transverse direction	0.025 m
- Air Layer	0.05 m
- wood fibre board	0.025 m
- weather resistive barrier (sd=0,05m)	0.0 m
- EcoCocon straw bales	0.4 m
- plasterboard	0.013 m

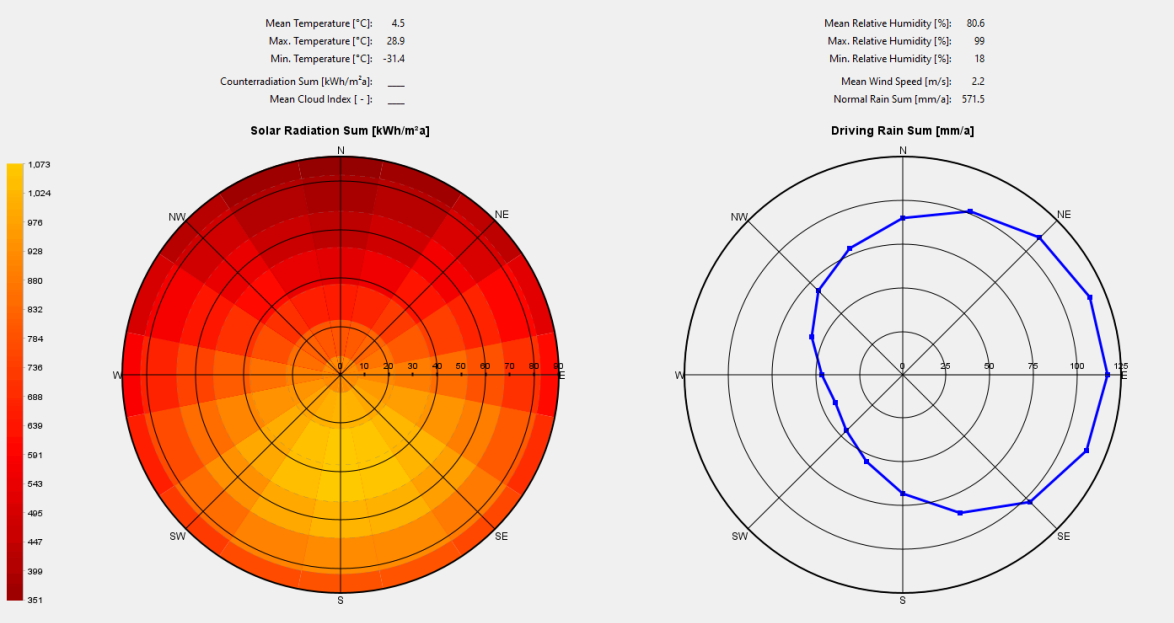
Construction of wall type M (only used in Aarslev's calculations):

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

Outdoor climate Borlänge (Sweden)





The direction with the most driving rain is east. There is also only moderate solar radiation, with lower drying capacity than that to the south. For analyses of plastered walls, the north-east orientation is used, as there is still a lot of driving rain there and also less drying from solar radiation. For ventilated facades, northward is always the decisive orientation.

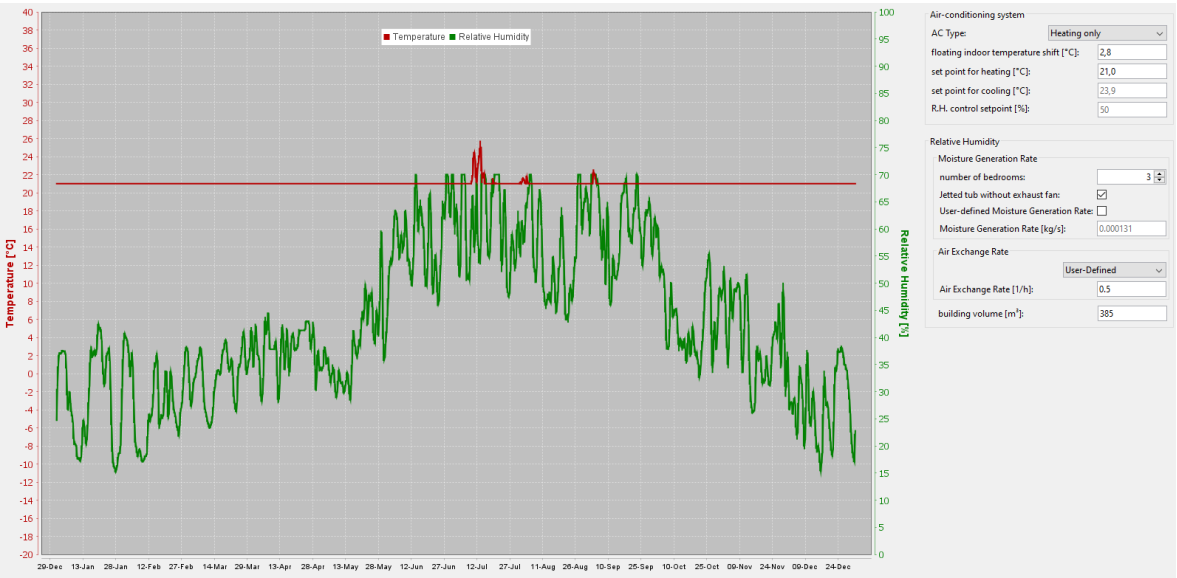
Indoor climate Borlänge

The same model building was used for all simulations: a three-bedroom villa with 385 m³ interior volume.

A ventilation unit delivers 0.5 air exchanges per hour. A whirlpool bath without (additional) exhaust fan was added for slightly higher humidity production - just to be on the safe side.

Airconditioning is only available in the form of heating, no active cooling and dehumidification. The set point for heating is 21°C (standard value according to BEN/BBR).

The indoor climate model was based on *ASHRAE 160-2021* as this provided the means to represent the above conditions. For Borlänge it looks like this:

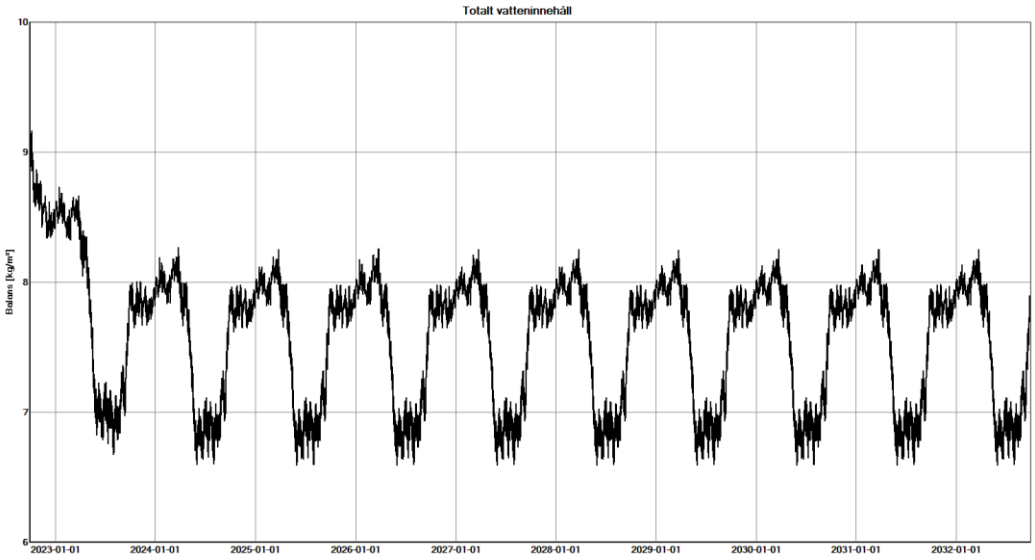


Results Borlänge

The following diagram shows the water content in total and in the individual layers.

Wall type A - ventilated facade, plaster on the inside

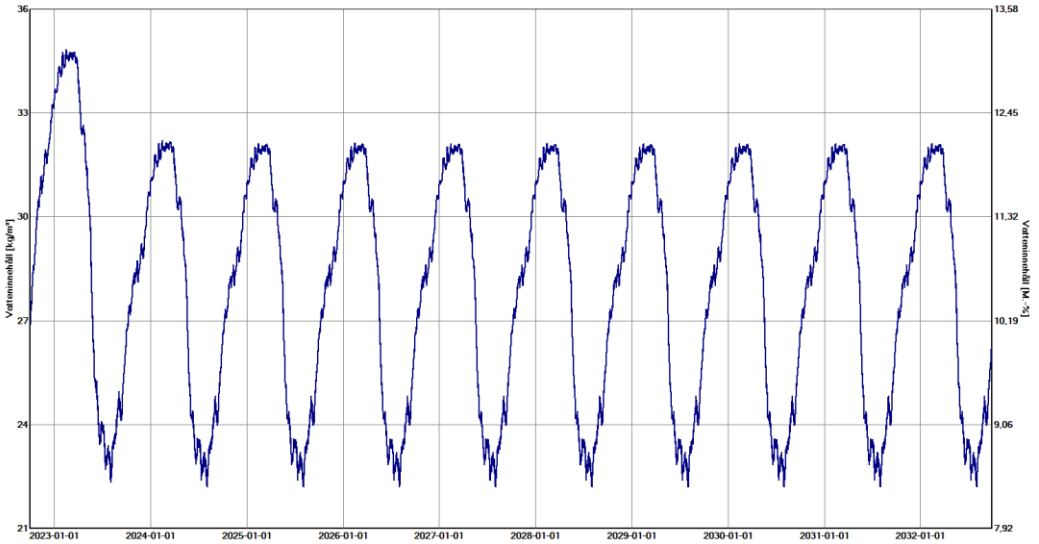
<u>The whole wall</u>



Even with high built-in moisture content (assumed at 80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

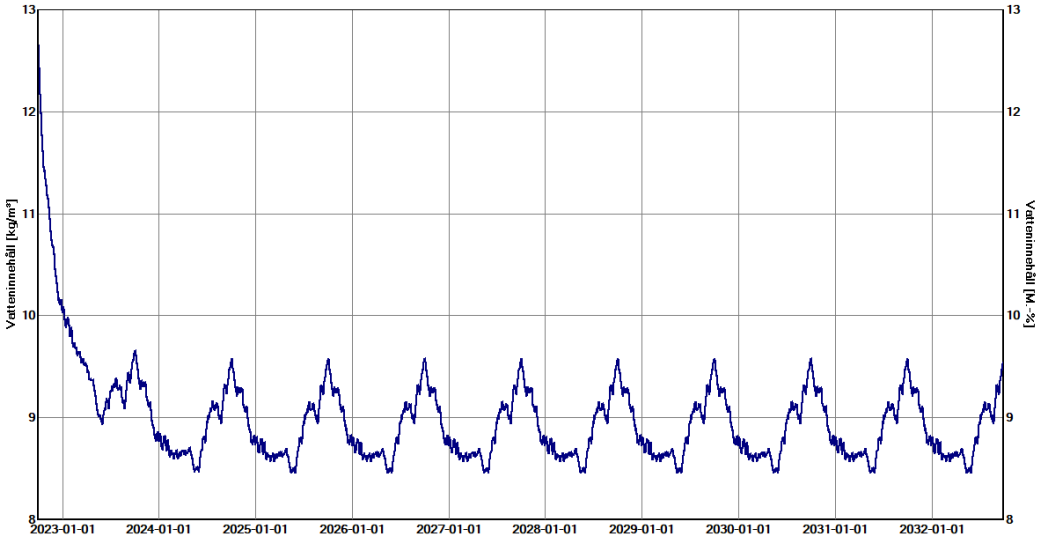
Single layers

Wood fibre behind the air gap:



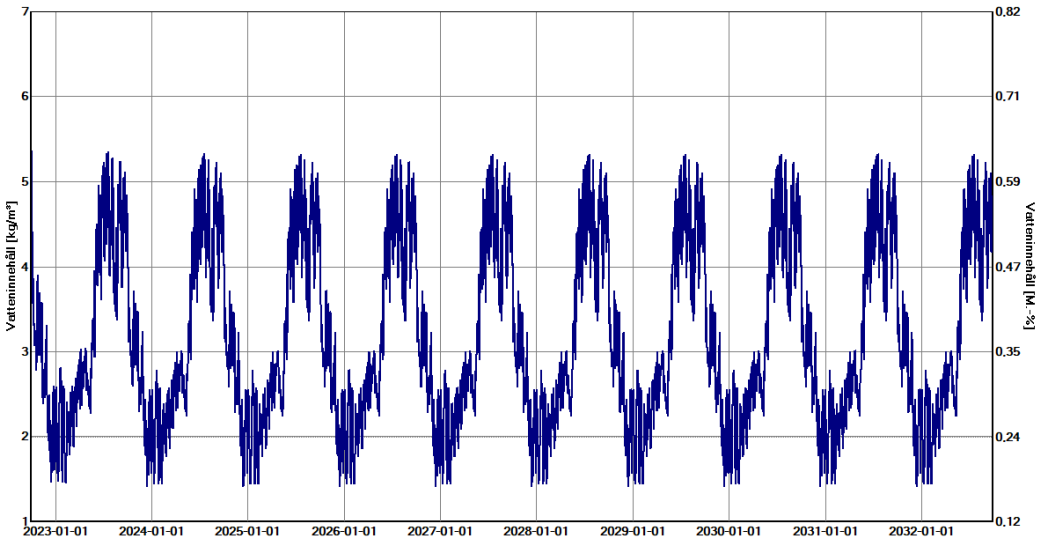
The wood fibreboard has the chance to dry out and the moisture content is always below 13 M.-% and thus far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays well below 10 M.-% all the time.

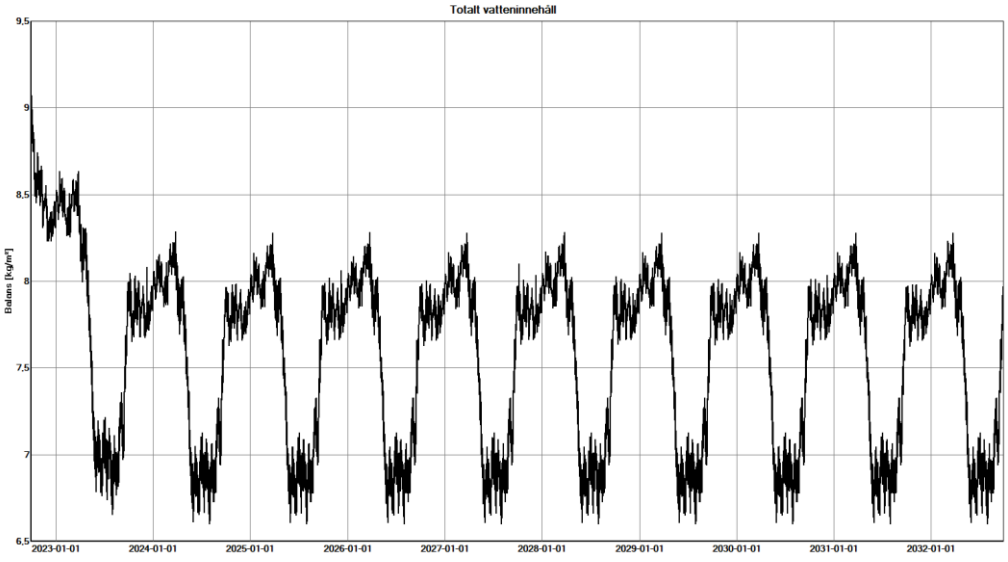
Plaster layer:



The moisture content does not take any harmful forms here. On the contrary: the layer helps to improve the indoor climate by buffering the humidity.

Wall type B - ventilated facade, plasterboard on the inside

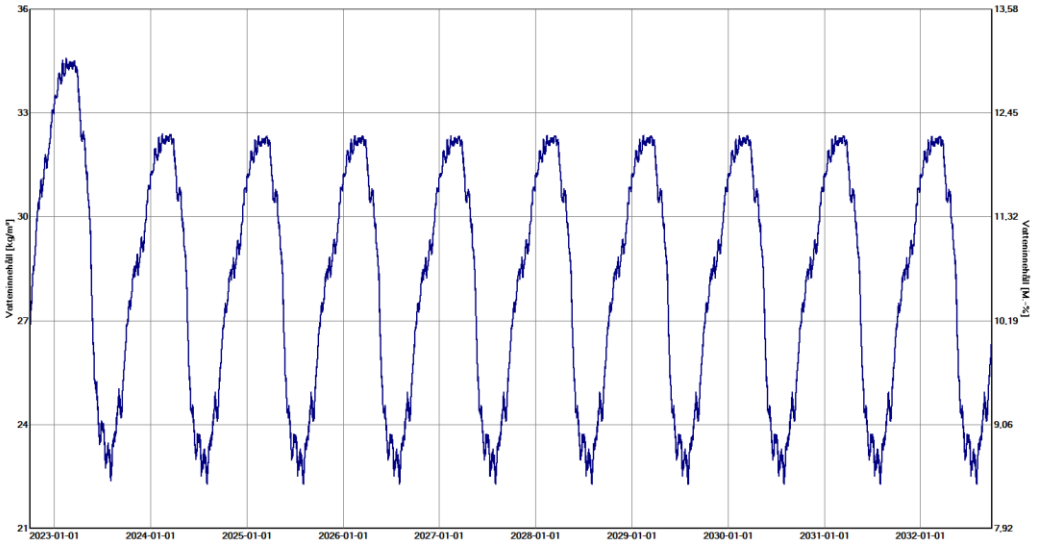
<u>The whole wall</u>



Even with a lot of built-in moisture, the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

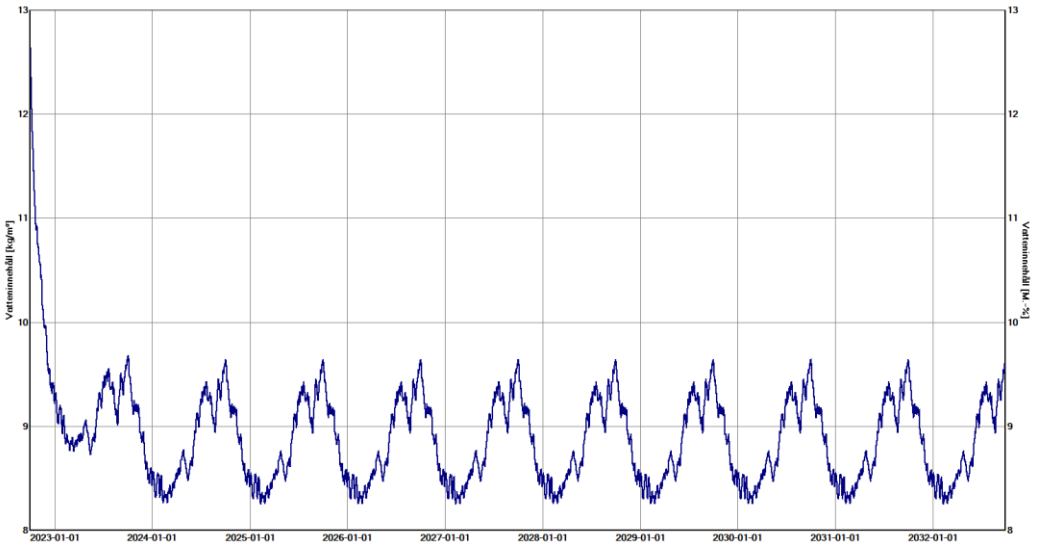
Single layers

Wood fibre behind the air gap:



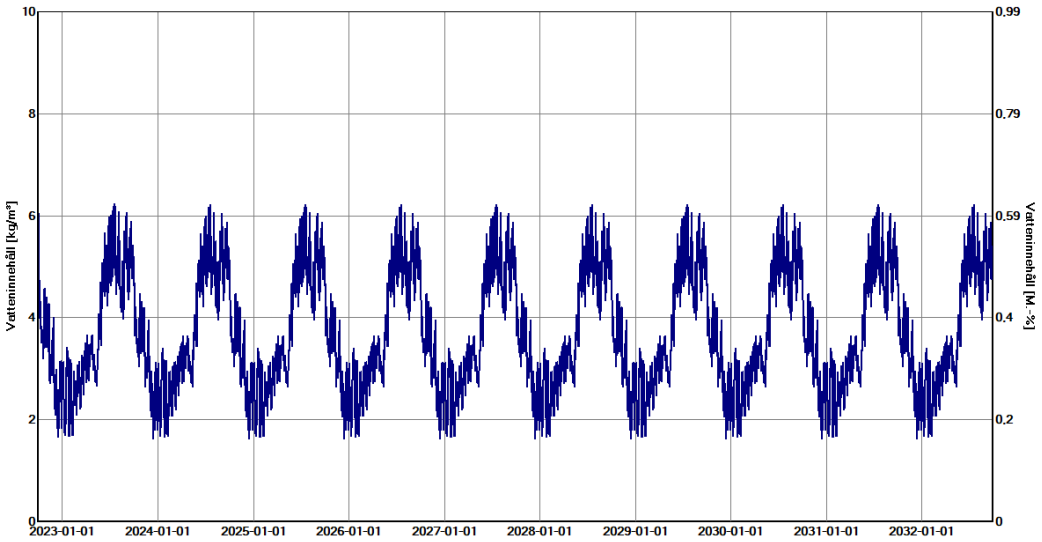
The wood fibreboard has the chance to dry out and the moisture content is always below 13 M.-% and thus far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays well below 10 M.-% all the time.

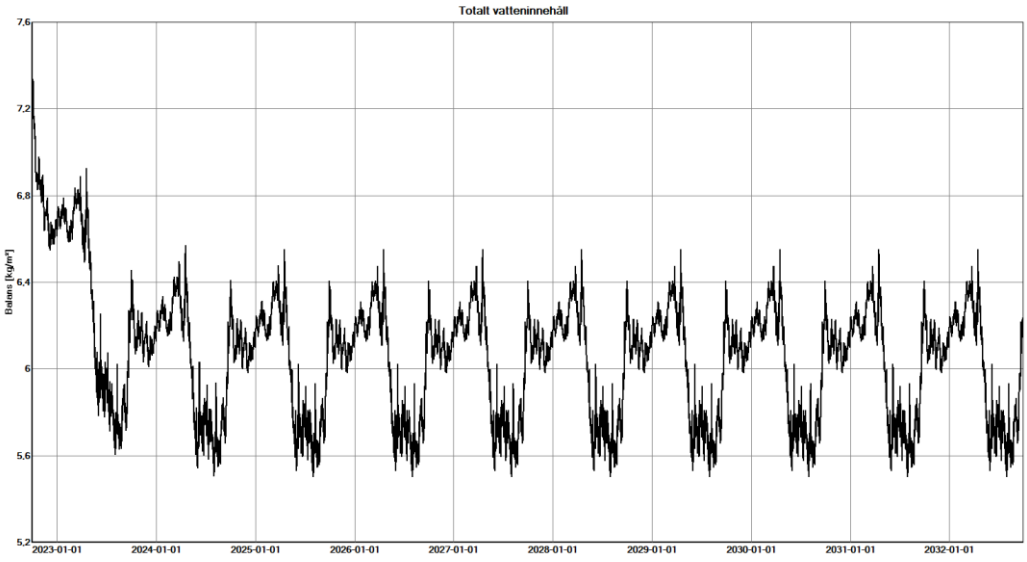
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type C - plastered facade, plaster on the inside

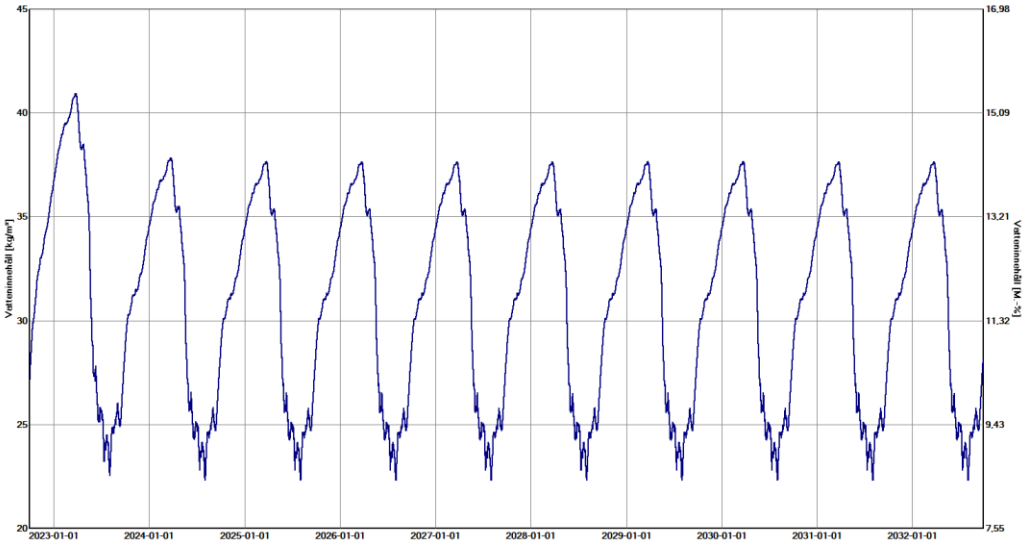
<u>The whole wall</u>



Even with high built-in moisture content (assumed at 80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

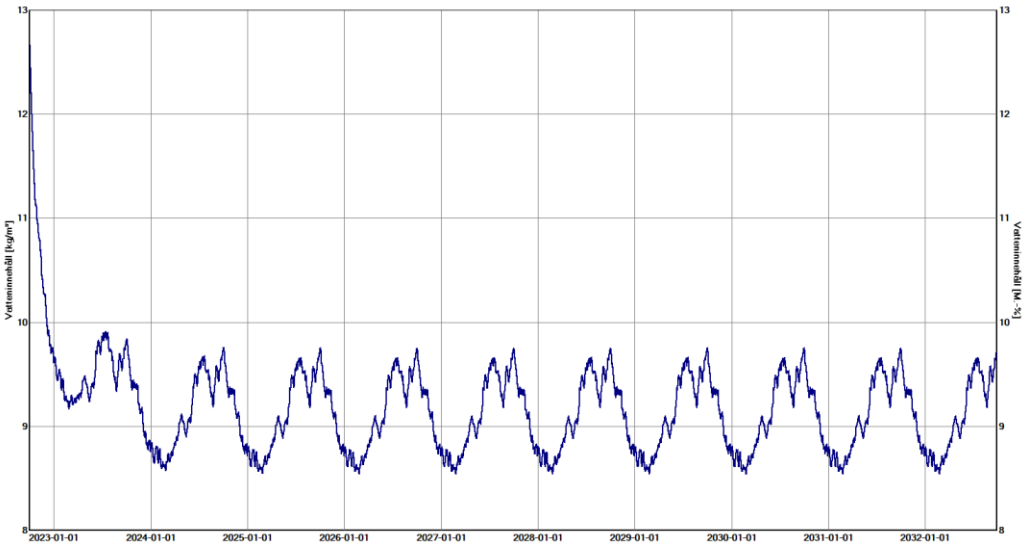
Single layers

Wood fibre behind the plaster:



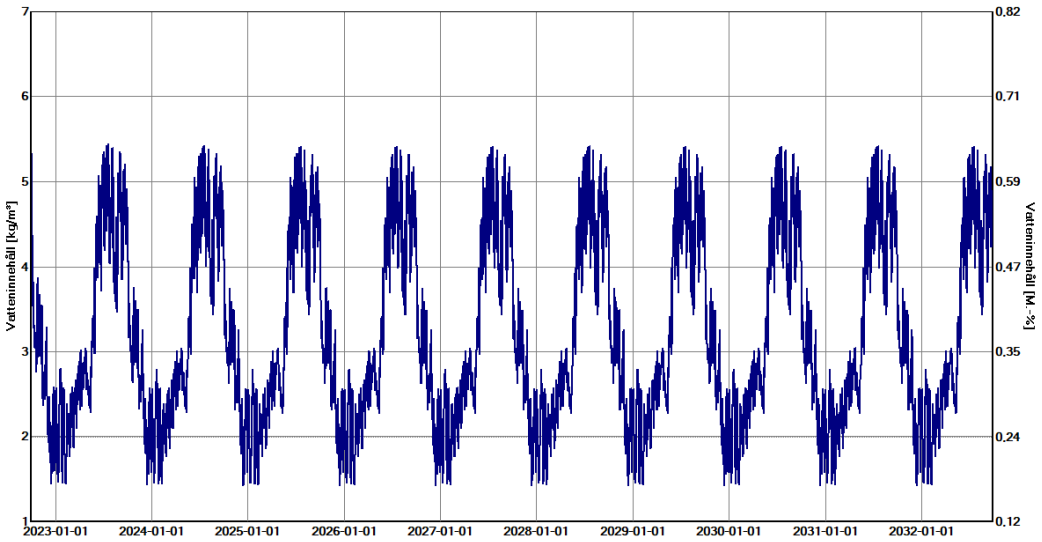
The wood fibreboard has the chance to dry out and the moisture content is always below 15 M.-% and thus below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

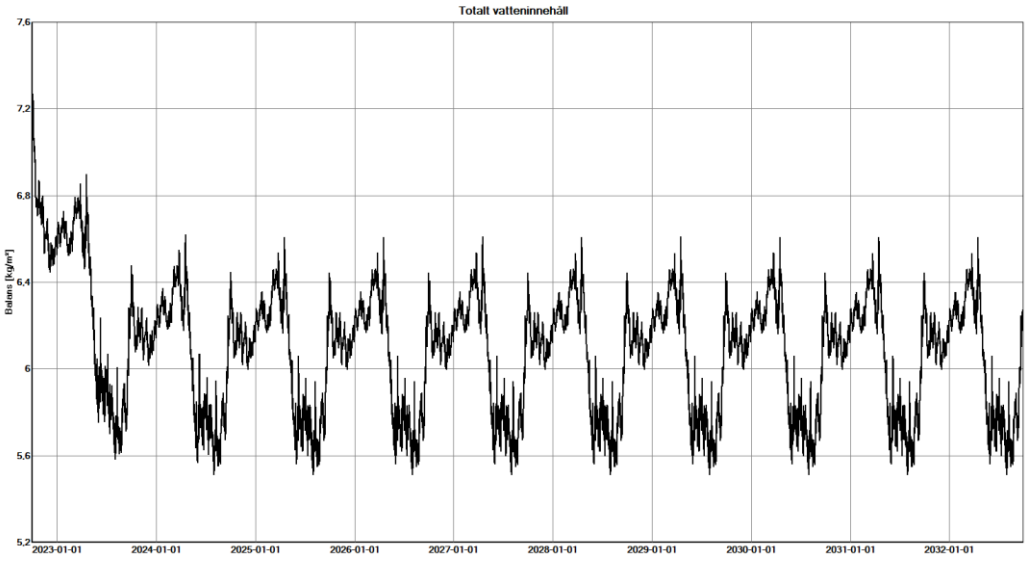
Plaster layer:



The moisture content does not take any harmful forms here.

Wall type D - plastered facade, plasterboard on the inside

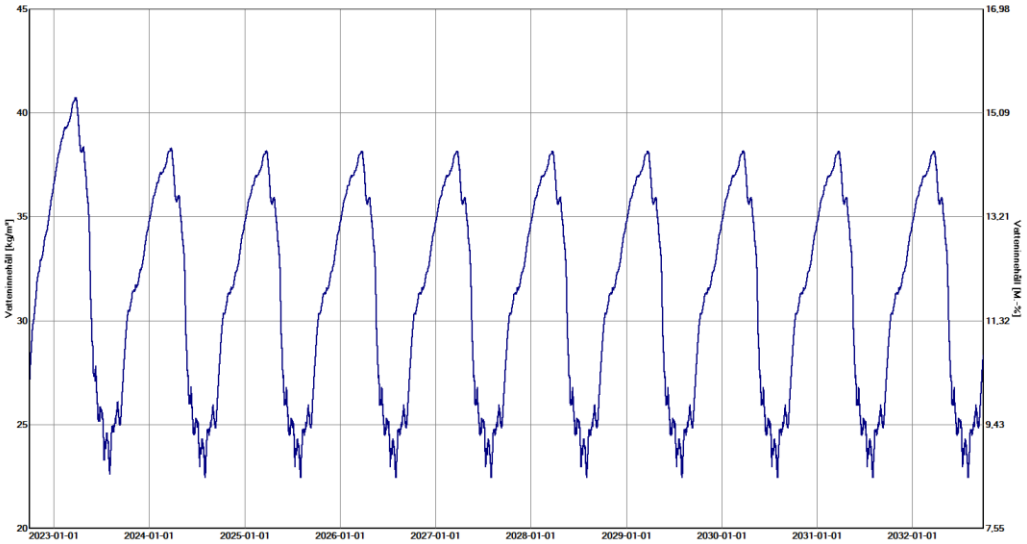
<u>The whole wall</u>



Even with a high built-in moisture content, the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

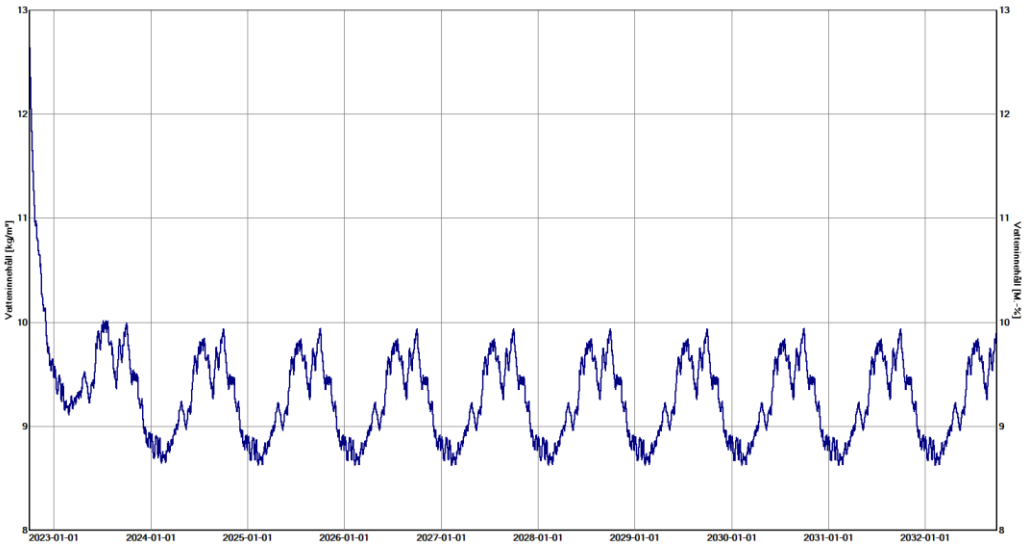
Single layers

Wood fibre behind the plaster:



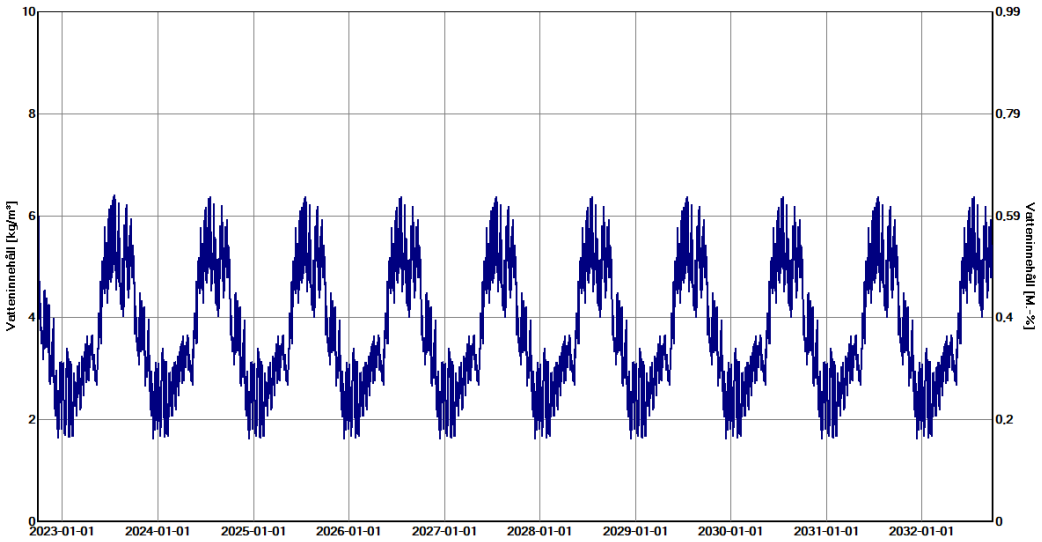
The wood fibreboard has the chance to dry out and the moisture content is always below 15 M.-% and thus below the critical limit.

EcoCocon panel (straw):



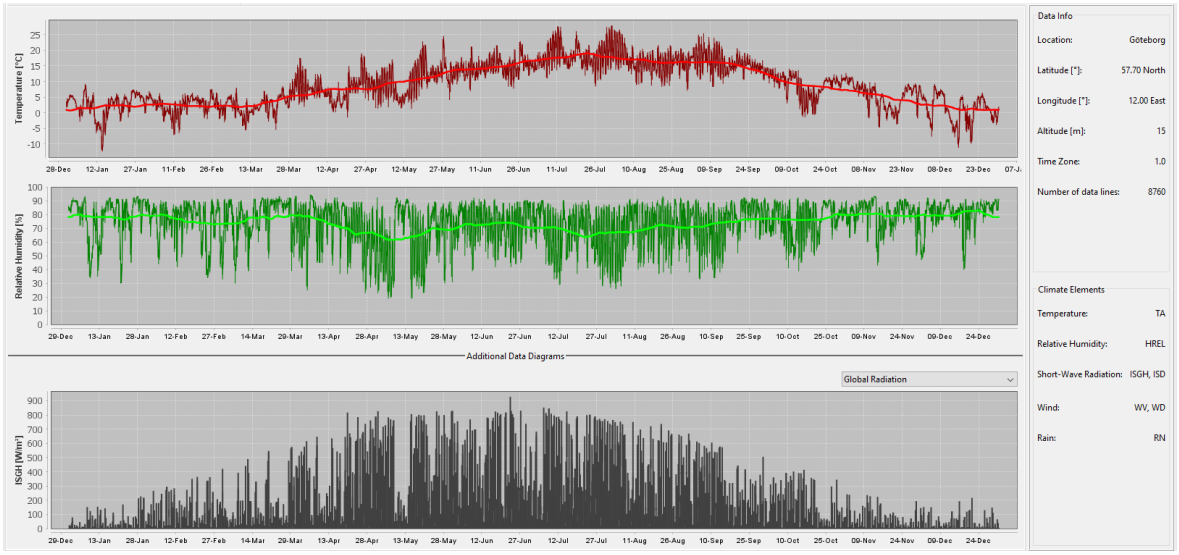
After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

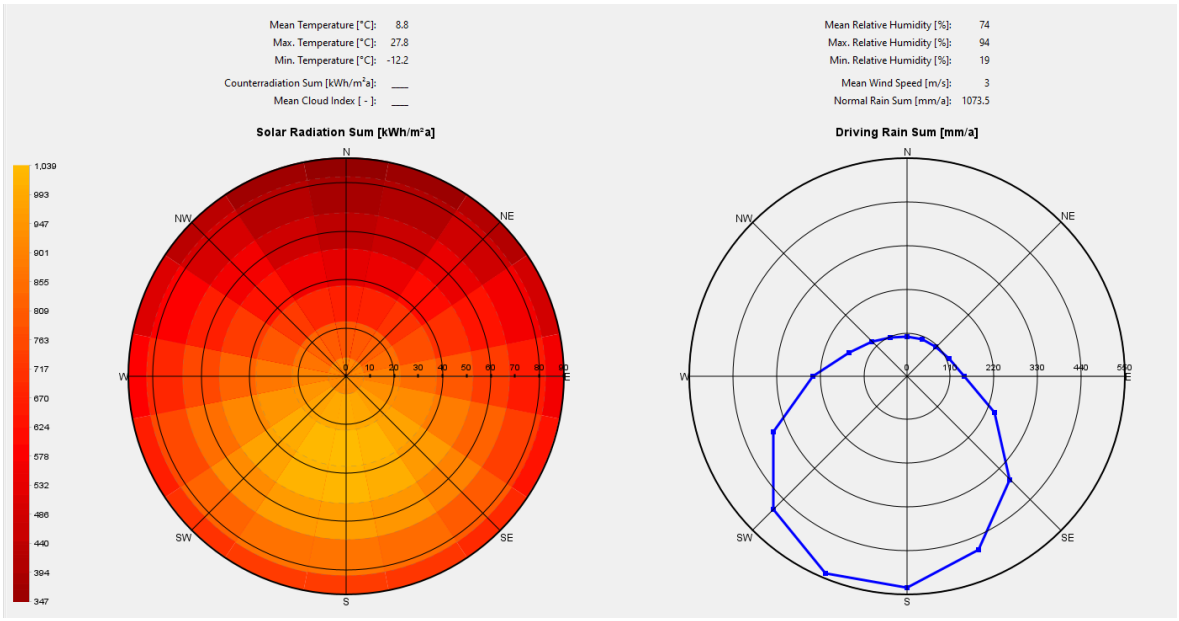
Plasterboard:



The moisture content does not take any harmful forms here.

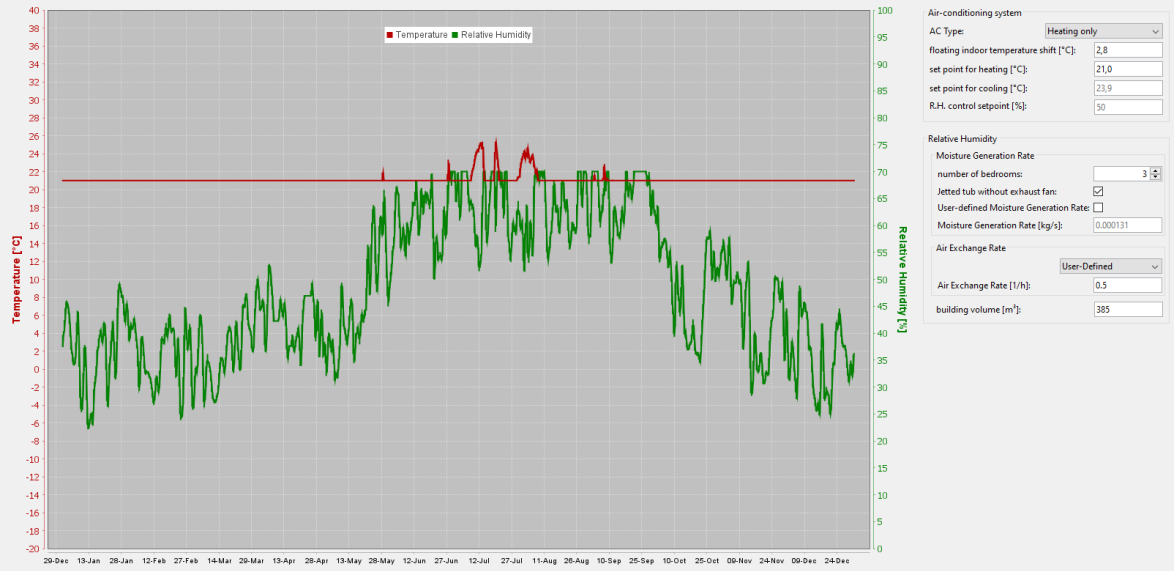
Outdoor climate Gothenburg (Sweden)





The direction with the most driving rain is south-southwest. There is a lot of solar radiation, with higher drying capacity than that towards most other orientations. Therefore, the southwest orientation is used for analyses of plastered walls, still with a lot of driving rain but slightly less drying capacity. For ventilated facades, straight north is always the decisive orientation.

Indoor climate Gothenburg

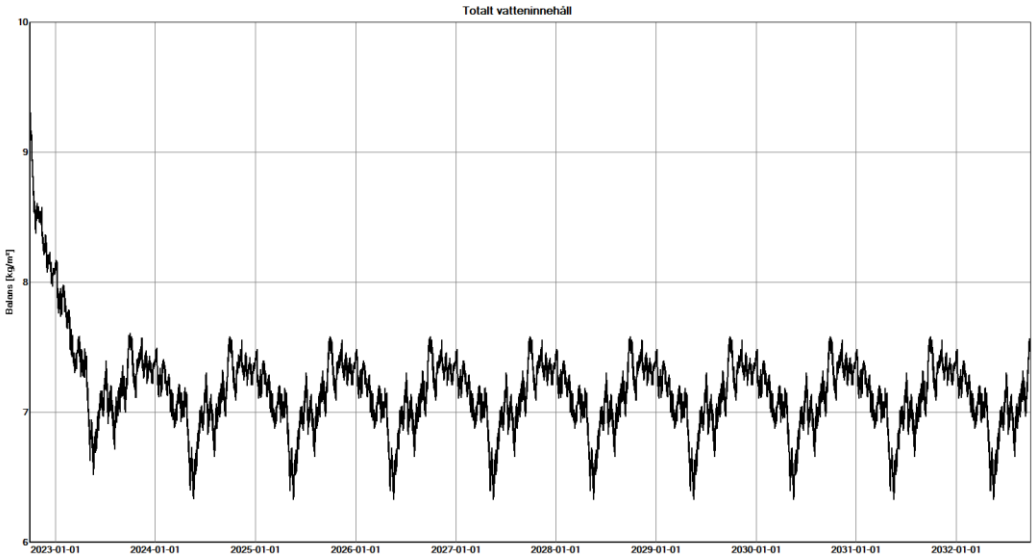


Results Gothenburg

The following diagram shows the water content in total and in the individual layers.

Wall type A - ventilated facade, plaster on the inside

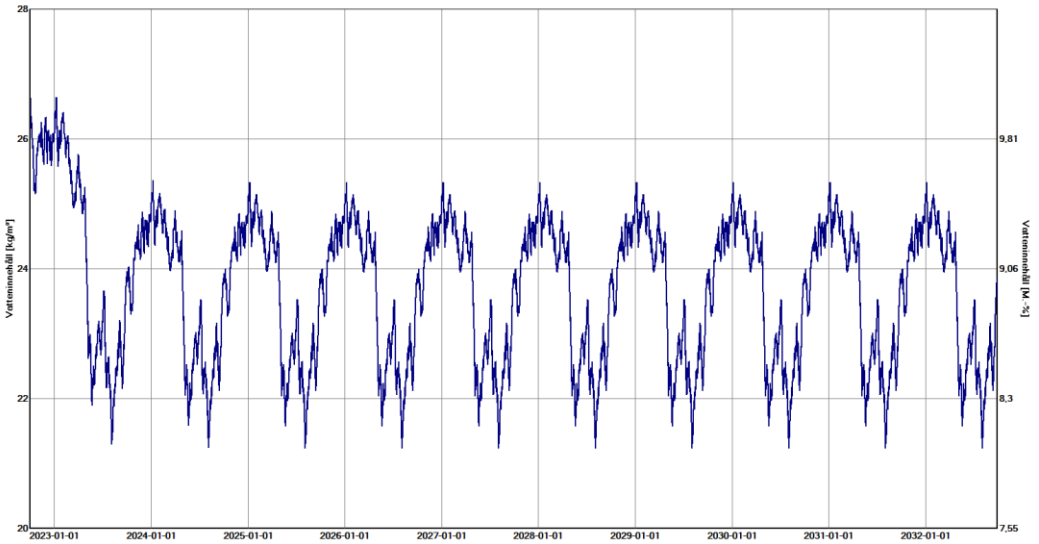
<u>The whole wall</u>



Even with high built-in moisture content (assumed at 80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

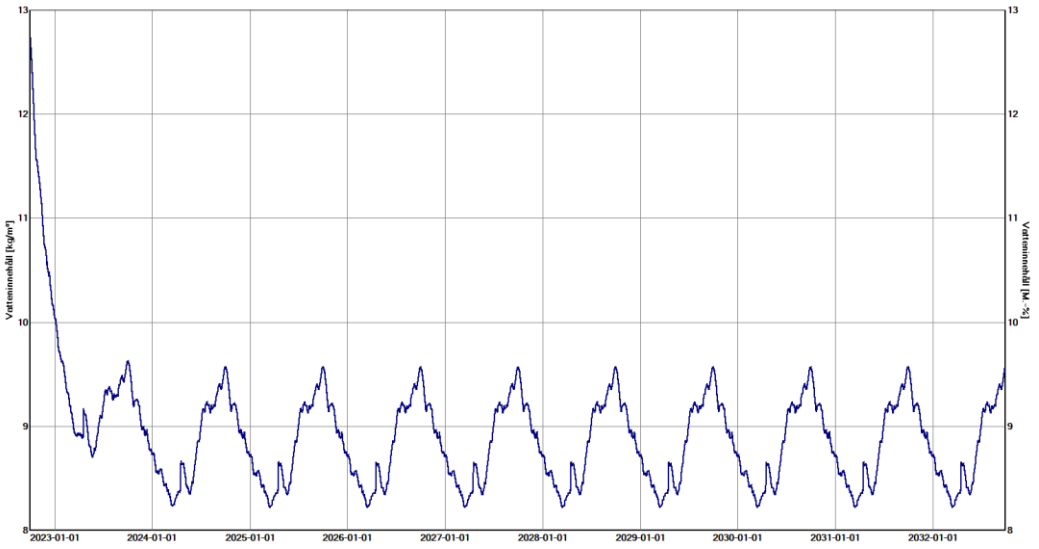
Single layers

Wood fibre behind the air gap:



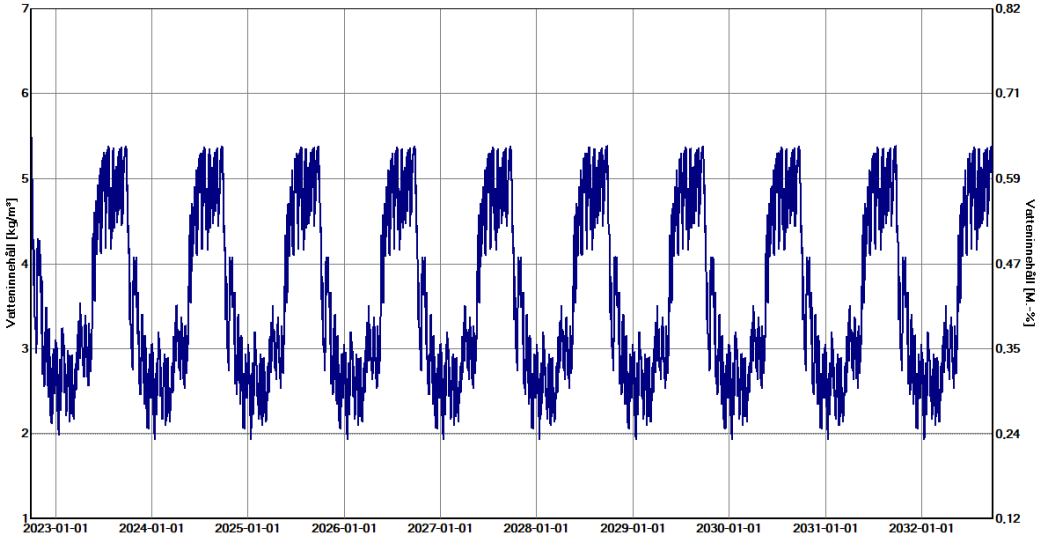
The wood fibreboard has the chance to dry out and the humidity is always below 10 M.-% and thus far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

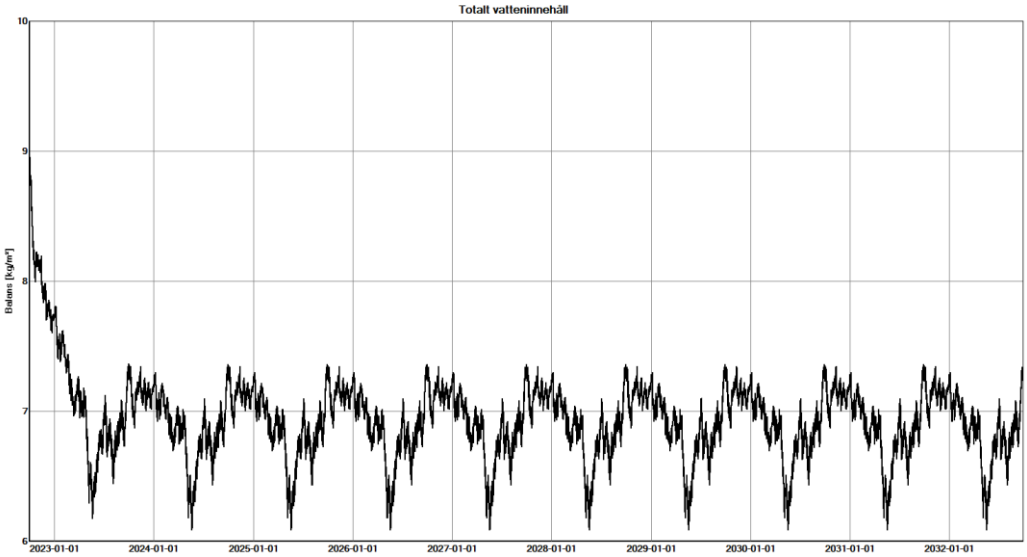
Plaster layer:



The moisture content does not take any harmful forms here. On the contrary: the layer helps to improve the indoor climate by buffering the humidity.

Wall type B - ventilated facade, plasterboard on the inside

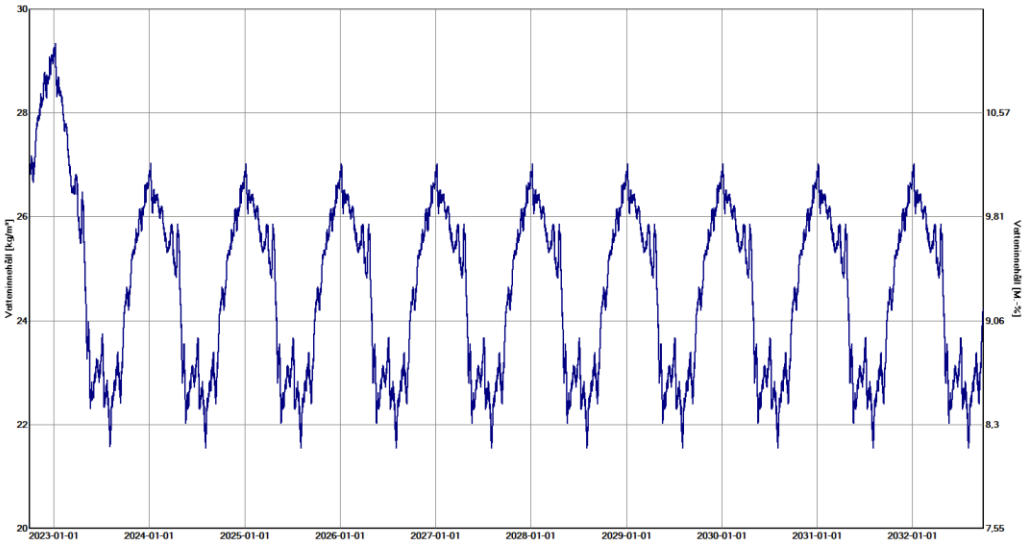
<u>The whole wall</u>



Even with a high built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

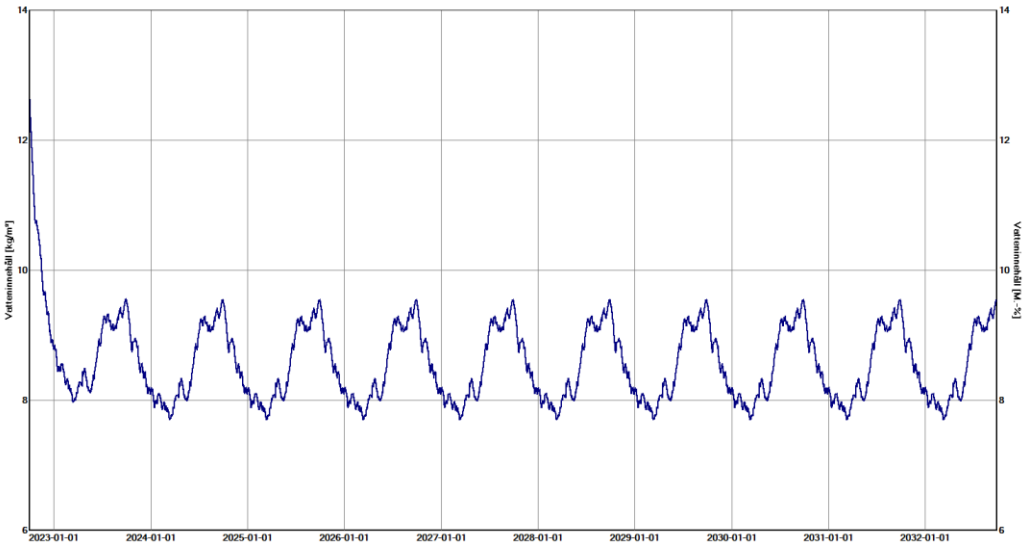
Single layers

Wood fibre behind the air gap:



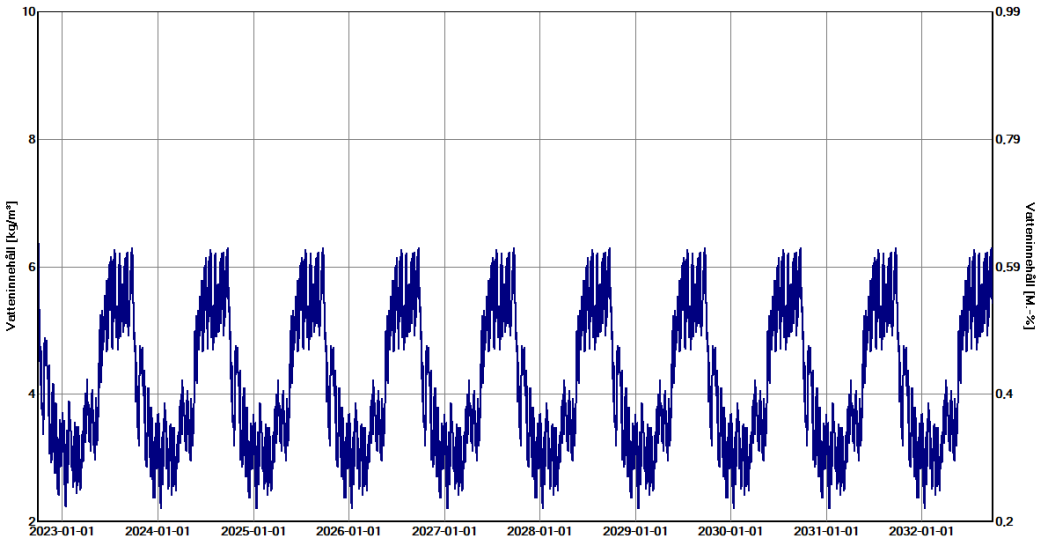
The wood fibreboard has the chance to dry out and the water content is always below the 18 M.-% which is considered to be the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

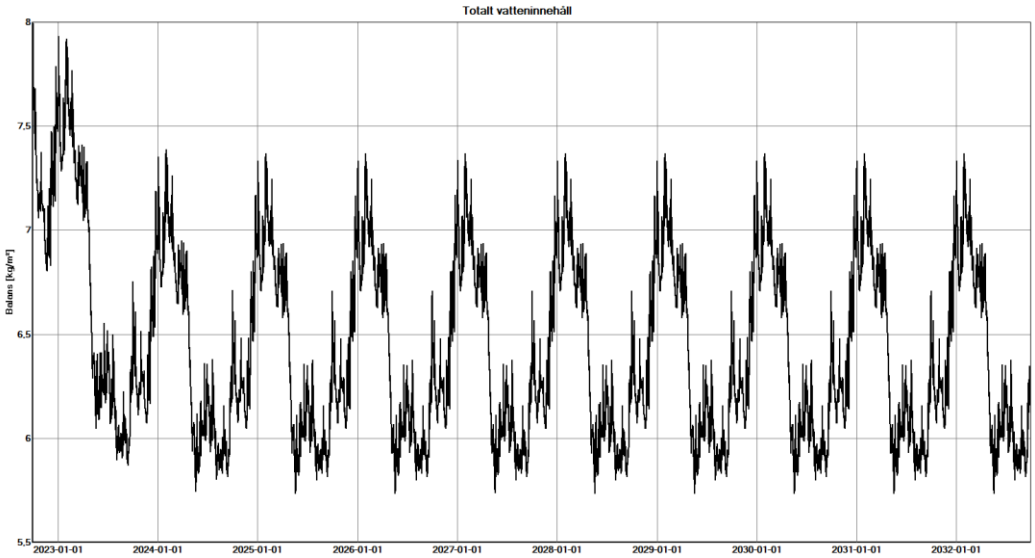
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type C - plastered facade, plaster on the inside

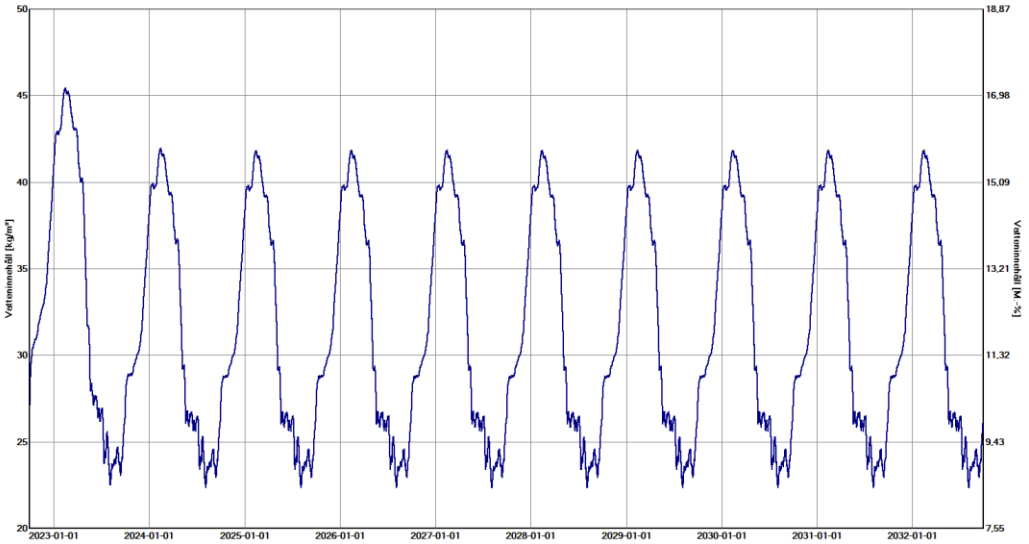
<u>The whole wall</u>



Even with high built-in moisture content (assumed at 80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

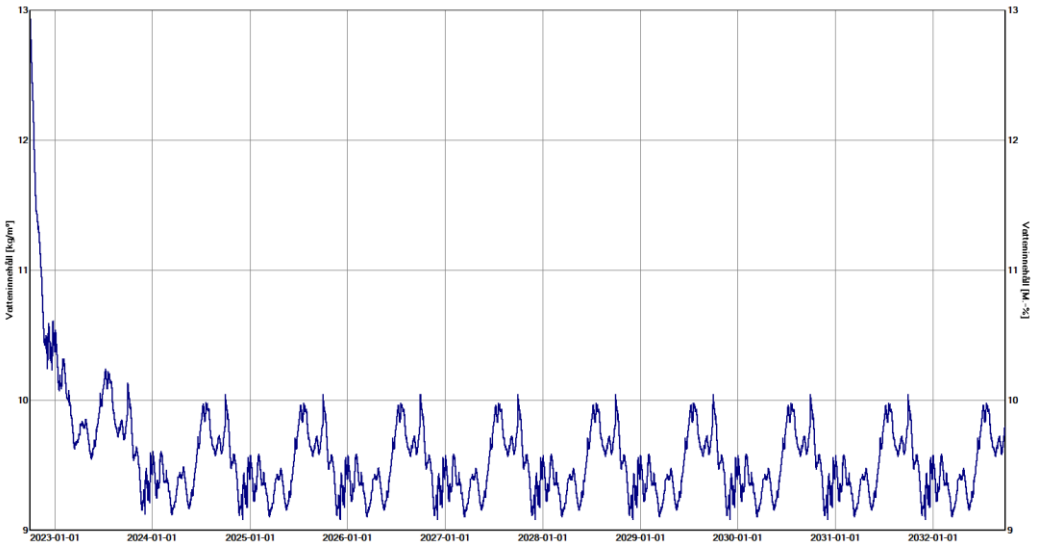
Single layers

Wood fibre behind the plaster:



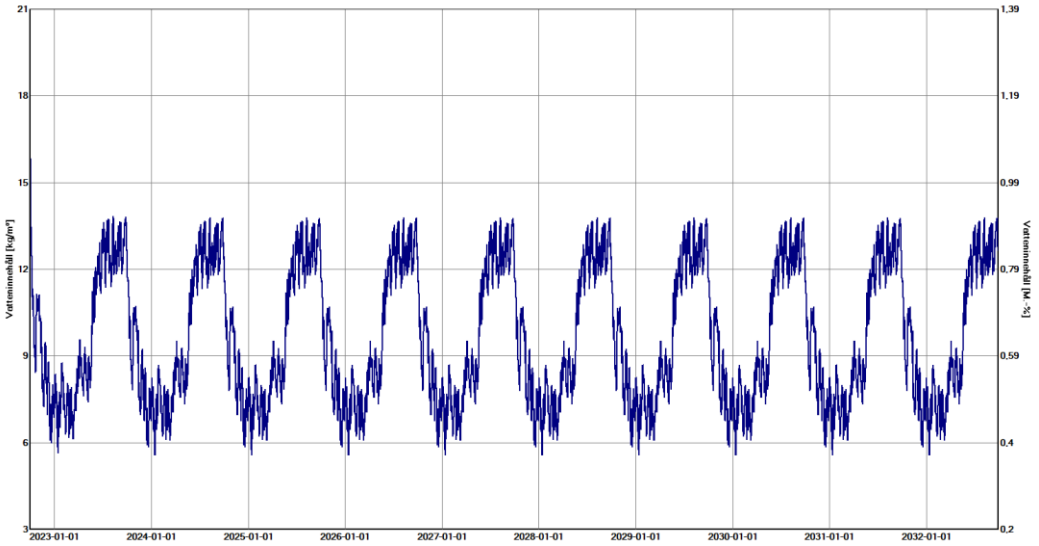
The wood fibreboard has the chance to dry out and the water content is always below 16 M.-% and thus below the lowest critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

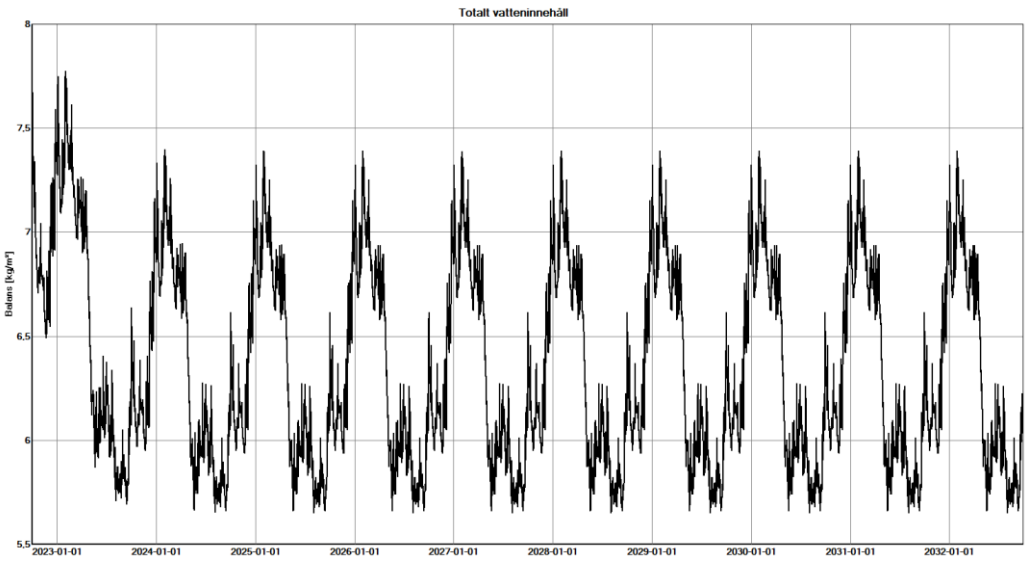
Plaster layer:



The moisture content does not take any harmful forms here.

Wall type D - plastered facade, plasterboard on the inside

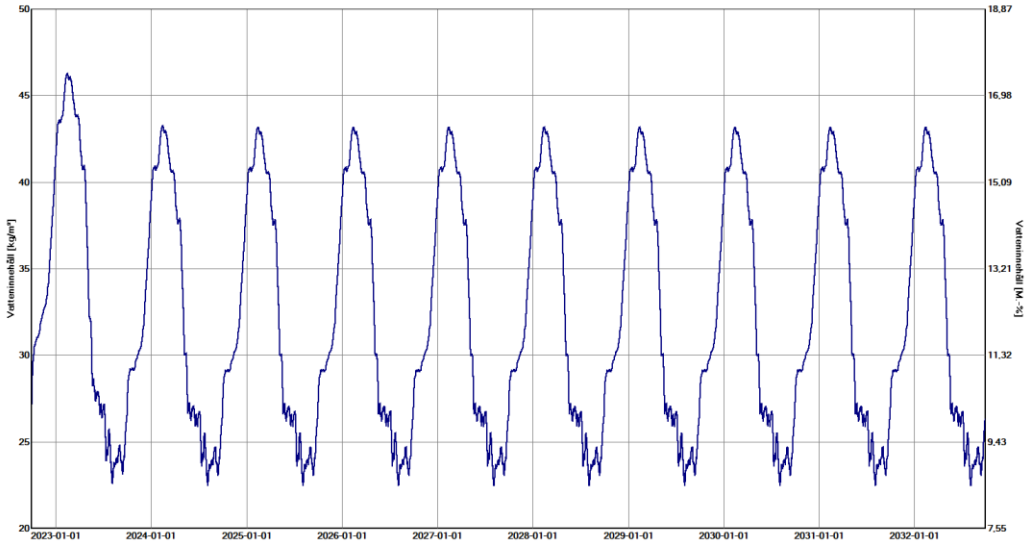
<u>The whole wall</u>



Even with a high built-in moisture content, the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

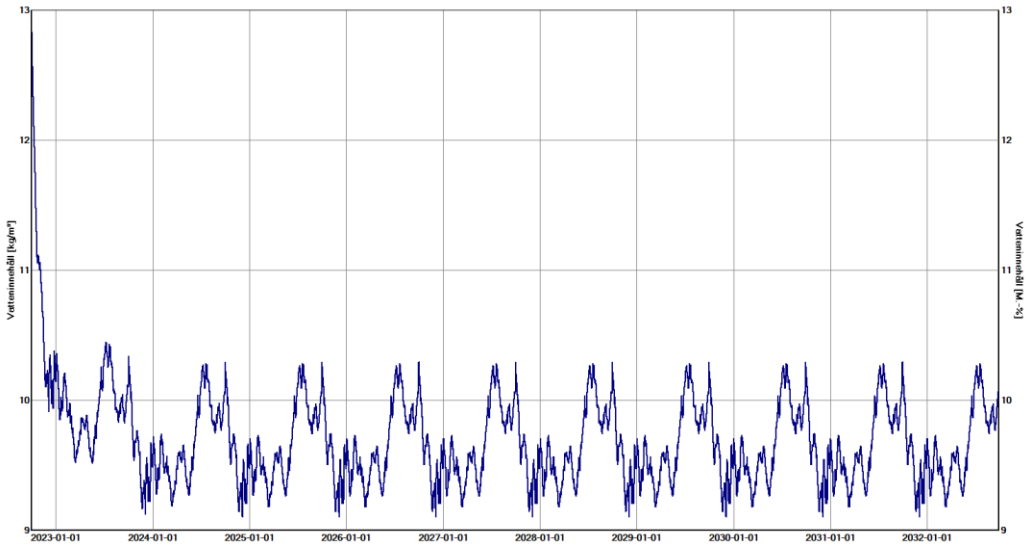
Single layers

Wood fibre behind the plaster:



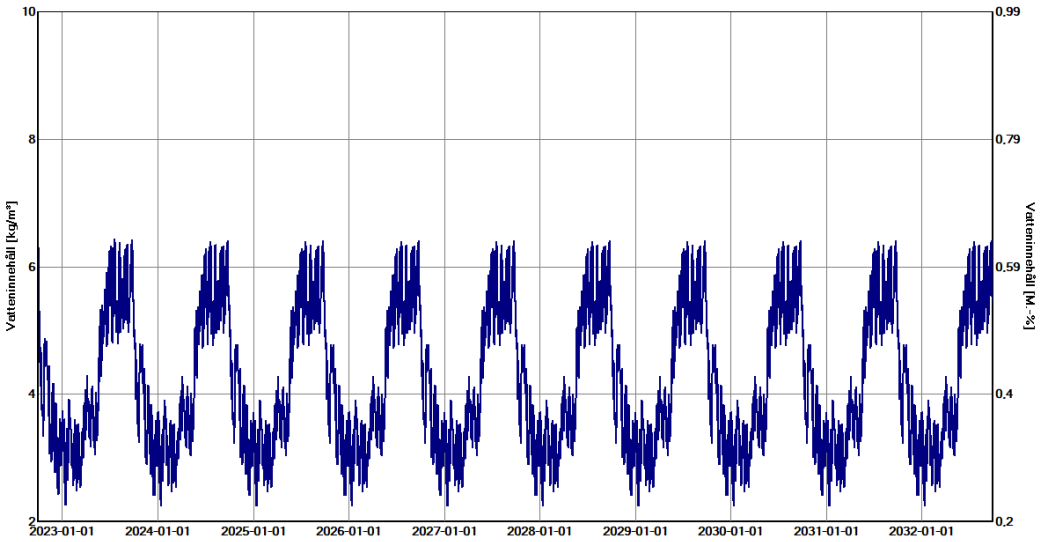
The wood fibreboard has the chance to dry out and the moisture content is always below 17 M.-% and thus below the critical limit.

EcoCocon panel (straw):



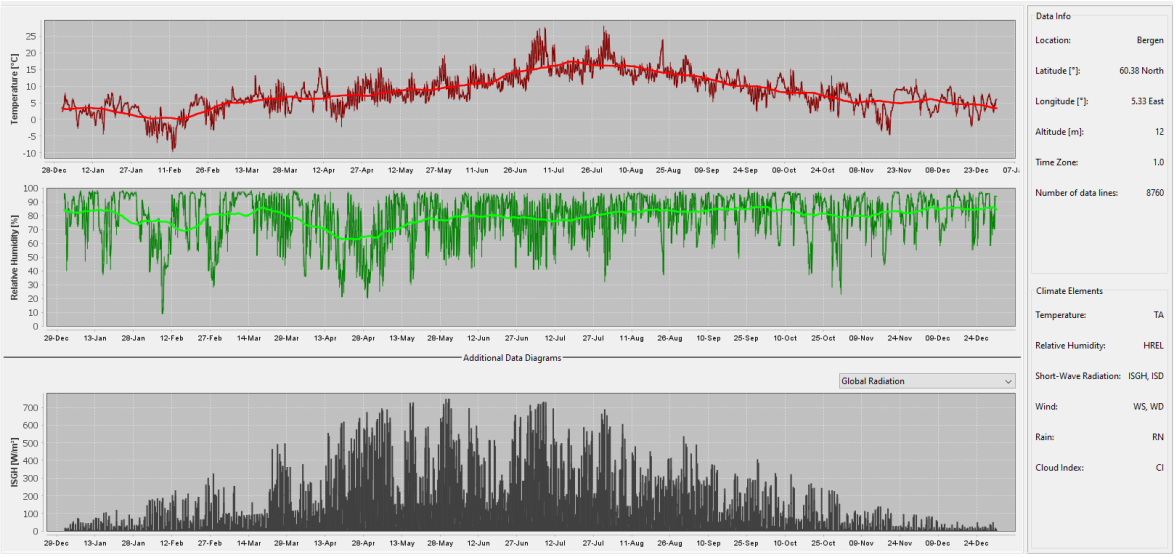
After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

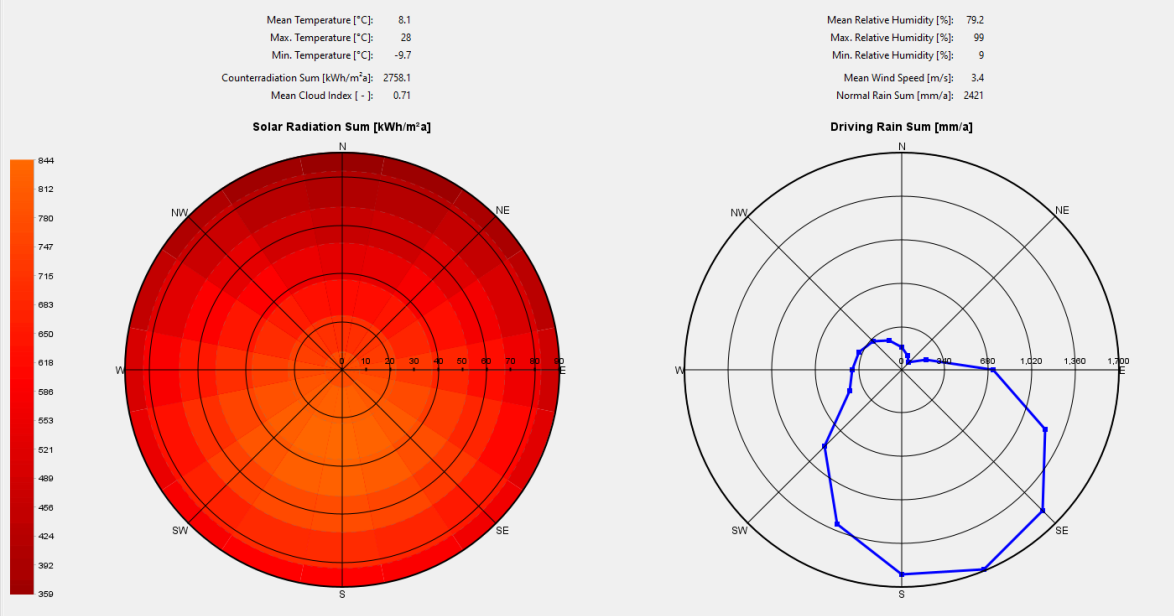
Plasterboard:



The moisture content does not take any harmful forms here.

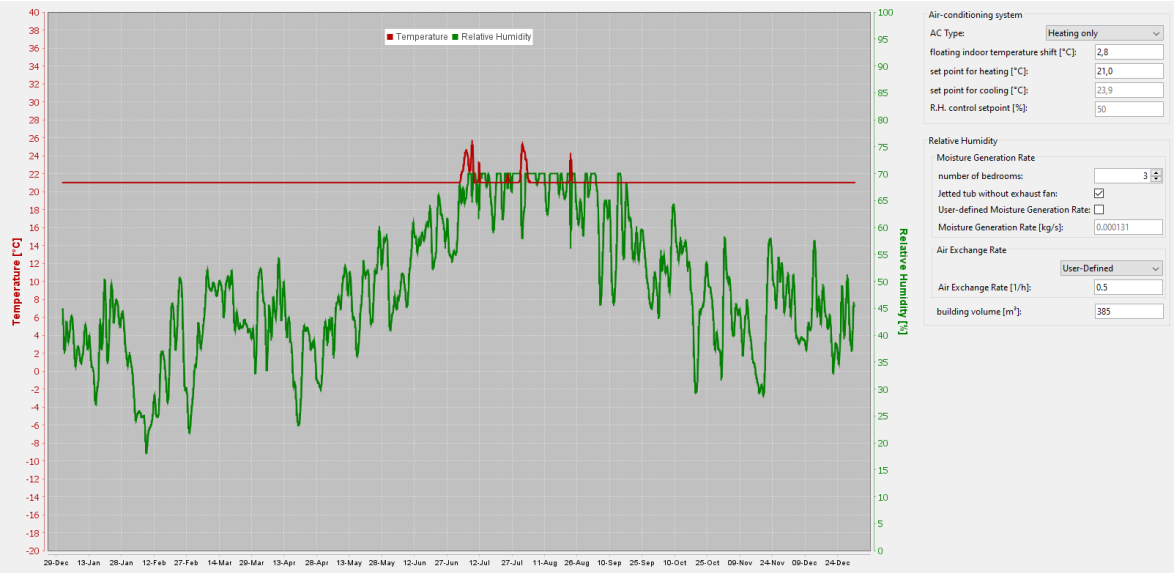
Outdoor climate Bergen (Norway)





The direction with the most driving rain is south-southeast. There is a lot of solar radiation, with higher drying capacity than that towards most other orientations. Therefore, the southeast orientation is used for analyses of plastered walls, with still a lot of driving rain but slightly less drying capacity. For ventilated facades, the north orientation is always the decisive one.

Indoor climate Bergen

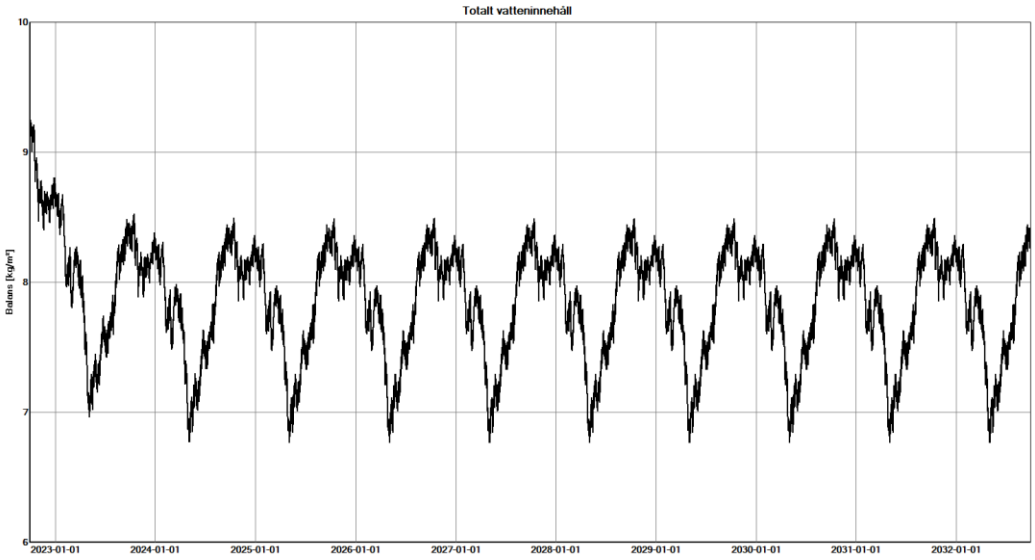


Results Bergen

The following diagram shows the water content in total and in the individual layers.

Wall type A - ventilated facade, plaster on the inside

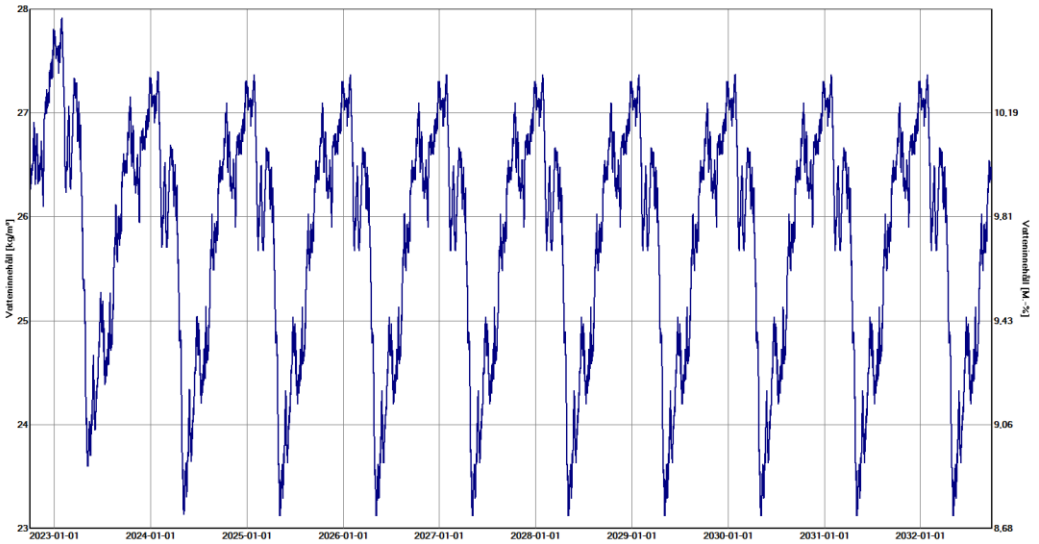
<u>The whole wall</u>



Even with a high built-in moisture content at the beginning, the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

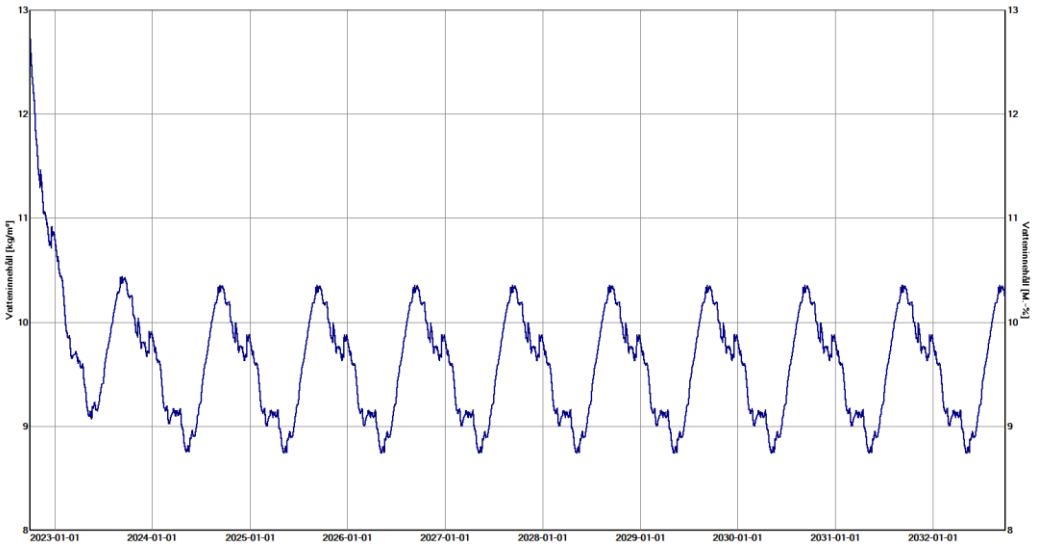
Single layers

Wood fibre behind the air gap:



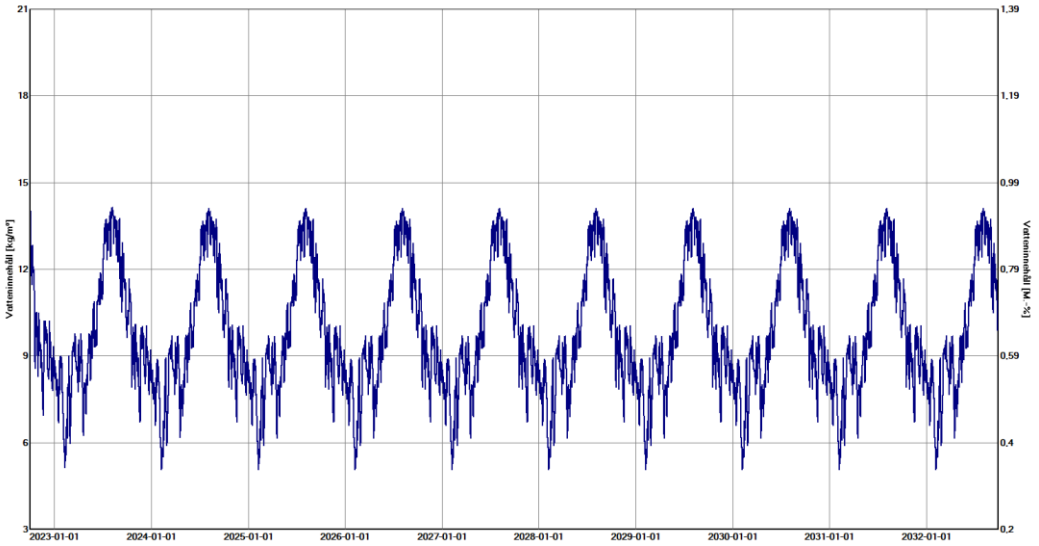
The wood fibreboard has the chance to dry out and the moisture content is always below 11 M.-% and thus far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

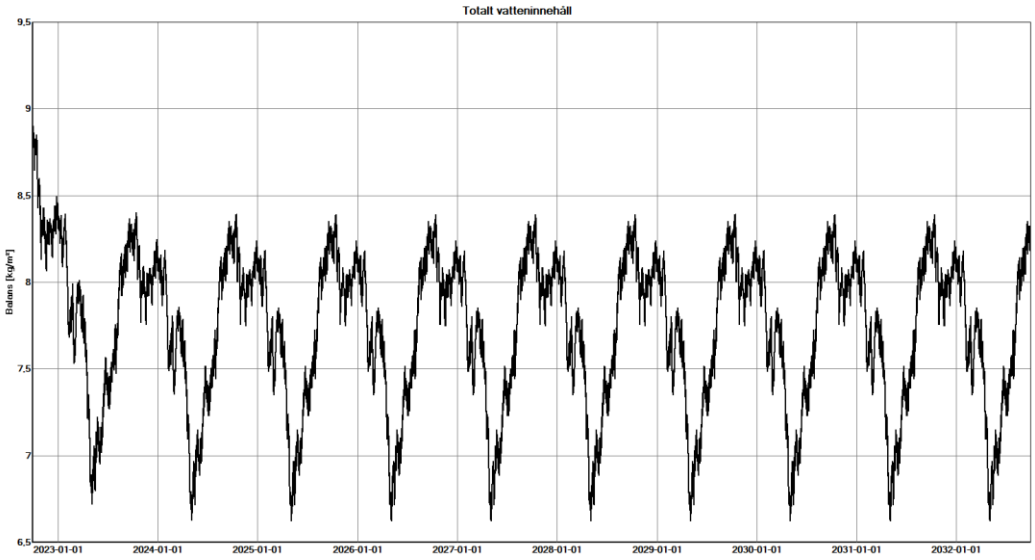
Plaster layer:



The moisture content does not take any harmful forms here - on the contrary: the layer helps to improve the indoor climate by buffering the humidity.

Wall type B - ventilated facade, plasterboard on the inside

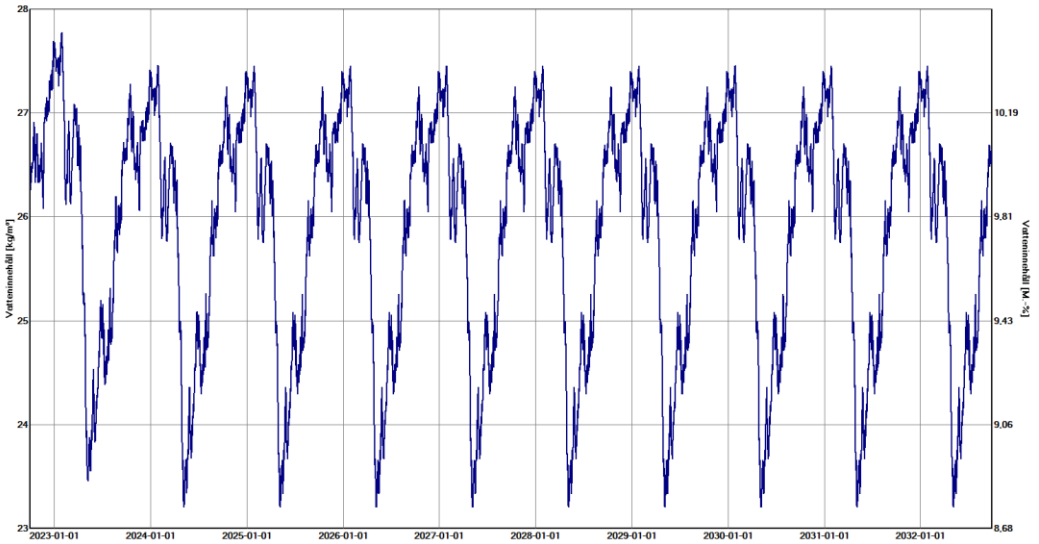
<u>The whole wall</u>



Even with high built-in moisture content (assumed at 80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

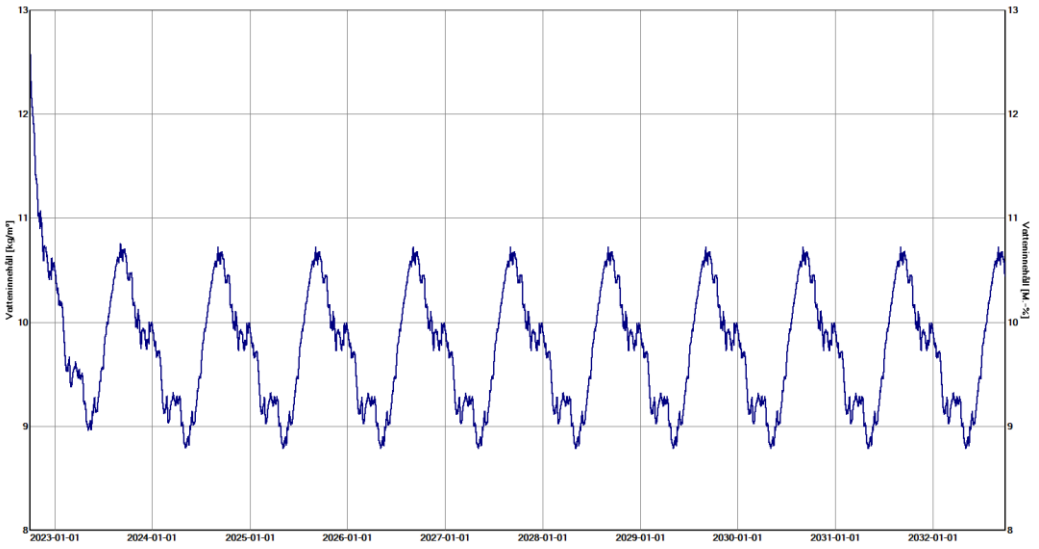
Single layers

Wood fibre behind the air gap:



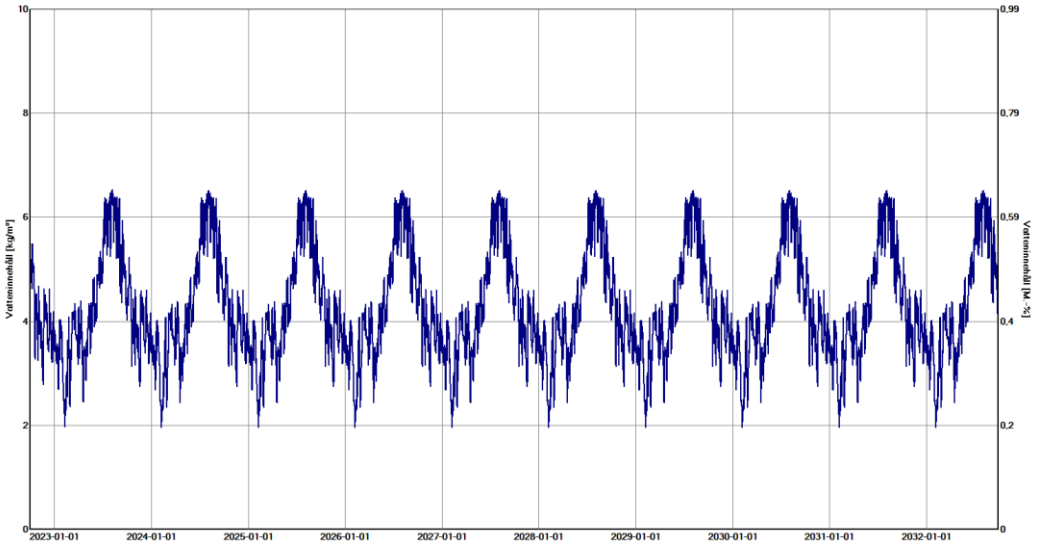
The wood fibreboard has the chance to dry out and the moisture content is always below 11 M.-% and thus far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

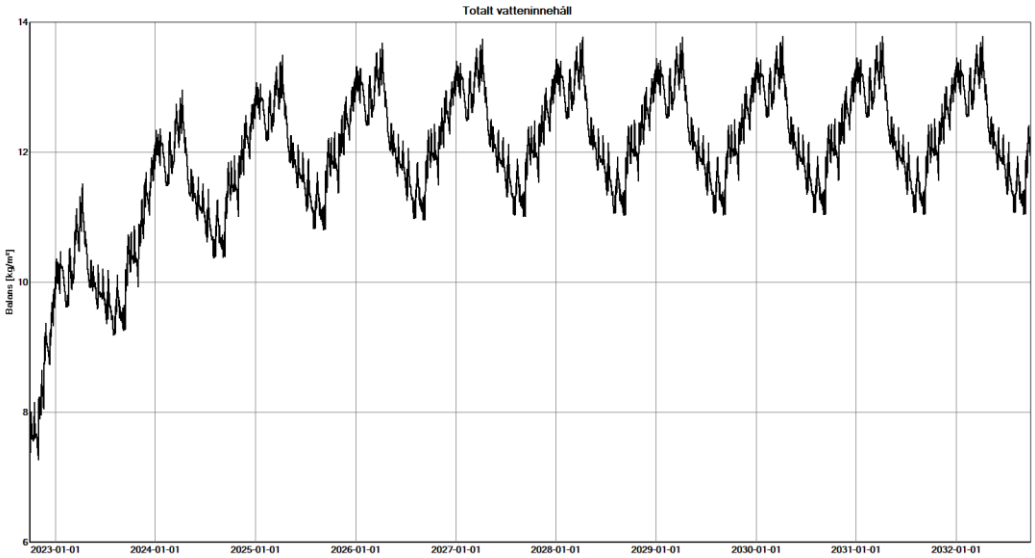
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type C - plastered facade, plaster on the inside

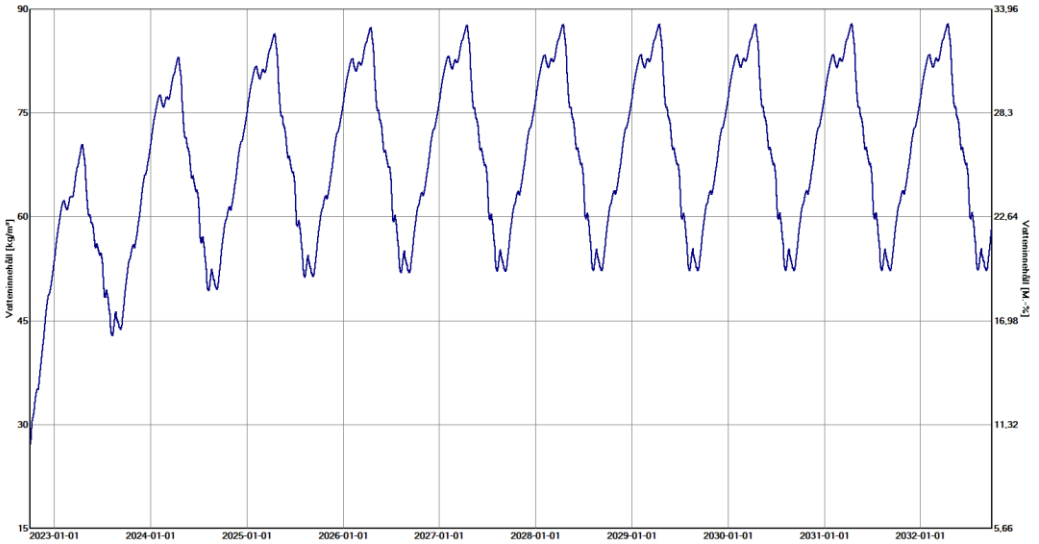
<u>The whole wall</u>



The simulation over 10 years shows an increasing percentage of moisture at the beginning and a relatively high level thereafter. There is therefore a risk of damage to the building fabric even if the work is carried out correctly.

Single layers

Wood fibre behind the plaster:

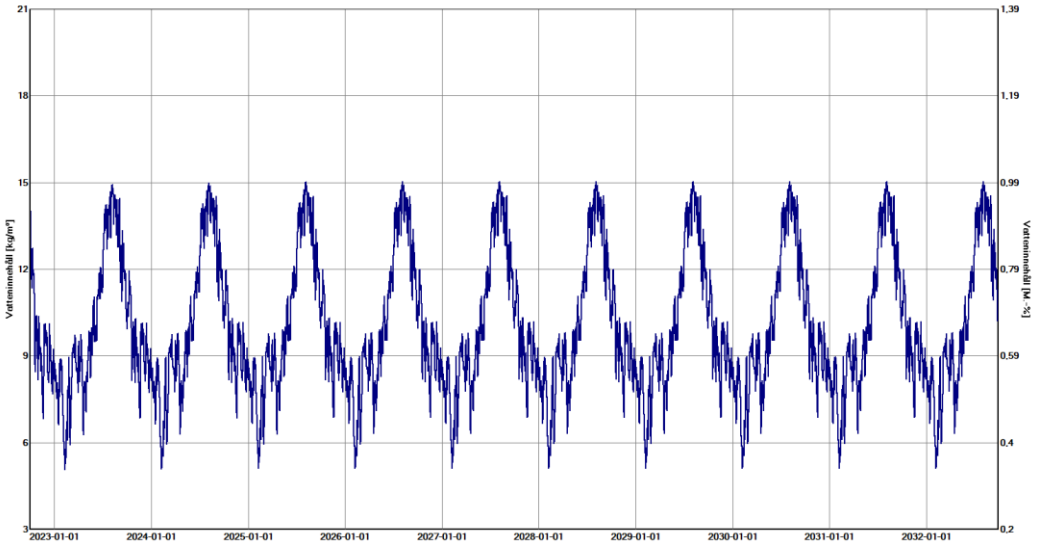


The wood fibreboard does not have the chance to dry out and the moisture content rises initially to stay all the time above the 18 M.-% which is considered the critical limit. Mould growth is likely and it is therefore not recommended to build in this way in the Bergen area.

EcoCocon panel (straw):

The water content rises in the first years and then remains at a high level throughout.

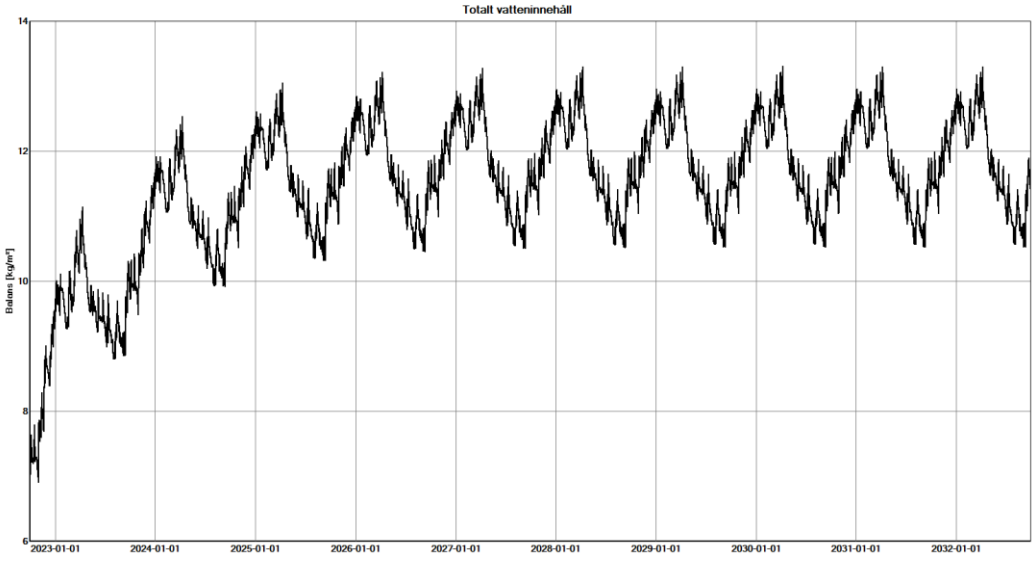
Plaster layer:



This is the only layer that does not give cause for concern. The moisture content does not take any harmful forms here.

Wall type D - plastered facade, plasterboard on the inside

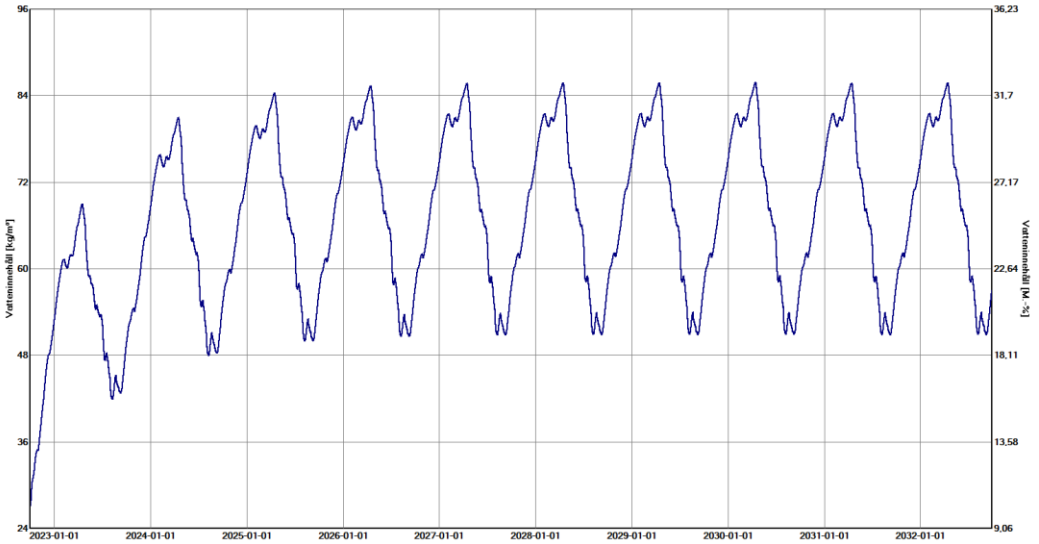
<u>The whole wall</u>



The simulation over 10 years shows an increasing percentage of moisture at the beginning and a relatively high level thereafter. There is therefore a risk of damage to the building fabric even if the work is carried out correctly.

Single layers

Wood fibre behind the plaster:

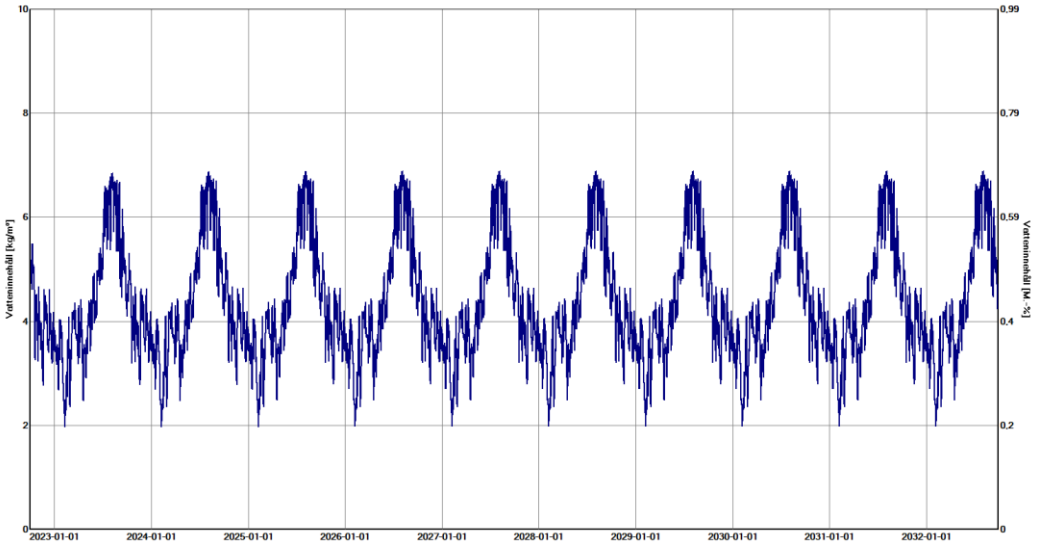


The wood fibreboard does not have the chance to dry out and the moisture content rises initially to stay all the time above the 18 M.-% which is considered the critical limit. Mould growth is likely and it is therefore not recommended to build in this way in the Bergen area.

EcoCocon panel (straw):

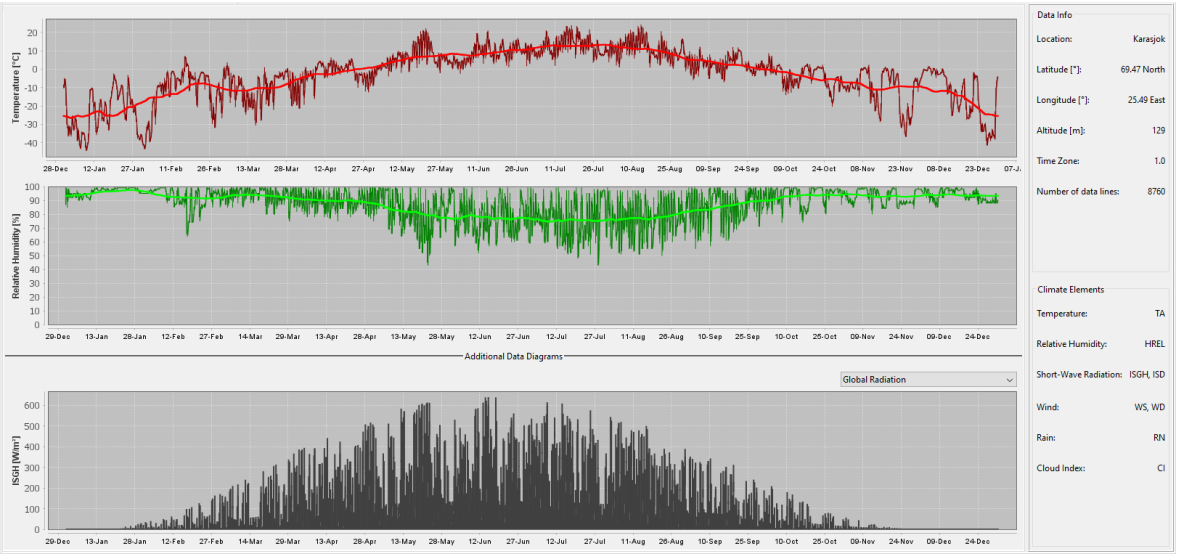
The water content rises in the first years and then remains at a high level throughout.

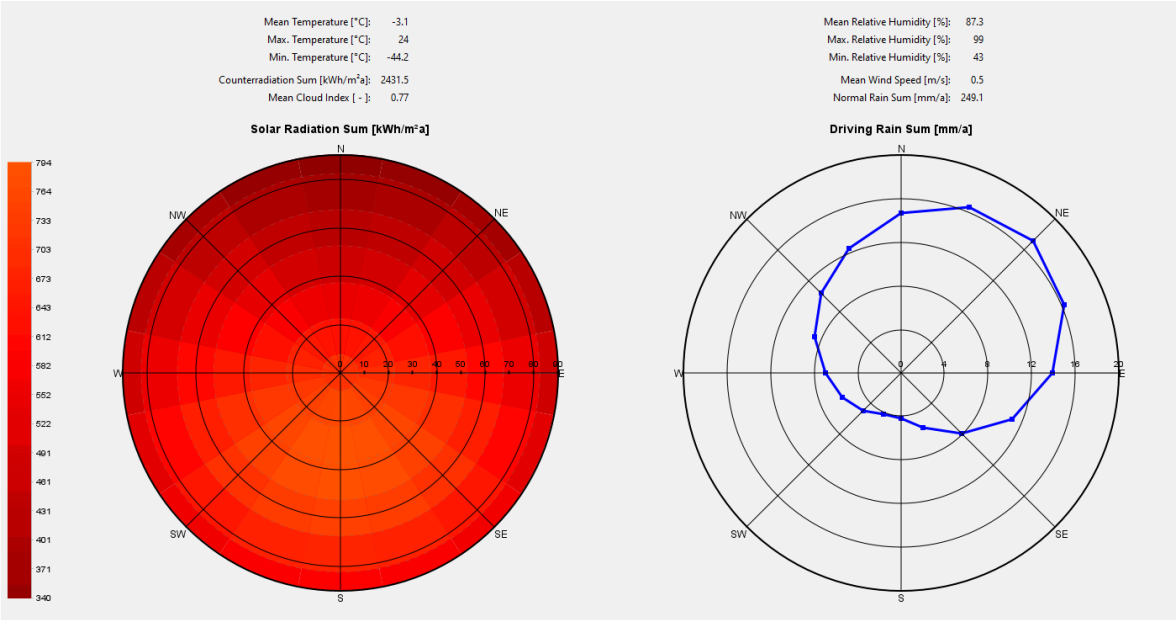
Plasterboard:



As with wall type C, this is the only layer that does not give cause for concern. The moisture content here does not take any harmful forms.

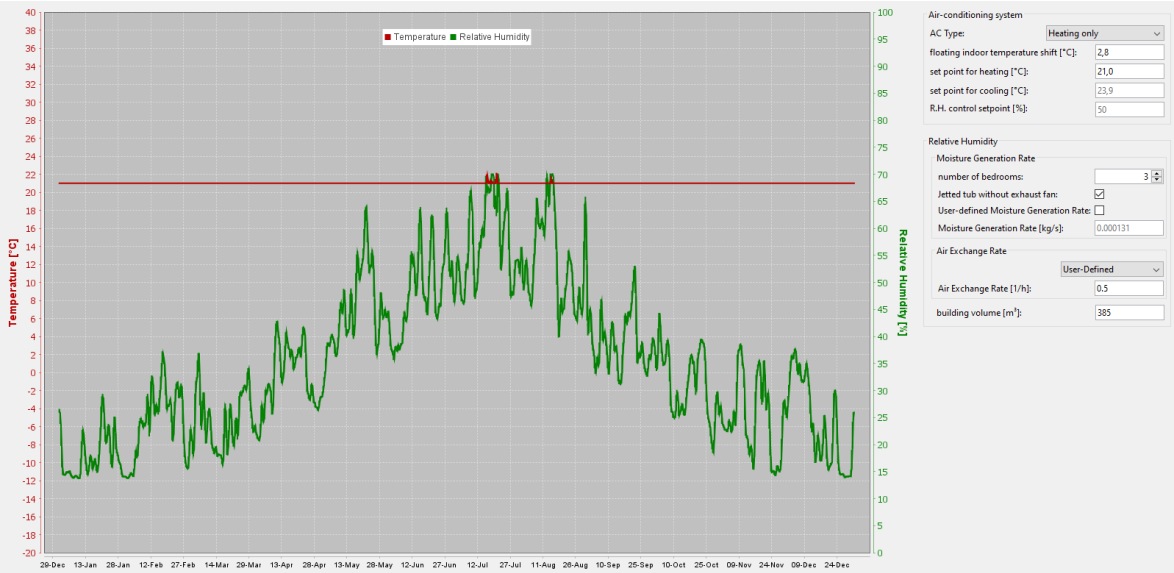
Outdoor climate Karasjok (Norway)





The direction with the most driving rain is northeast. There is also relatively little solar radiation, with lower drying capacity than that found, for example, towards the south. Therefore, this orientation is used for analyses of plastered walls. For ventilated facades, straight north is always the decisive orientation.

Indoor climate Karasjok

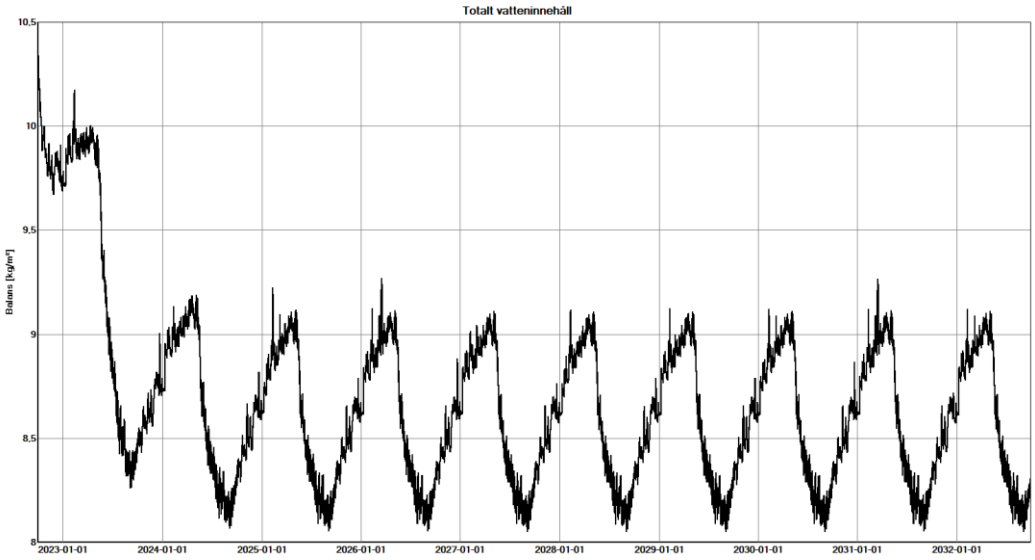


Results Karasjok

The following diagram shows the water content in total and in the individual layers.

Wall type E - ventilated facade, plaster on the inside

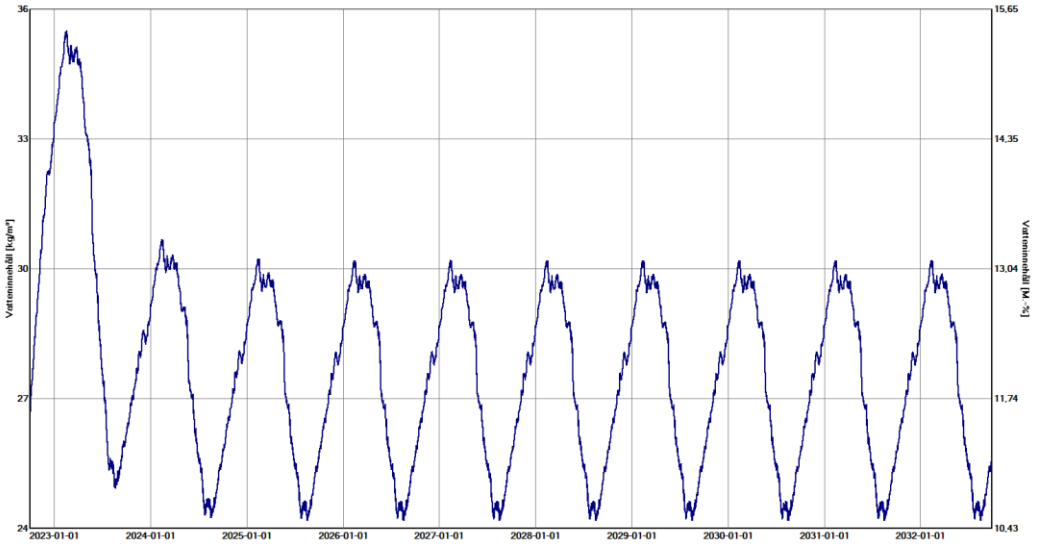
The whole wall



Even with high built-in moisture content, the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

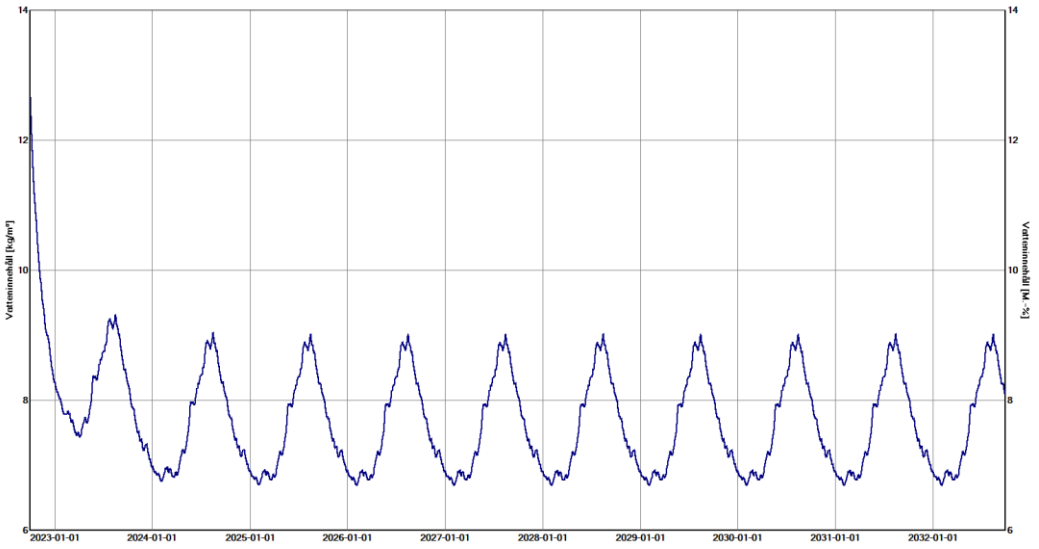
Single layers

Wood fibre behind the air gap:



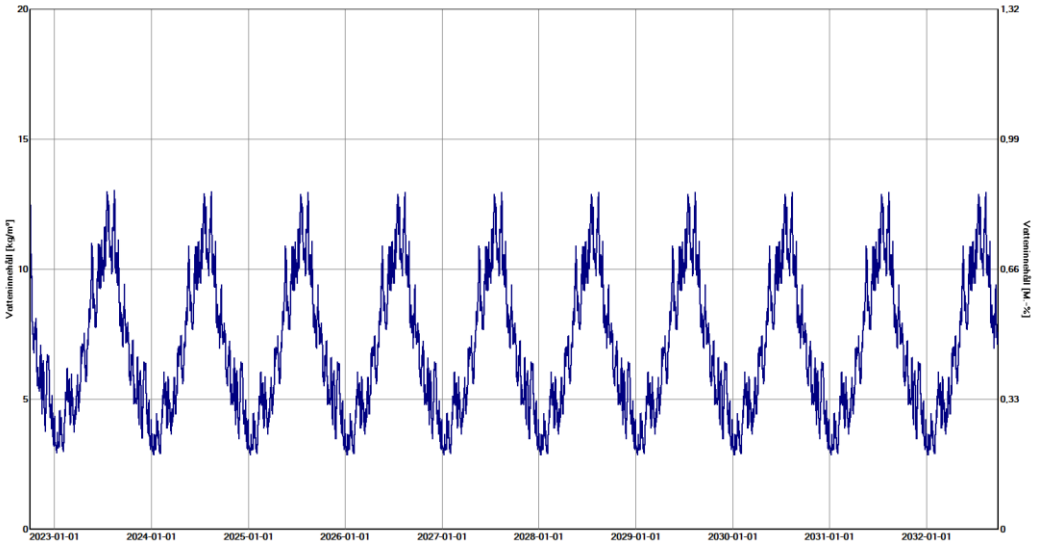
The wood fibreboard has the chance to dry out and the water content is always below 14 M.-% which is far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

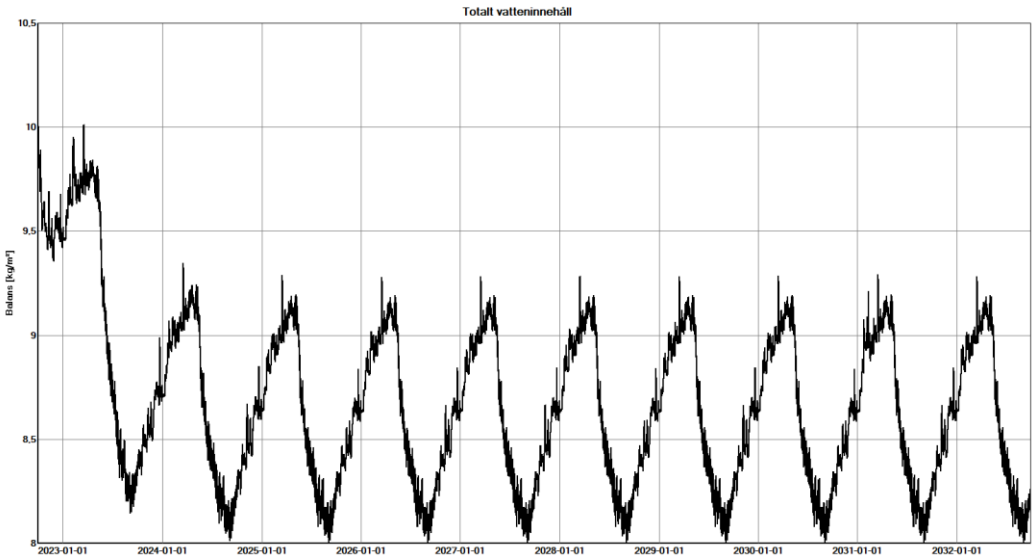
Plaster layer:



The moisture content does not take any harmful forms here - on the contrary: the layer helps to improve the indoor climate by buffering the humidity.

Wall type F - ventilated facade, plasterboard on the inside

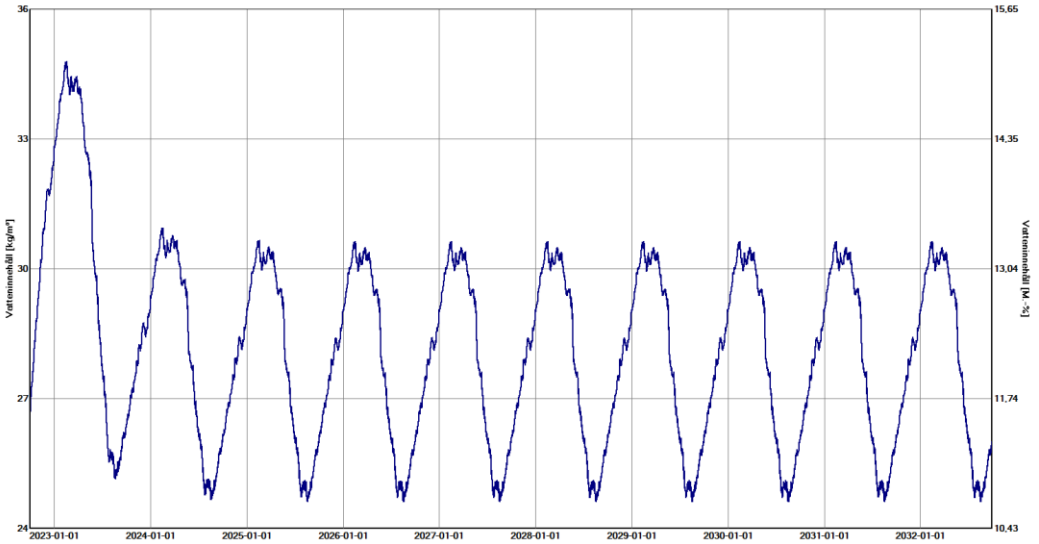
<u>The whole wall</u>



Even with a high built-in moisture content, the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

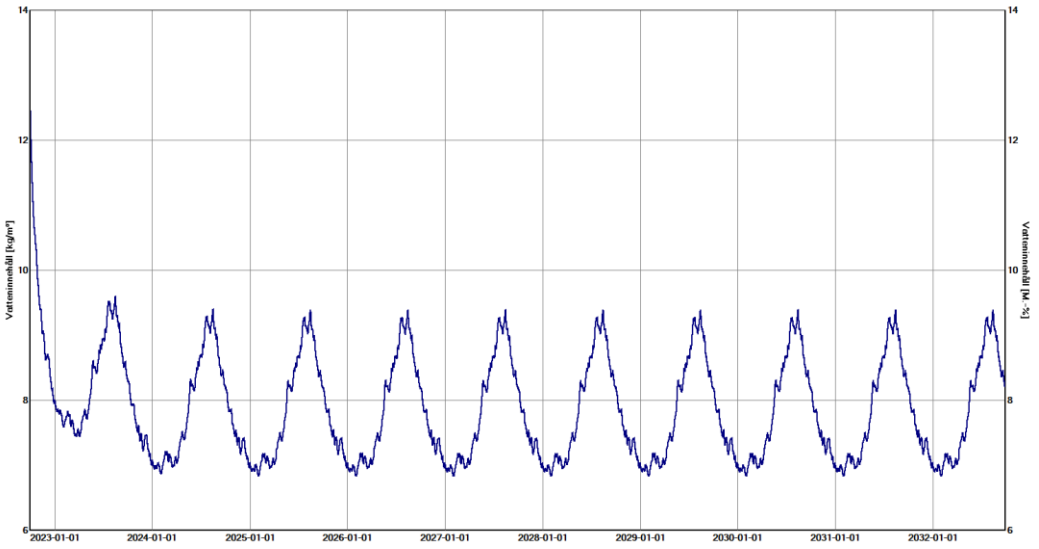
Single layers

Wood fibre behind the air gap:



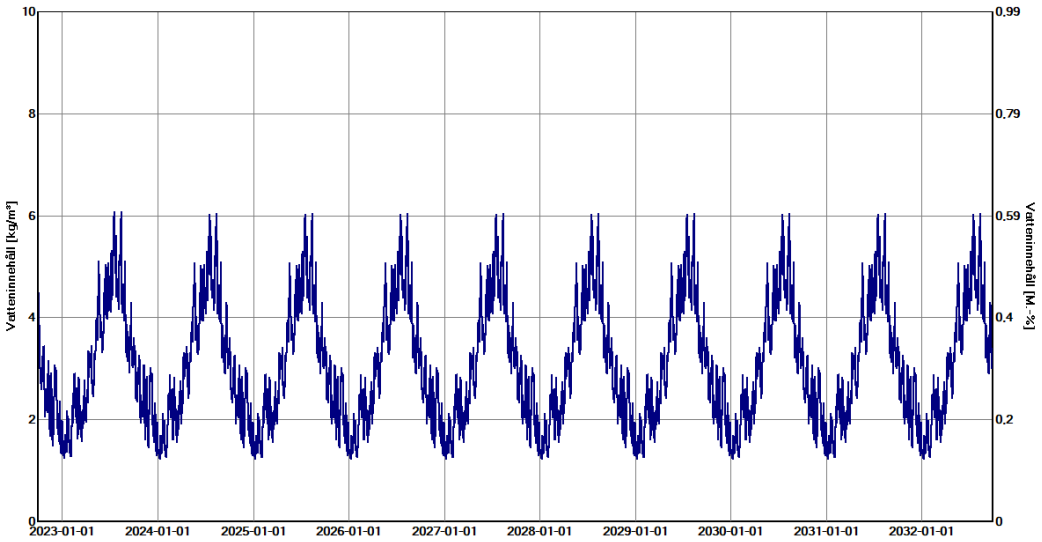
The wood fibreboard has the chance to dry out and the water content is always below 14 M.-% which is far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

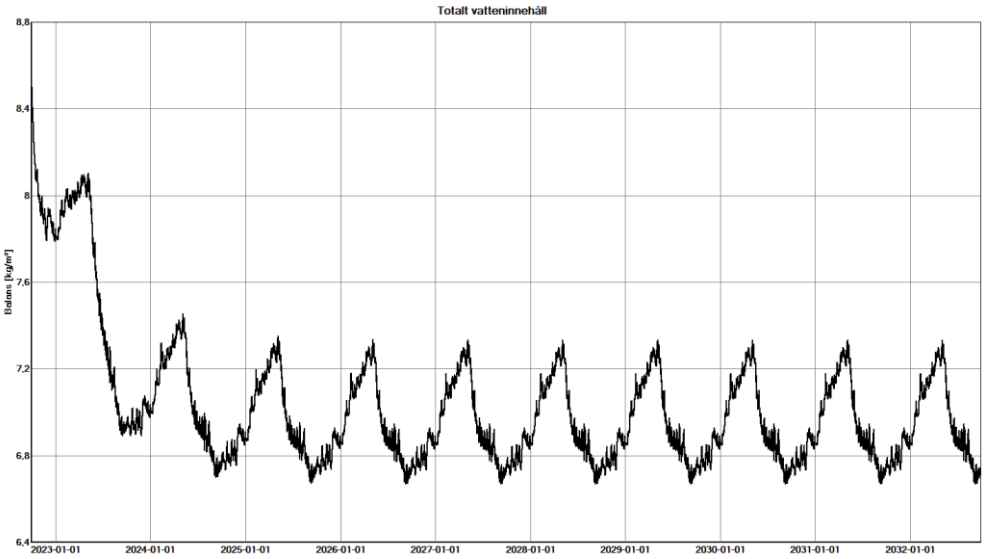
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type G - plastered facade, plaster on the inside

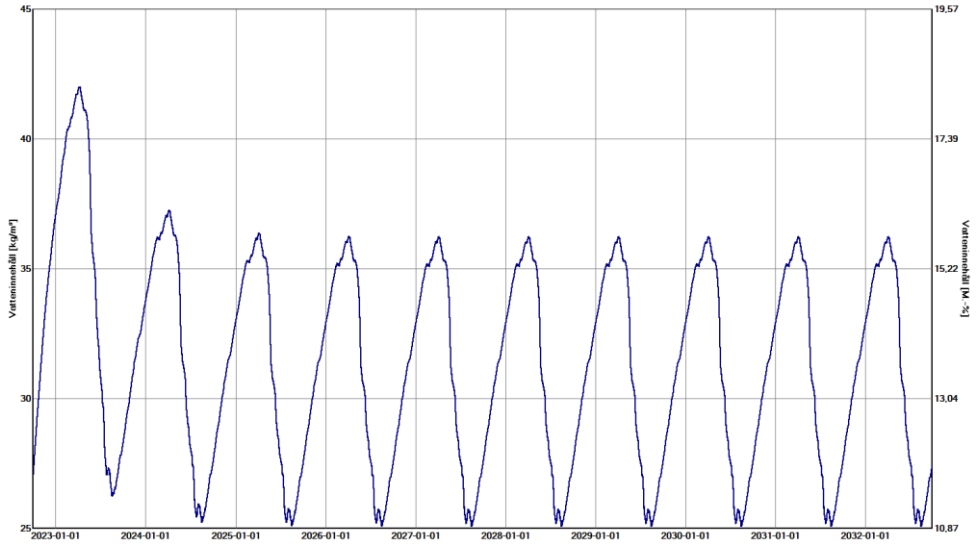
<u>The whole wall</u>



Even with high built-in moisture content (assumed at 80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

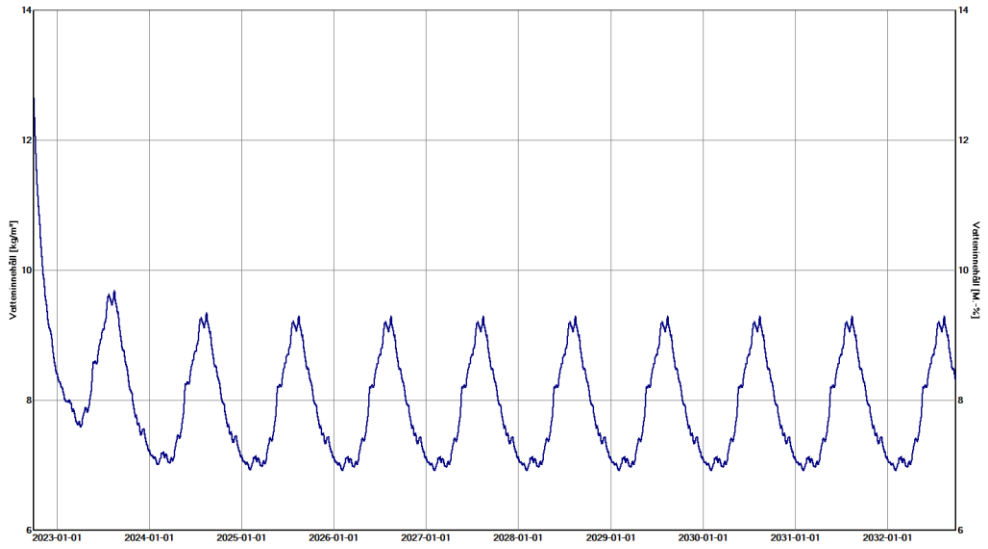
Single layers

Wood fibre behind the plaster:



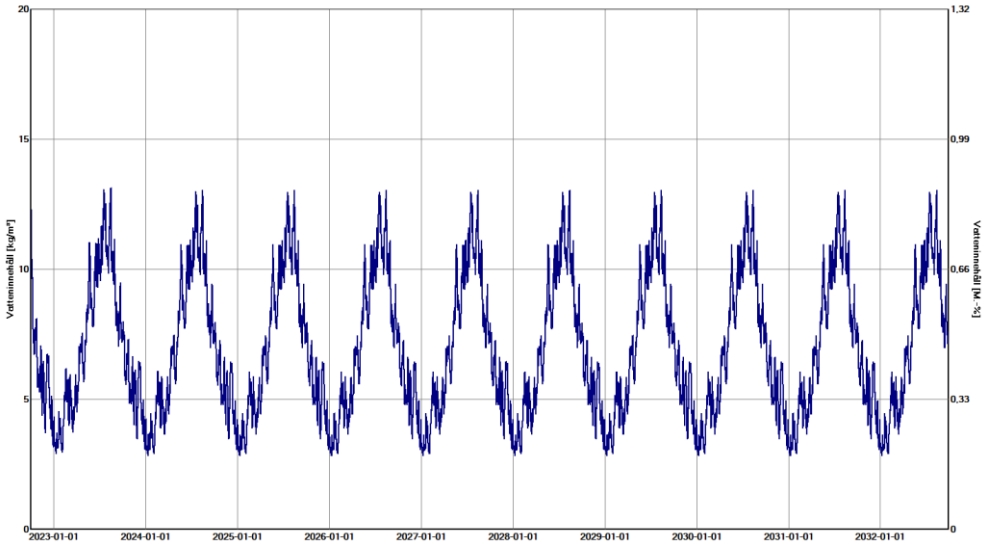
The wood fibreboard has the chance to dry out and the moisture content is always below 16 M.-%, which is below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

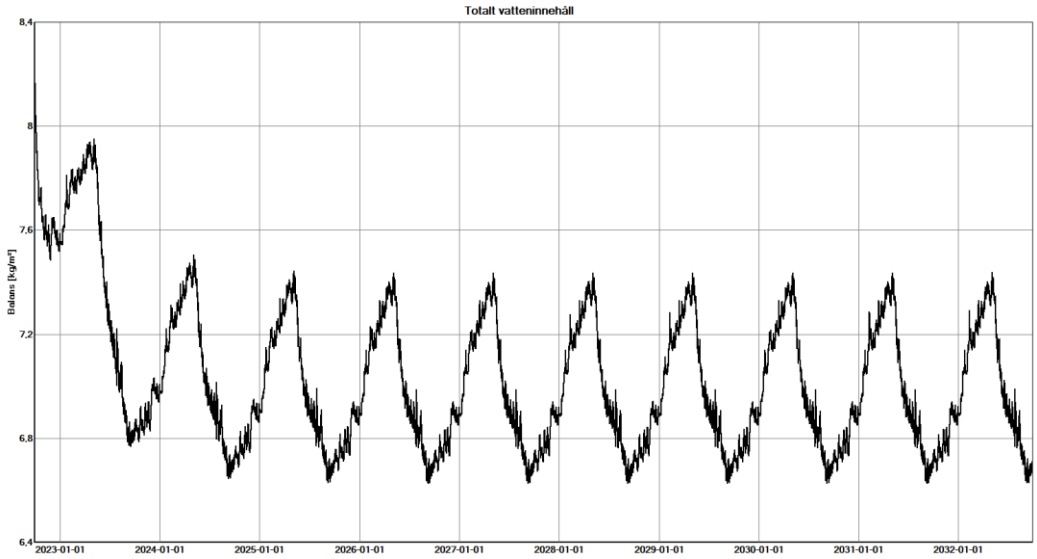
Plaster layer:



The moisture content does not take any harmful forms here.

Wall type H - plastered facade, plasterboard on the inside

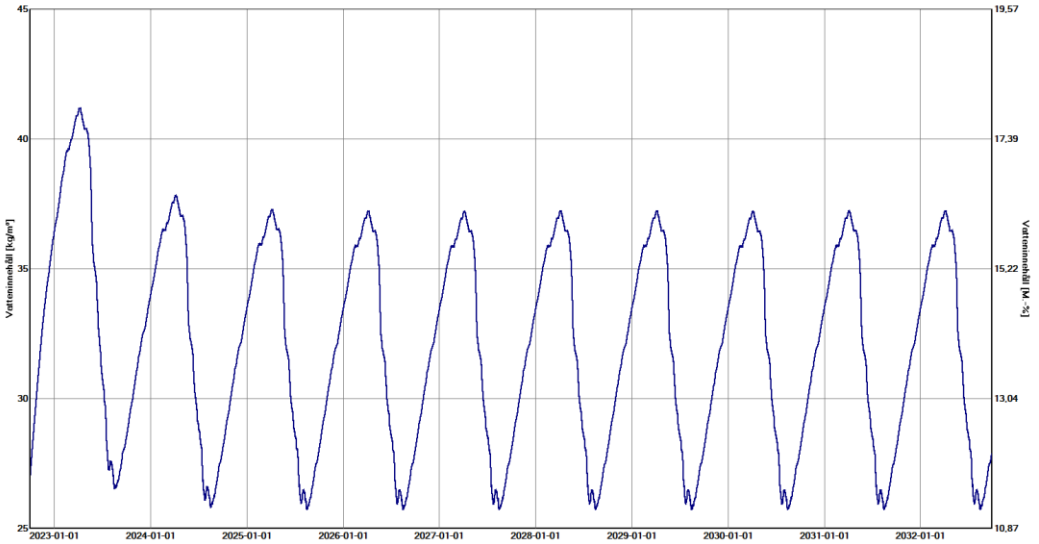
<u>The whole wall</u>



Even with a high built-in moisture content, the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

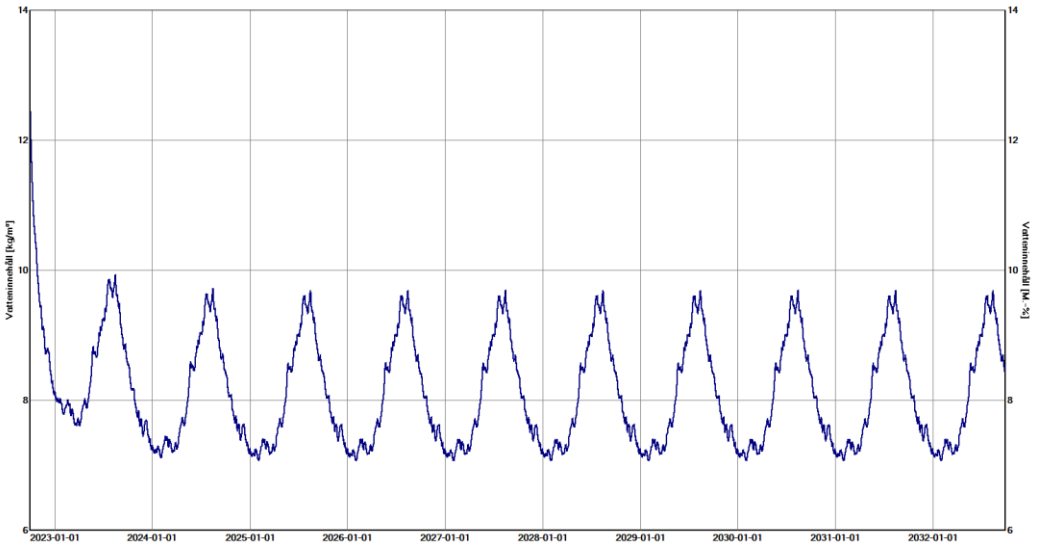
Single layers

Wood fibre behind the plaster:



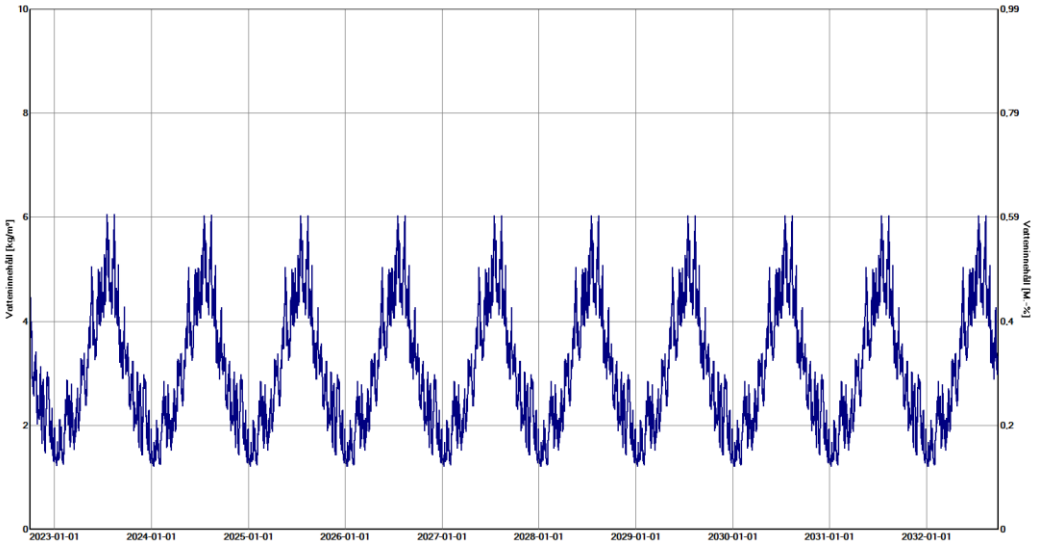
The wood fibreboard has the chance to dry out and the moisture content is always below 16 M.-% which is below the critical limit.

EcoCocon panel (straw):



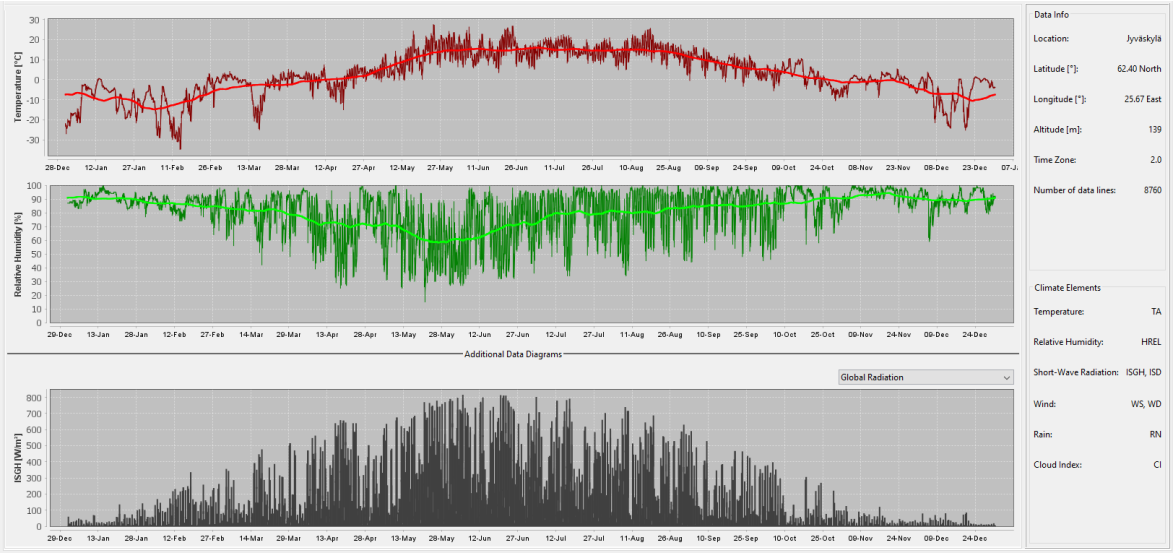
After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

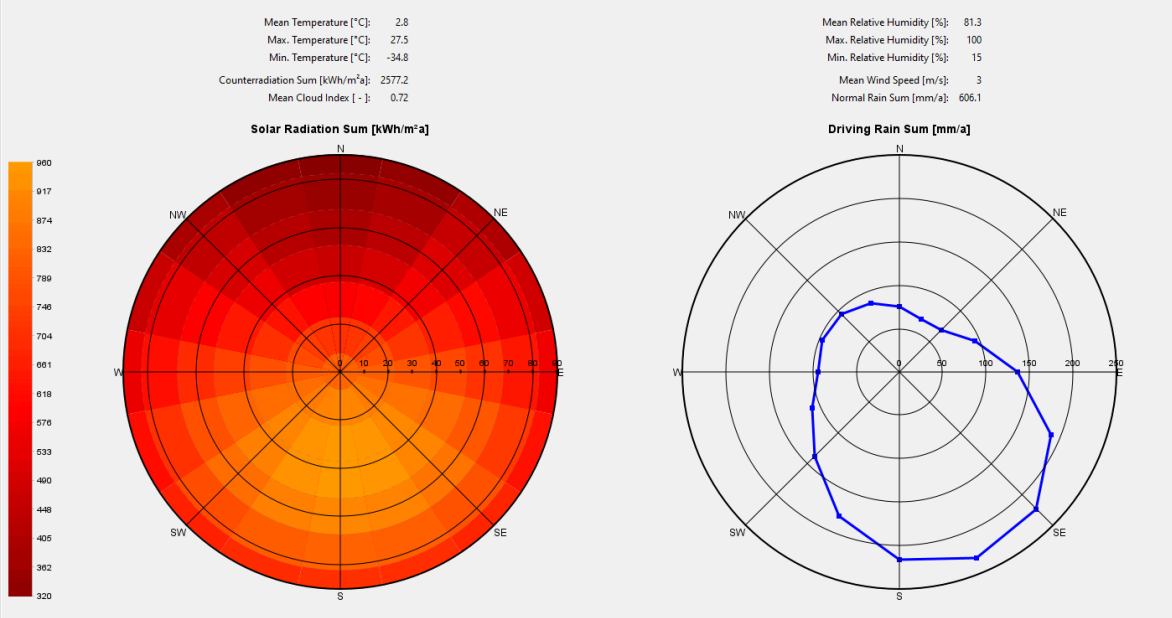
Plasterboard:



The moisture content does not take any harmful forms here.

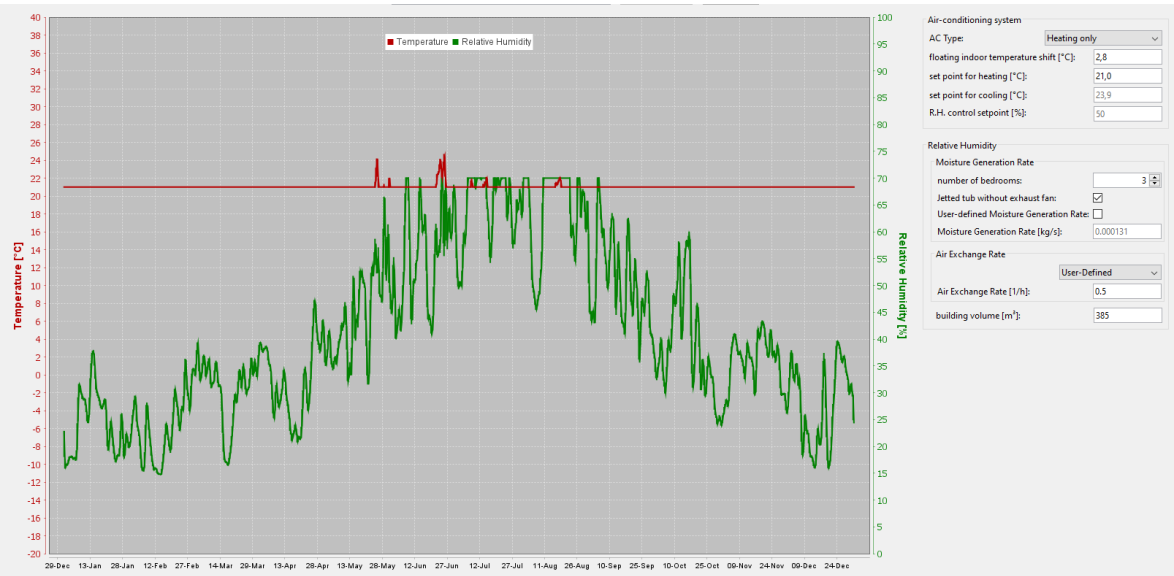
Outdoor climate Jyväskylä (Finland)





The direction with the most driving rain is south-southeast. There is a lot of solar radiation, with higher drying capacity than that towards most other orientations. Therefore, the southeast orientation is used for analyses of plastered walls, with still a lot of driving rain but slightly less drying capacity. For ventilated facades, straight north is always the decisive orientation.

Indoor climate Jyväskylä

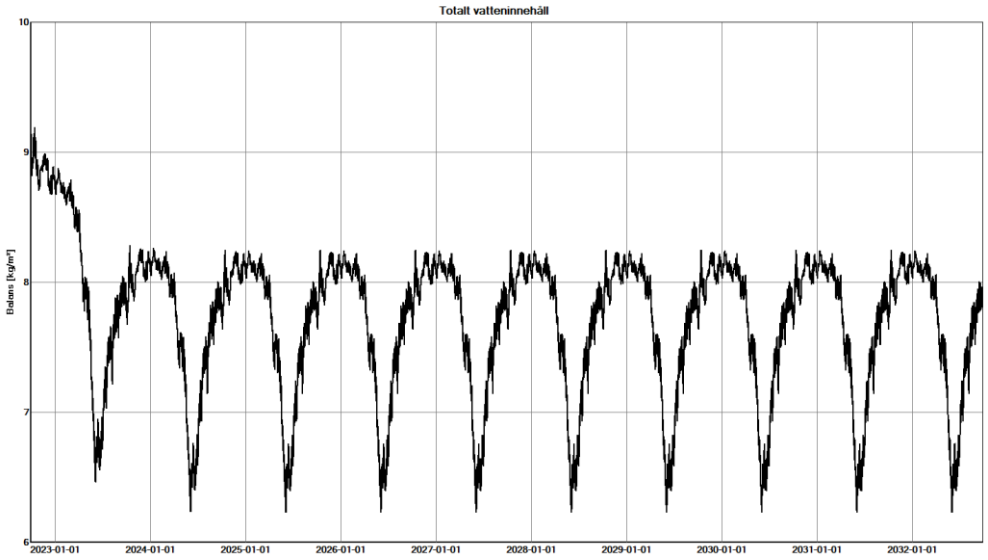


Results Jyväskyla

The following diagram shows the water content in total and in the individual layers.

Wall type A - ventilated facade, plaster on the inside

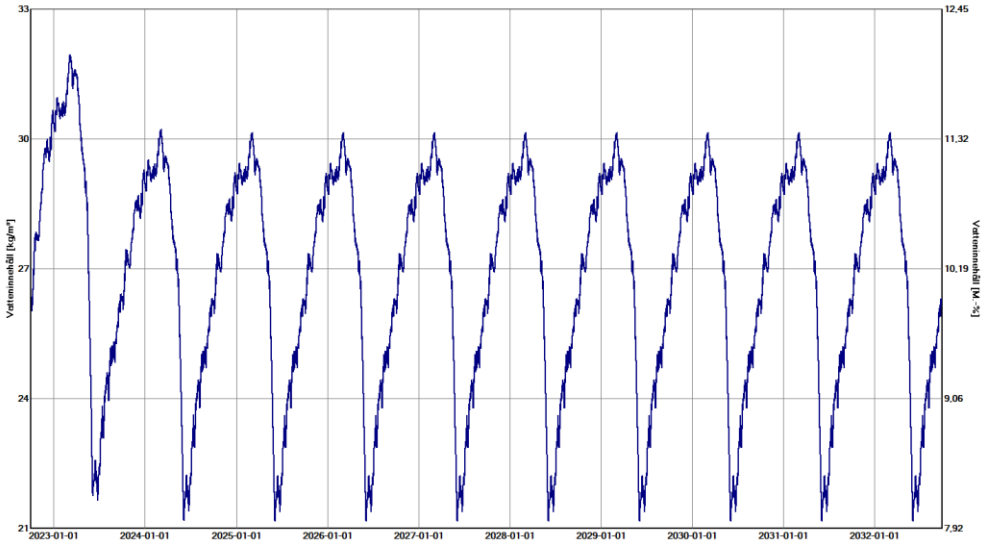
<u>The whole wall</u>



Even with a high built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

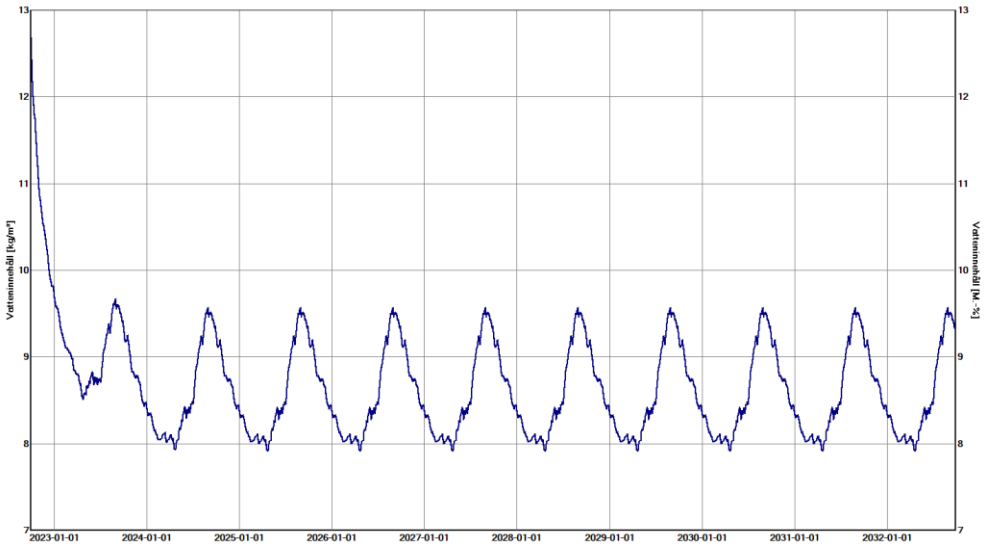
Single layers

Wood fibre behind the air gap:



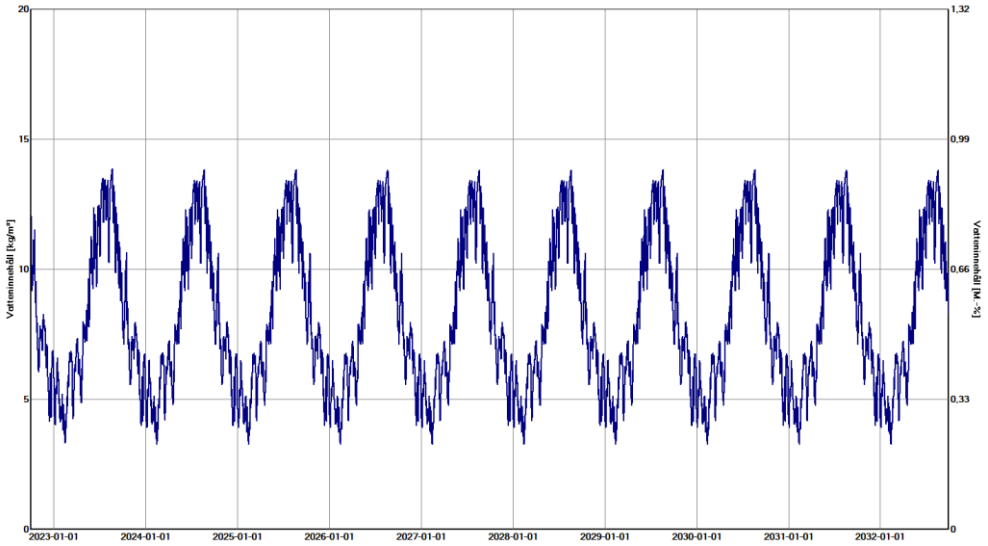
The wood fibreboard has the chance to dry out and the moisture content is always below 12 M.-% which is far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

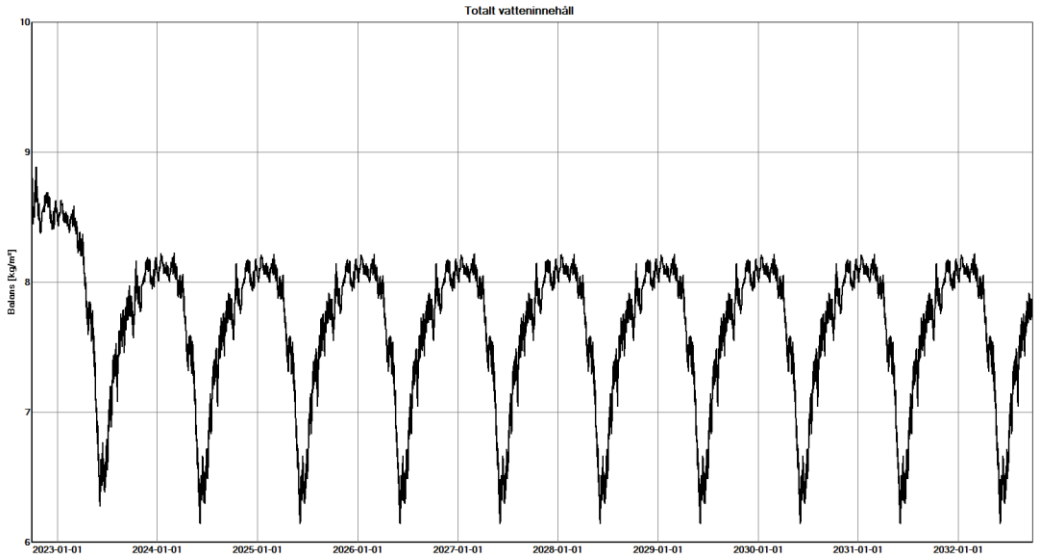
Plaster layer:



The moisture content does not take any harmful forms here. On the contrary: the layer helps to improve the indoor climate by buffering the humidity.

Wall type B - ventilated facade, plasterboard on the inside

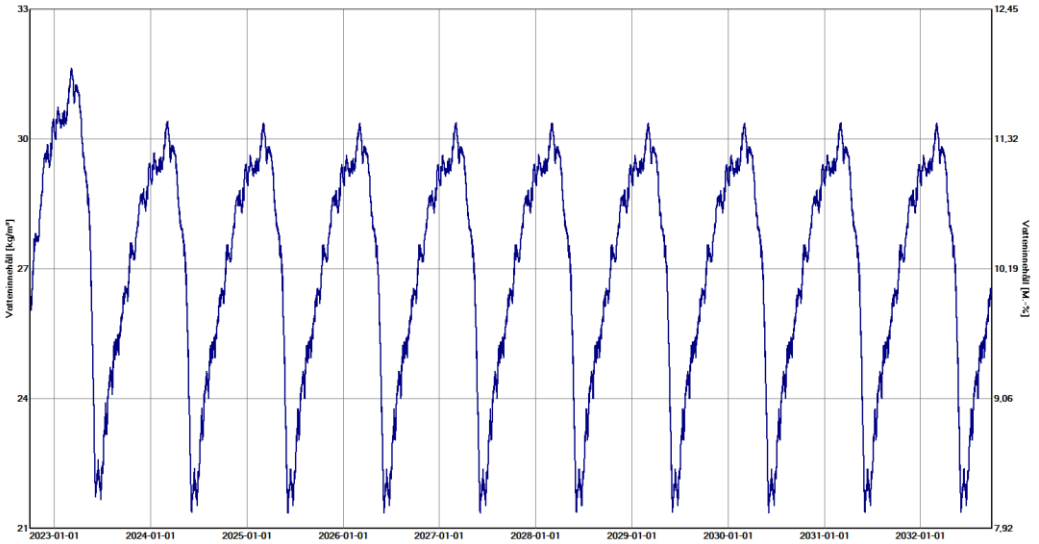
<u>The whole wall</u>



Even with a high built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

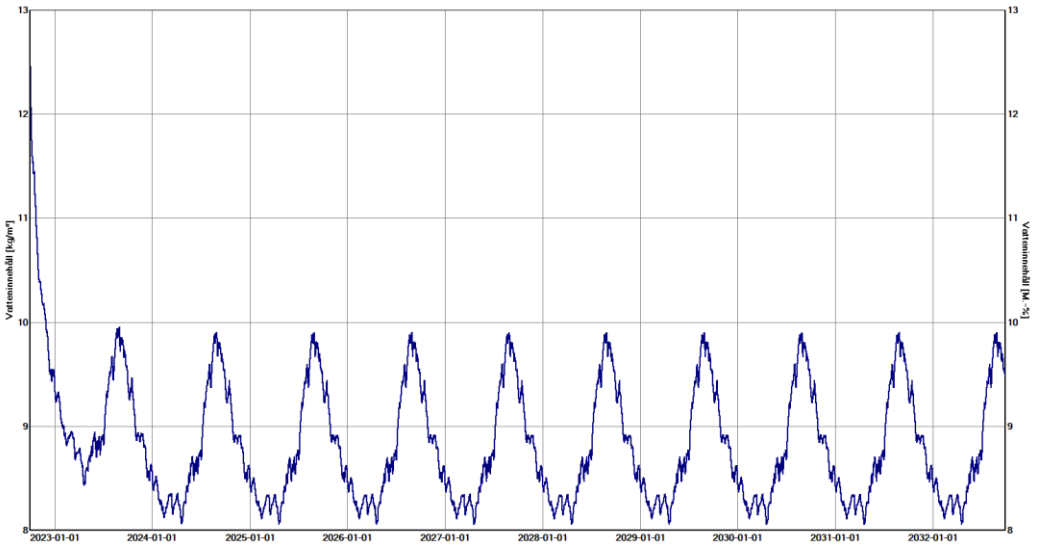
Single layers

Wood fibre behind the air gap:



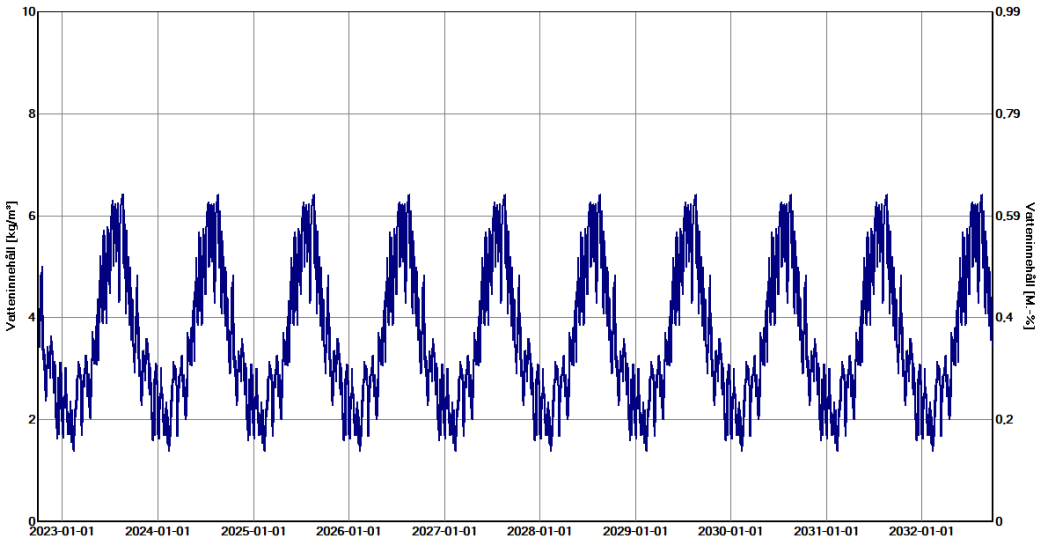
The wood fibreboard has the chance to dry out and the moisture content is always below 12 M.-% which is far below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 10 M.-% all the time.

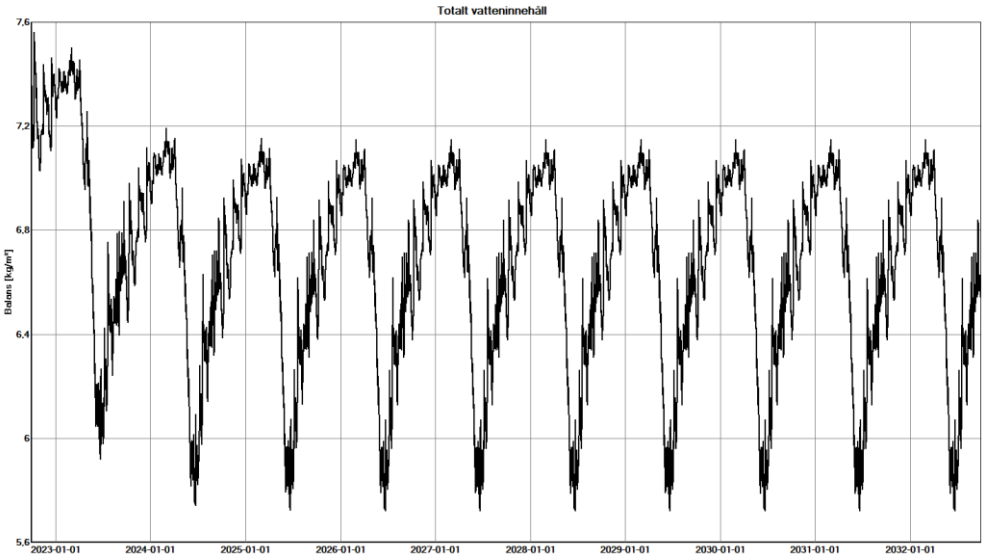
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type C - plastered facade, plaster on the inside

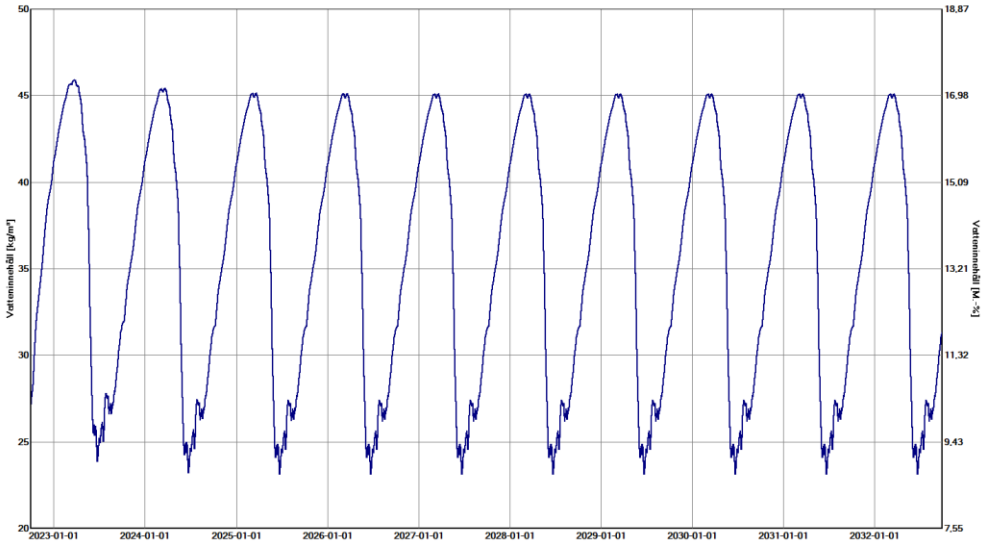
<u>The whole wall</u>



Even with a high built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

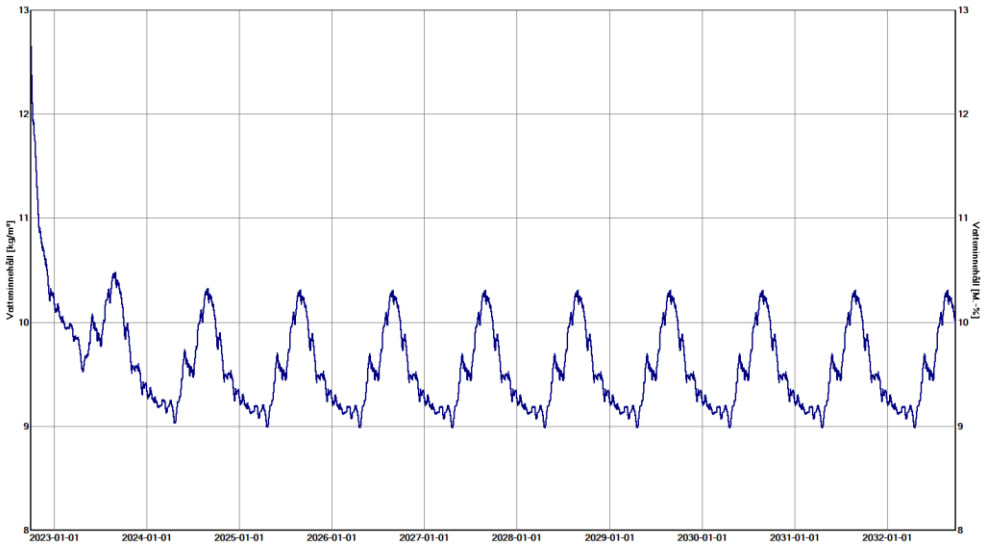
Single layers

Wood fibre behind the plaster:



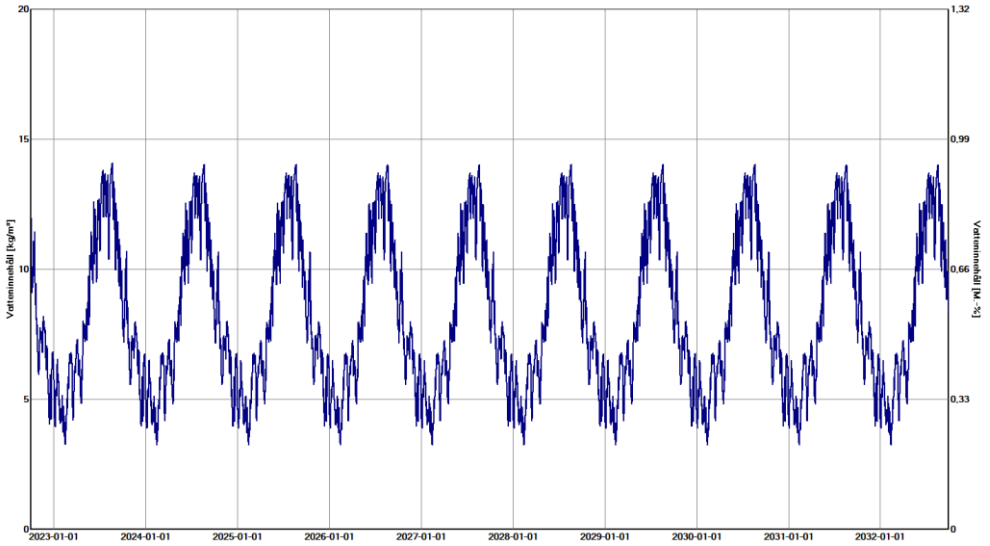
The wood fibreboard has the chance to dry out and the water content is always below the 18 M.-% which is considered the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

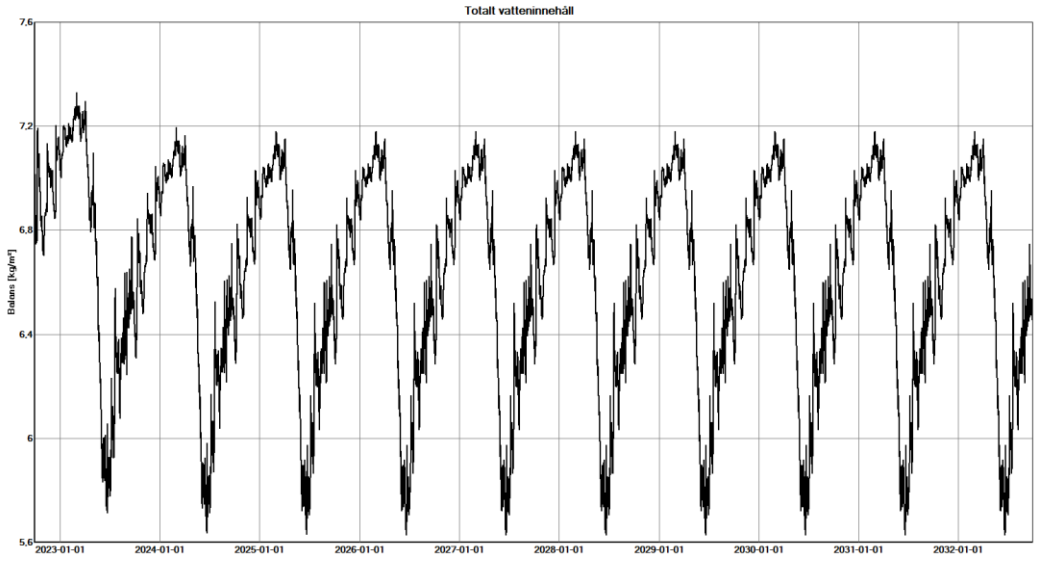
Plaster layer:



The moisture content does not take any harmful forms here.

Wall type D - plastered facade, plasterboard on the inside

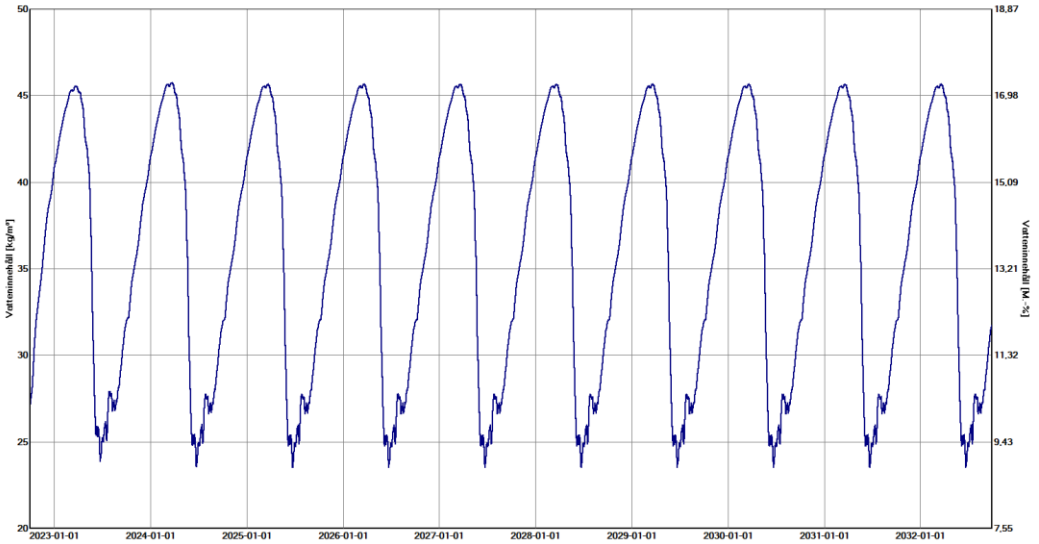
<u>The whole wall</u>



Even with a high built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

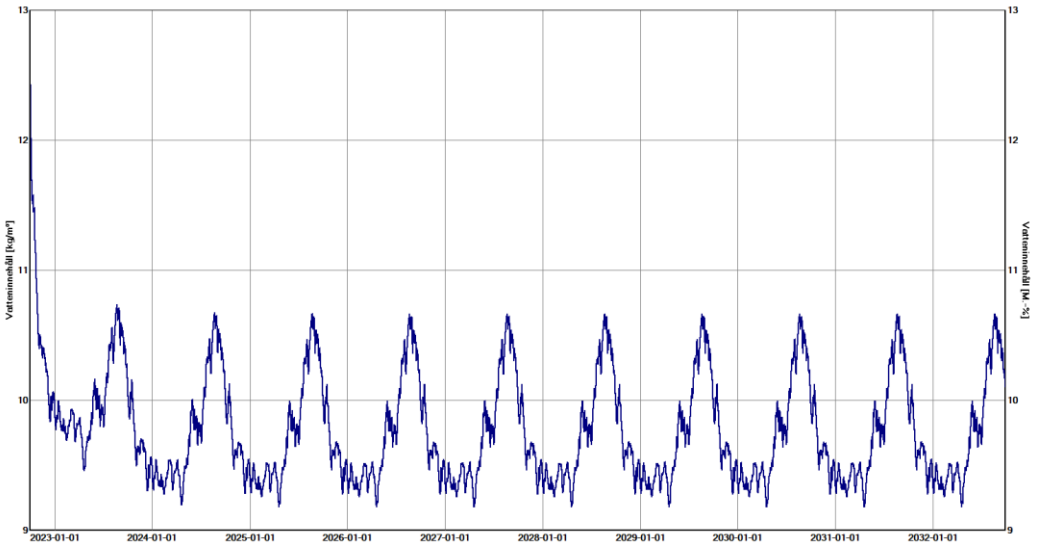
Single layers

Wood fibre behind the plaster:



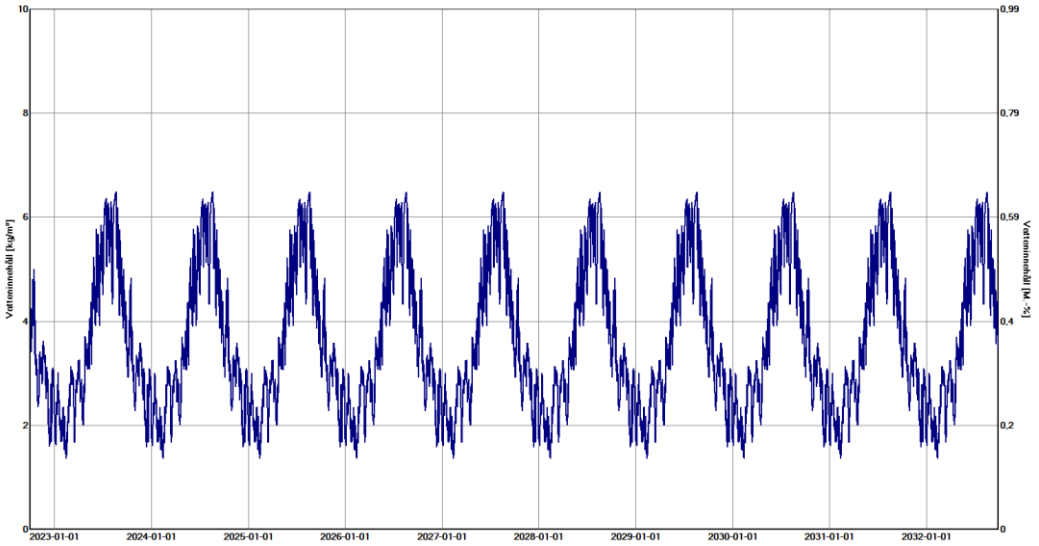
The wood fibreboard has the chance to dry out and the moisture content is always below the 18 M.-% which is considered the critical limit.

EcoCocon panel (straw):



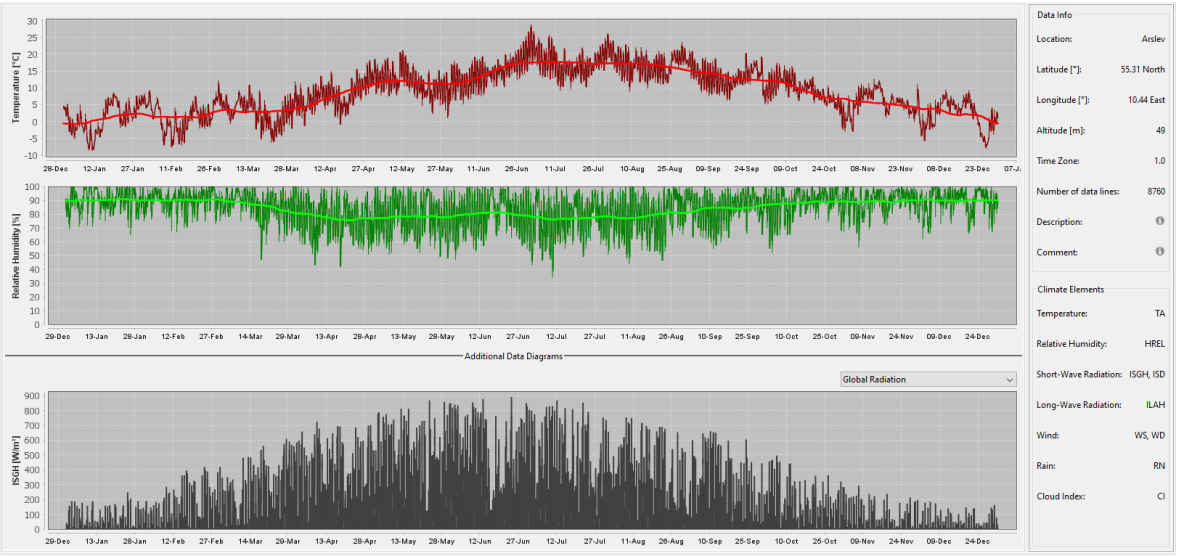
After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

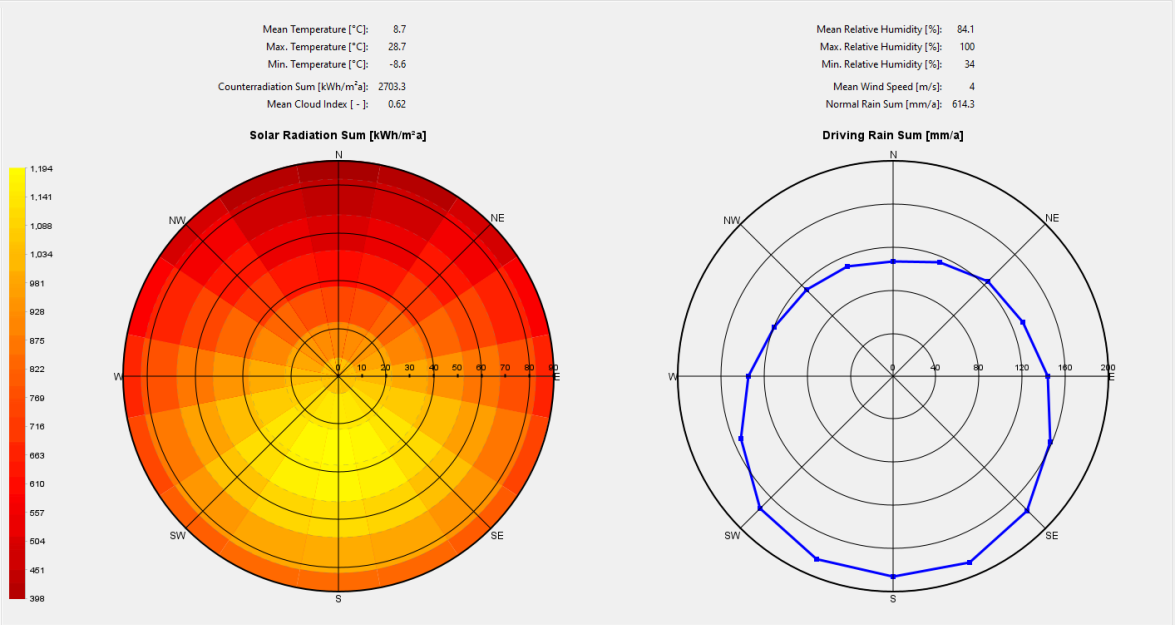
Plasterboard:



The moisture content does not take any harmful forms here.

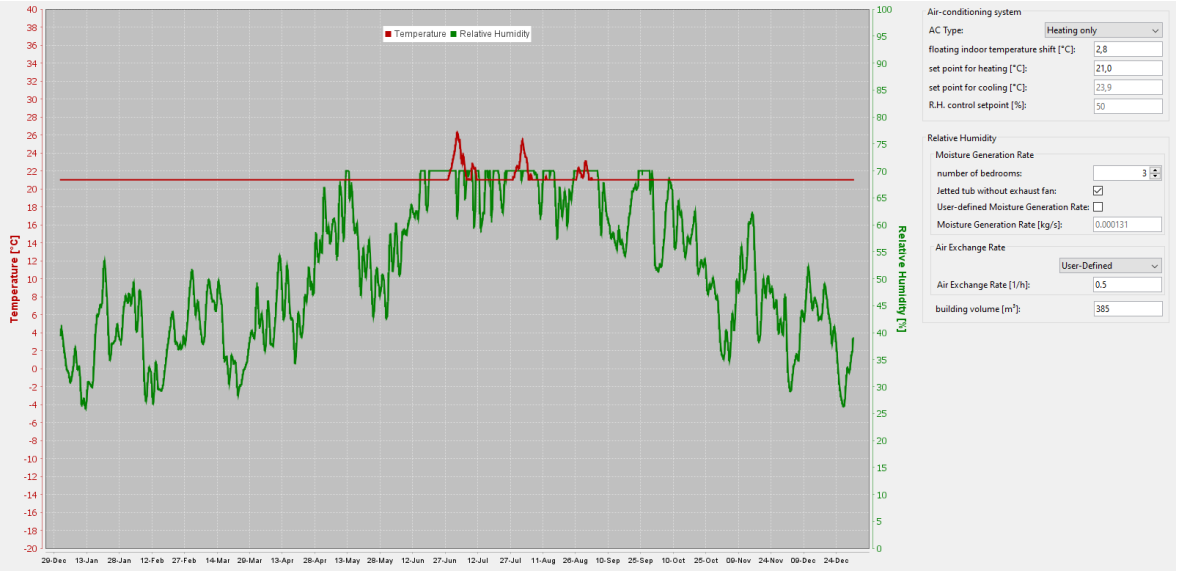
Outdoor climate Aarslev (Denmark)





The direction with the most driving rain is south. There is also the strongest solar radiation, with high drying capacity. Therefore, the southeast orientation is used for analyses of plastered walls, with still high driving rain, but less drying from solar irradiation. For ventilated facades, straight north orientation is always the decisive one.

Indoor climate Aarslev

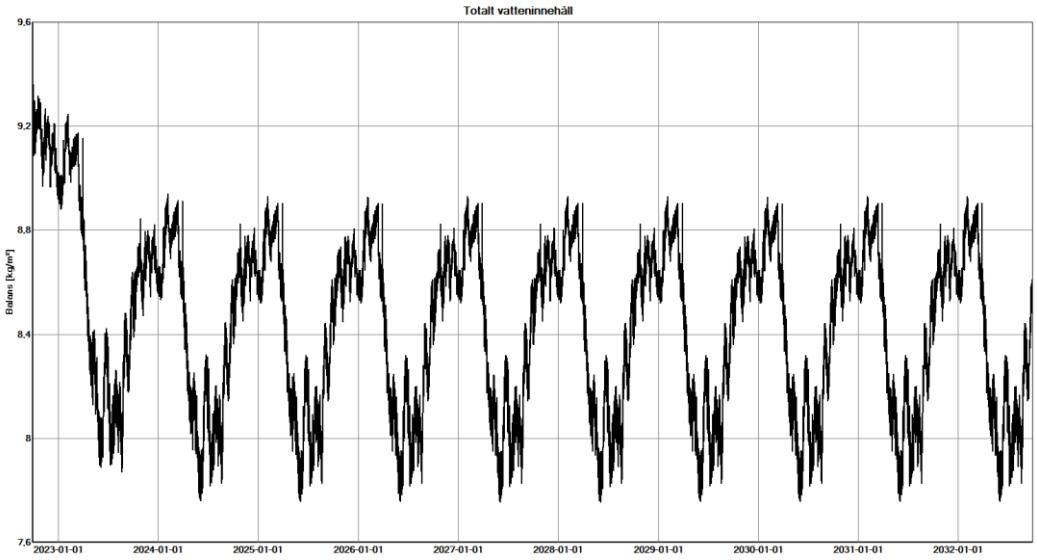


Results Aarslev

The following diagram shows the water content in total and in the individual layers.

Wall type A - ventilated facade, plaster on the inside

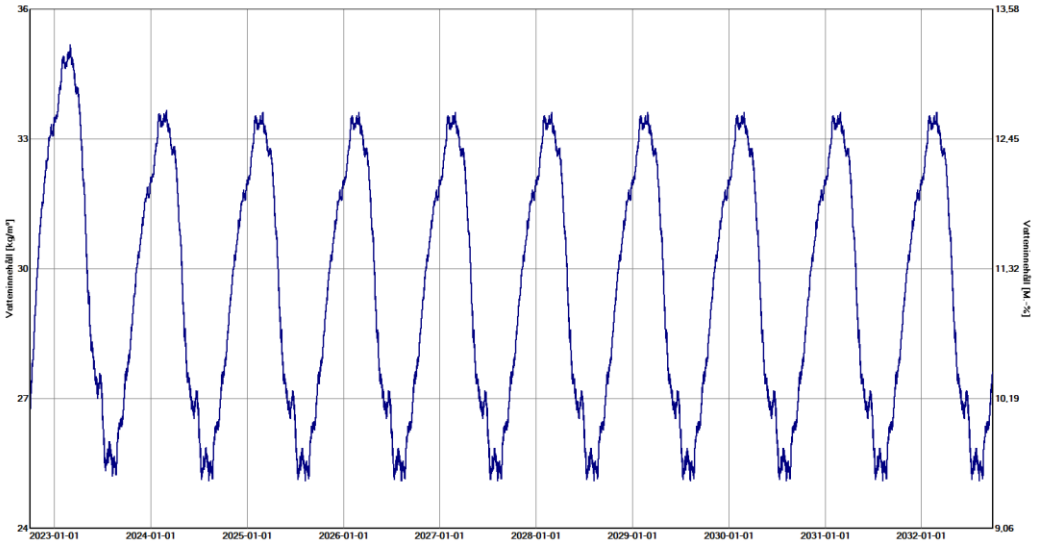
<u>The whole wall</u>



Even with built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

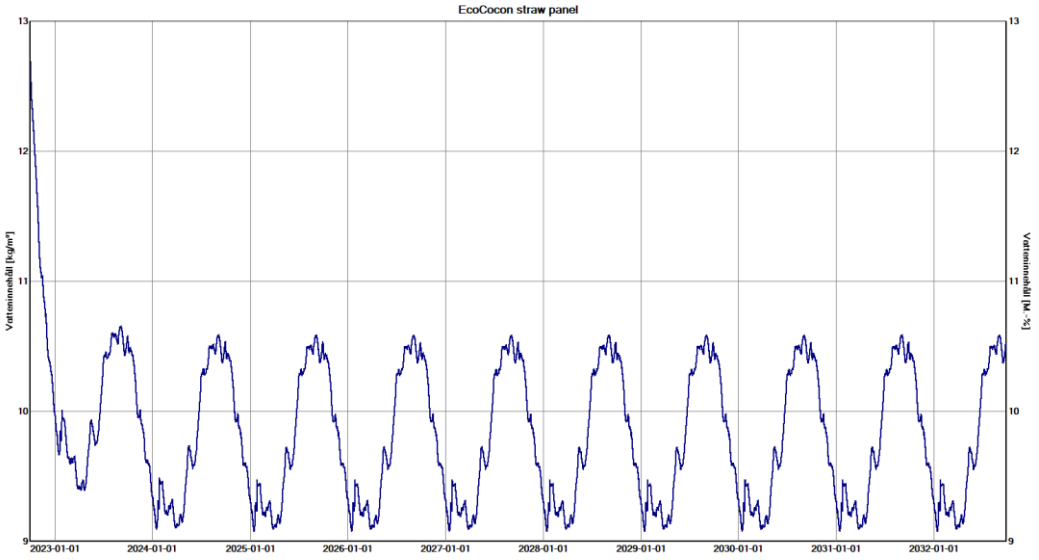
Single layers

Wood fibre behind the air gap:



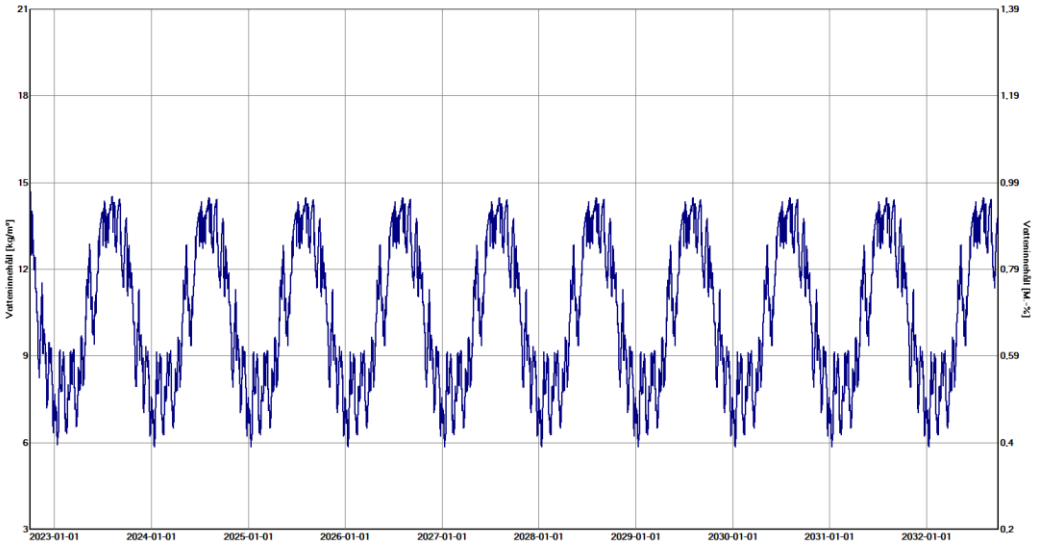
The wood fibreboard has the chance to dry out and the water content is then constantly below 13 M.-% and thus below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

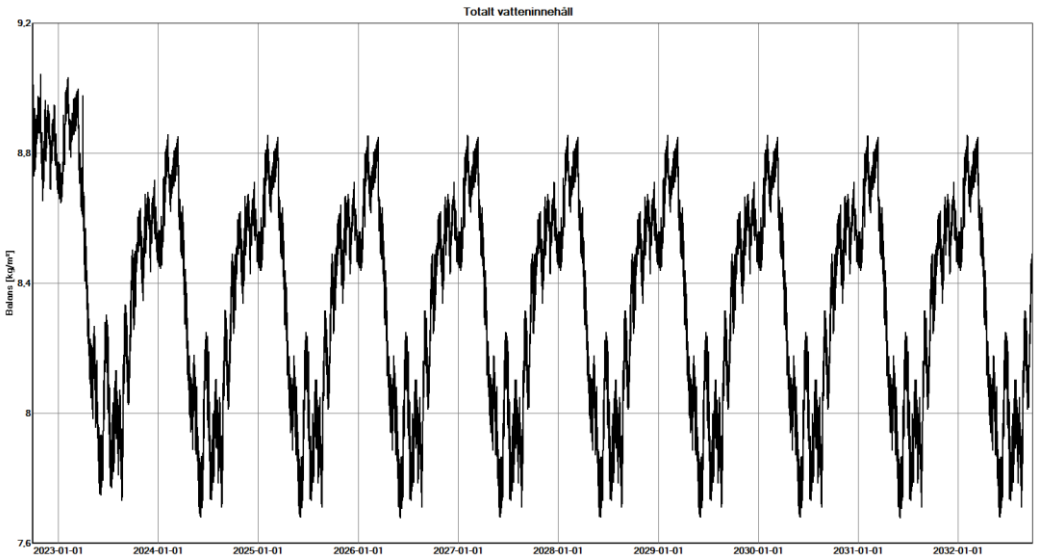
Plaster layer:



The moisture content does not take any harmful forms here - on the contrary: the layer helps to improve the indoor climate by buffering the humidity.

Wall type B - ventilated facade, plasterboard on the inside

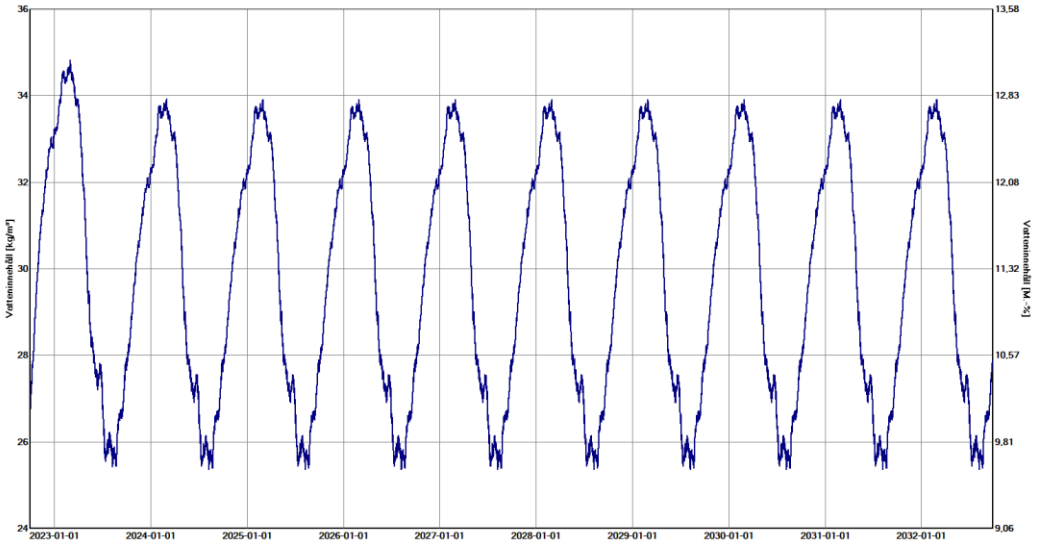
<u>The whole wall</u>



Even with built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

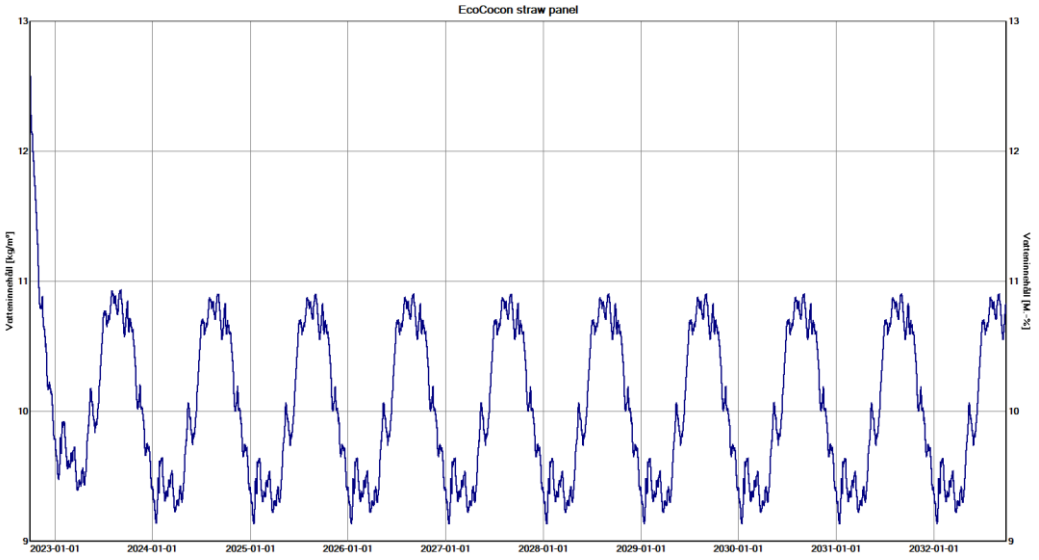
Single layers

Wood fibre behind the air gap:



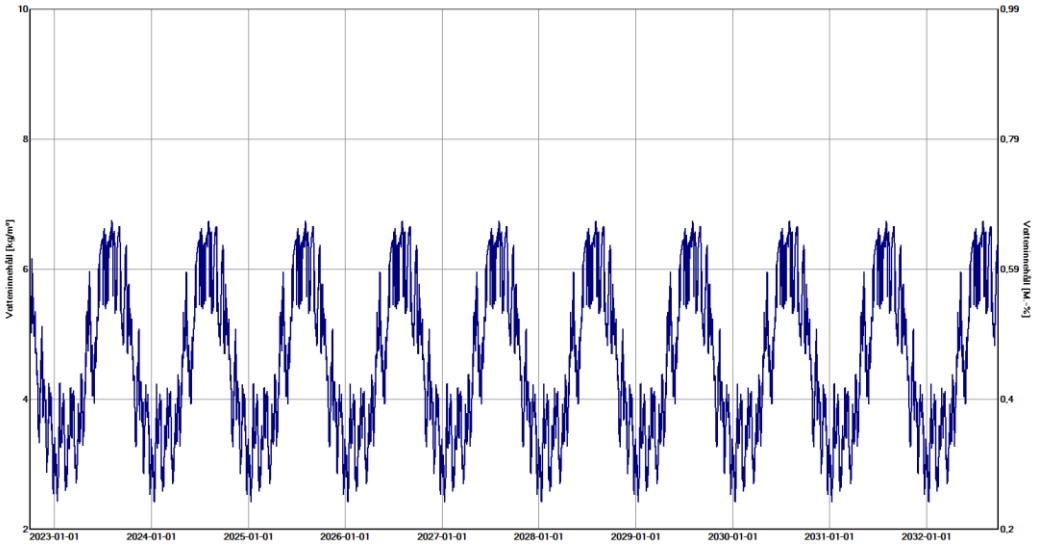
The wood fibreboard has the chance to dry out and the relative humidity is constantly below 13 M.-% and thus below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

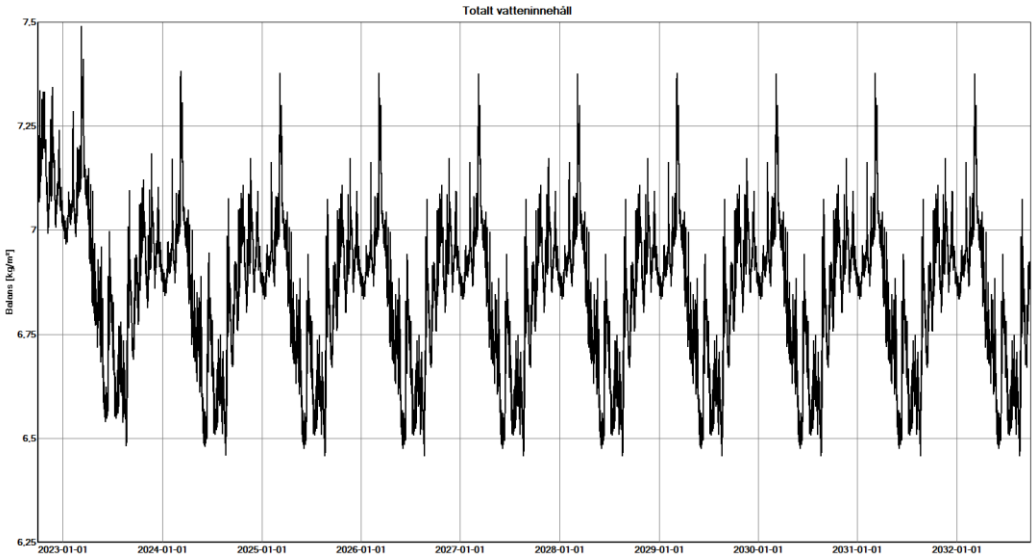
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type C - plastered facade, plaster on the inside

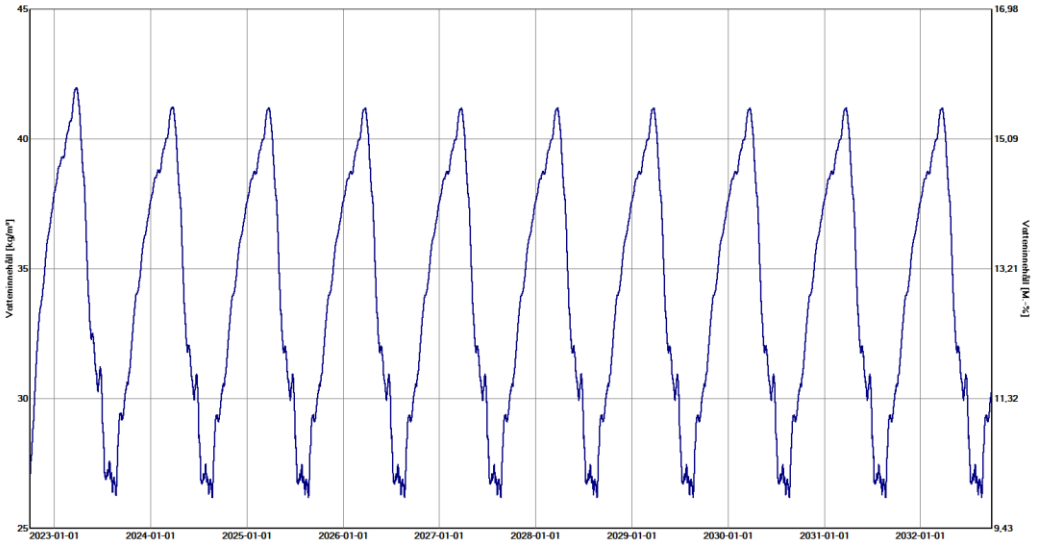
<u>The whole wall</u>



A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

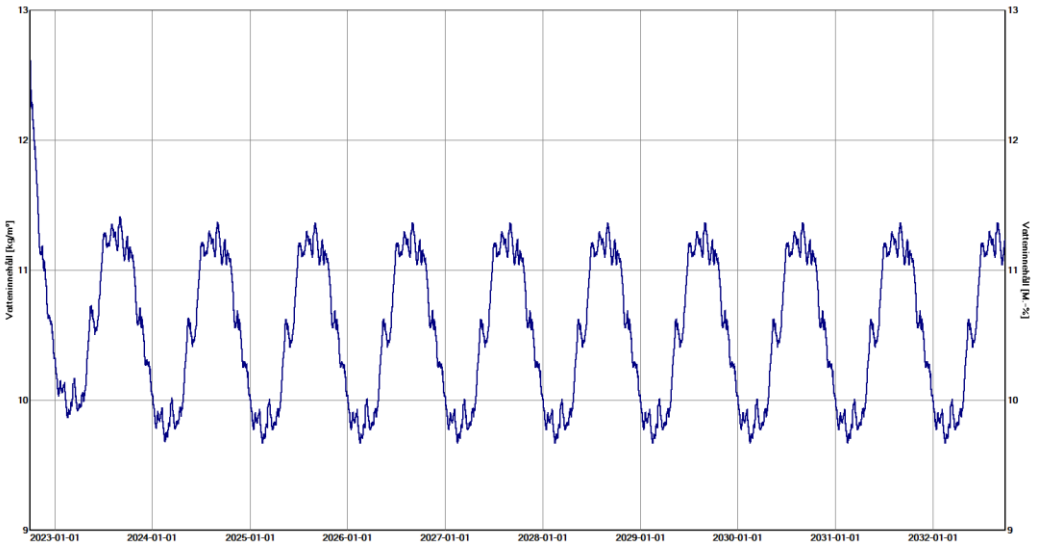
Single layers

Wood fibre behind the plaster:



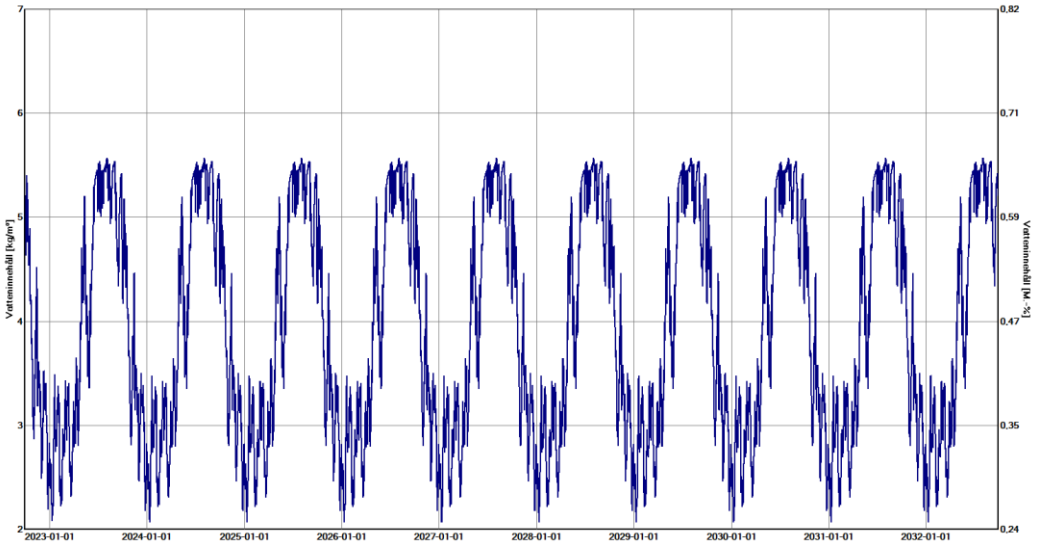
The wood fibreboard has the chance to dry out and the water content is always below the 18 M.-% which is considered the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 12 M.-% all the time.

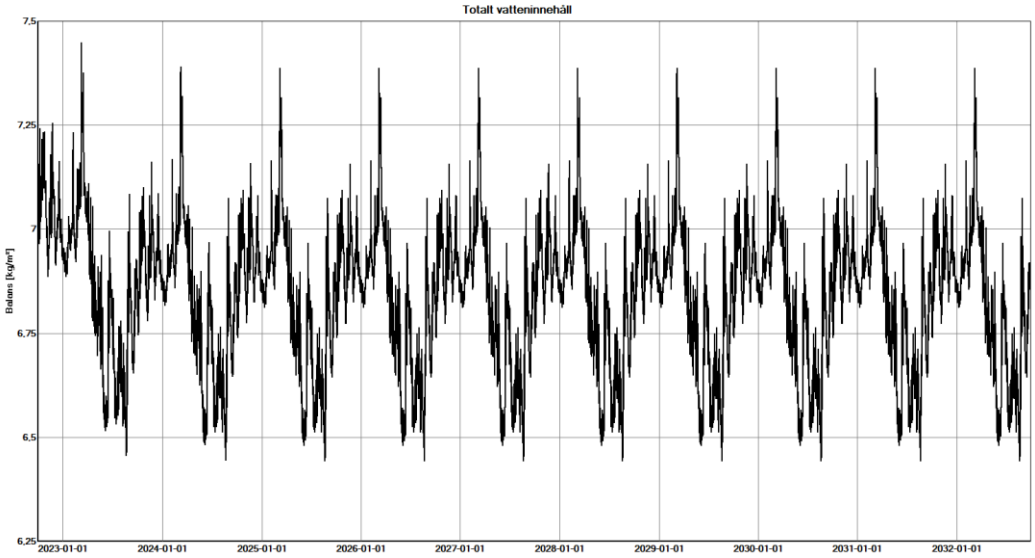
Plaster layer:



The moisture content does not take any harmful forms here.

Wall type D - plastered facade, plasterboard on the inside

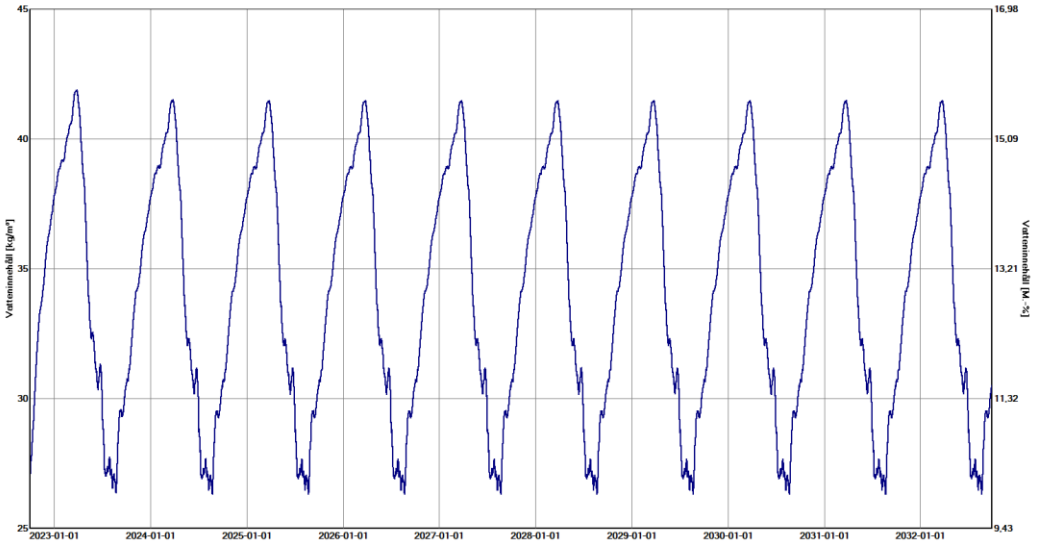
<u>The whole wall</u>



A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

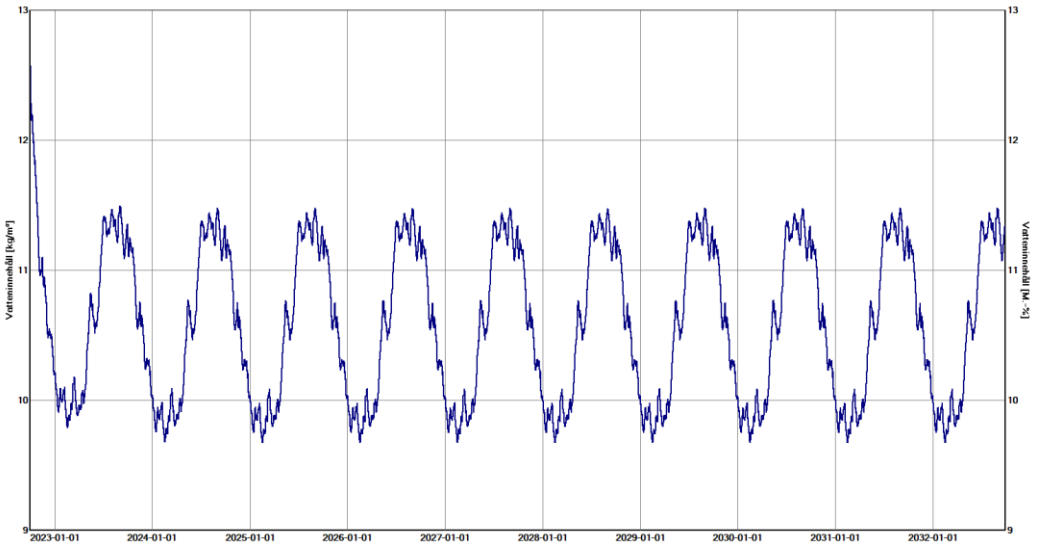
Single layers

Wood fibre behind the plaster:



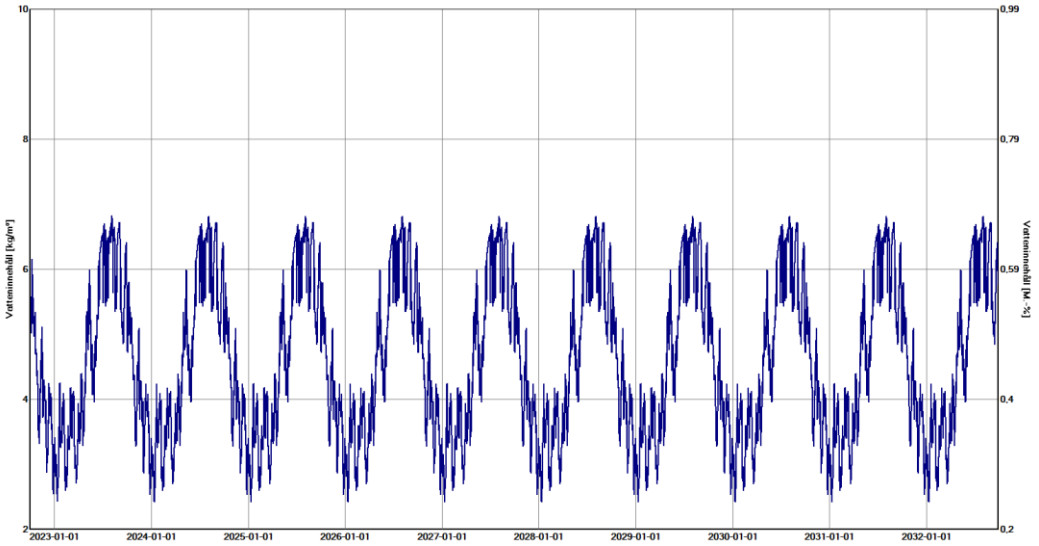
The wood fibreboard has the chance to dry out and the water content is always below the 18 M.-% which is considered to be the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 12 M.-% all the time.

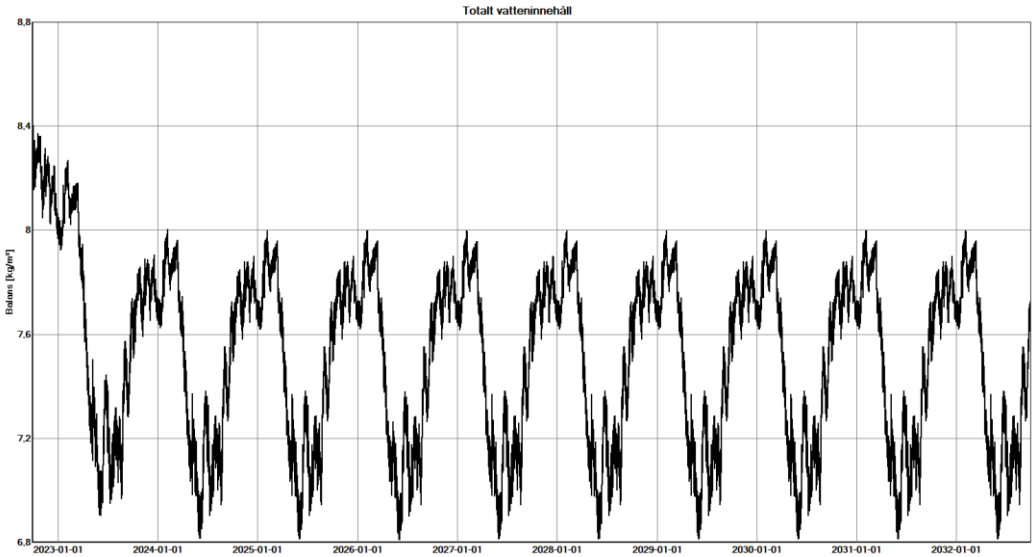
Plasterboard:



The moisture content here does not take any harmful forms.

Wall type J - ventilated facade, plaster on the inside

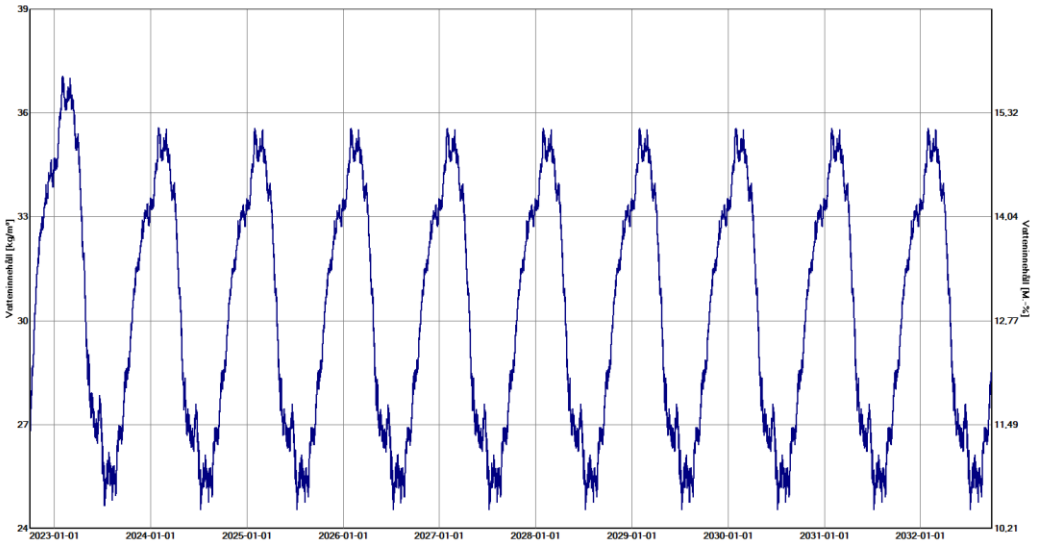
<u>The whole wall</u>



Even with built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

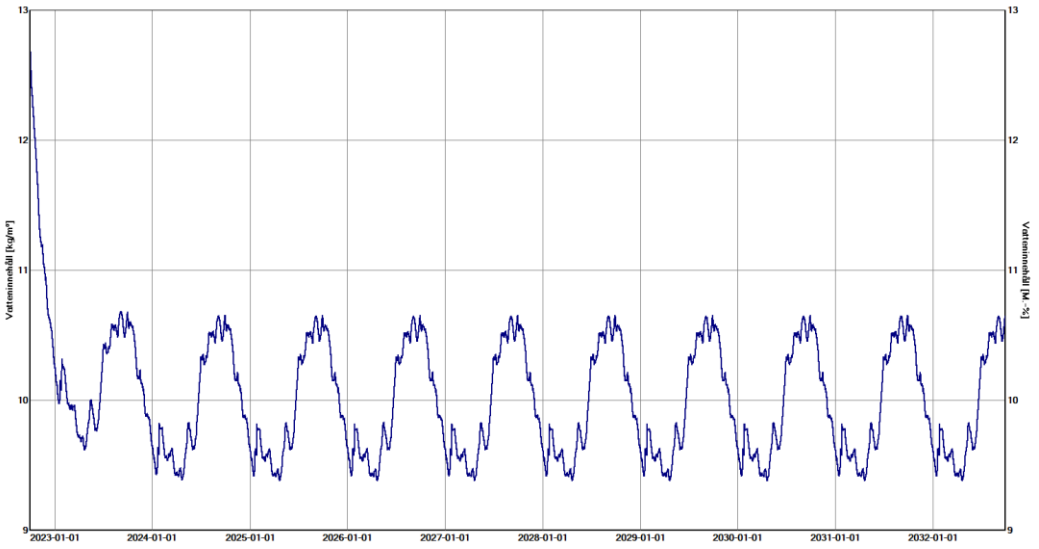
Single layers

Wood fibre behind the air gap:



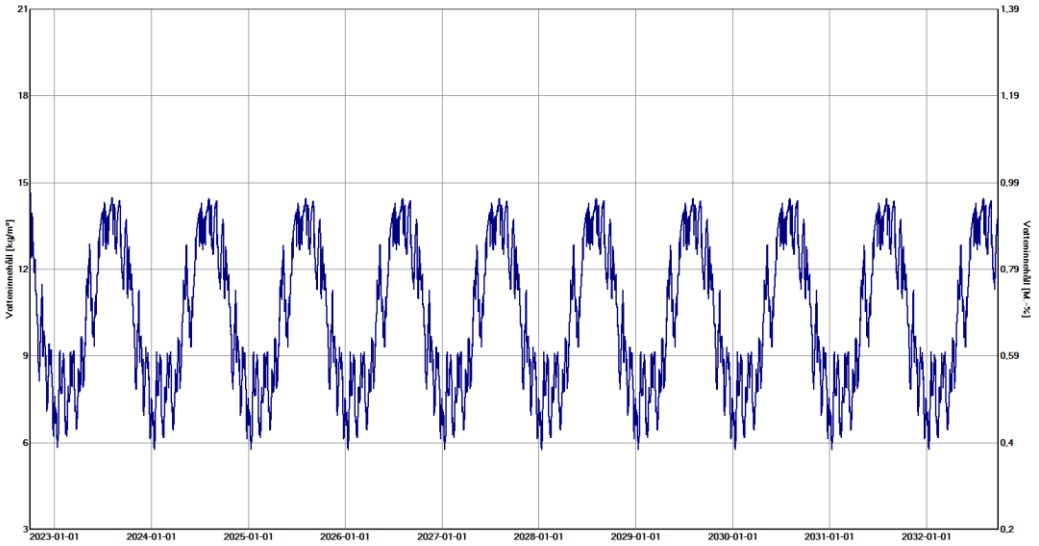
The wood fibreboard has the chance to dry out and the water content is then constantly below 15 M.-% and thus below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

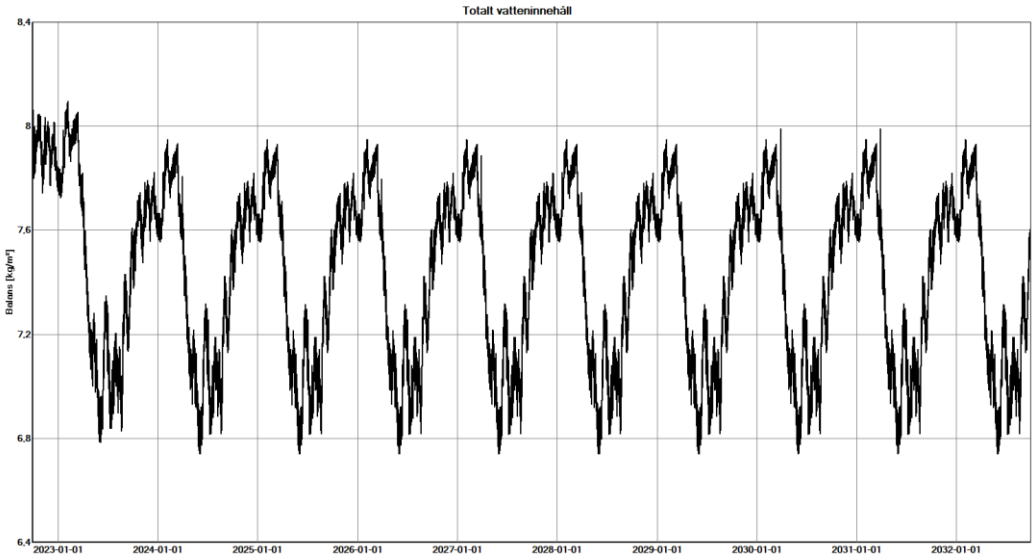
Plaster layer:



The moisture content does not take any harmful forms here - on the contrary: the layer helps to improve the indoor climate by buffering the humidity.

Wall type K - ventilated facade, plasterboard on the inside

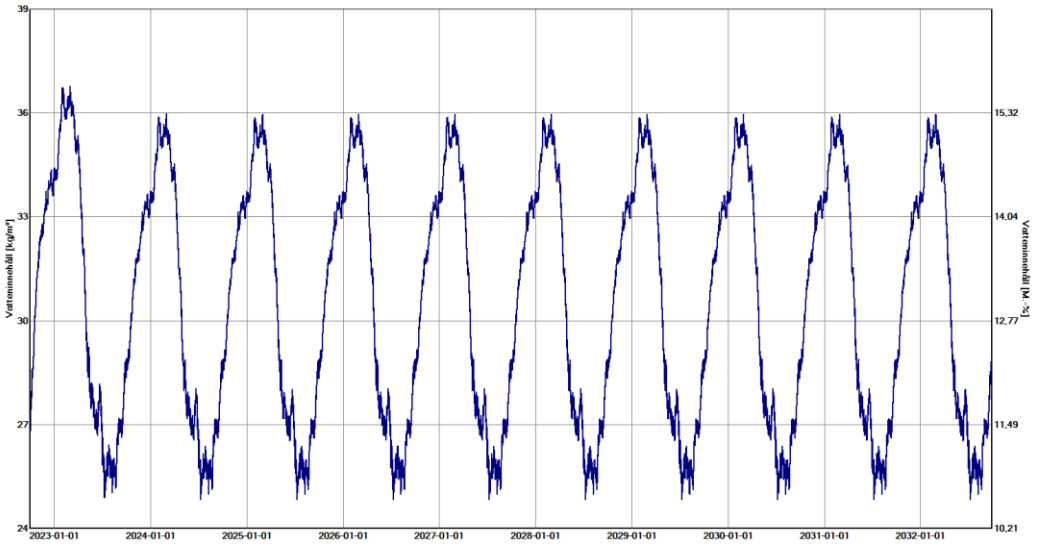
<u>The whole wall</u>



Even with built-in moisture content (80%), the entire wall structure dries out quite quickly. A simulation over 10 years shows that there is no accumulation of moisture over the long term. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly. As the building consists of prefabricated modules, the risk of internal moisture or leakage is even lower.

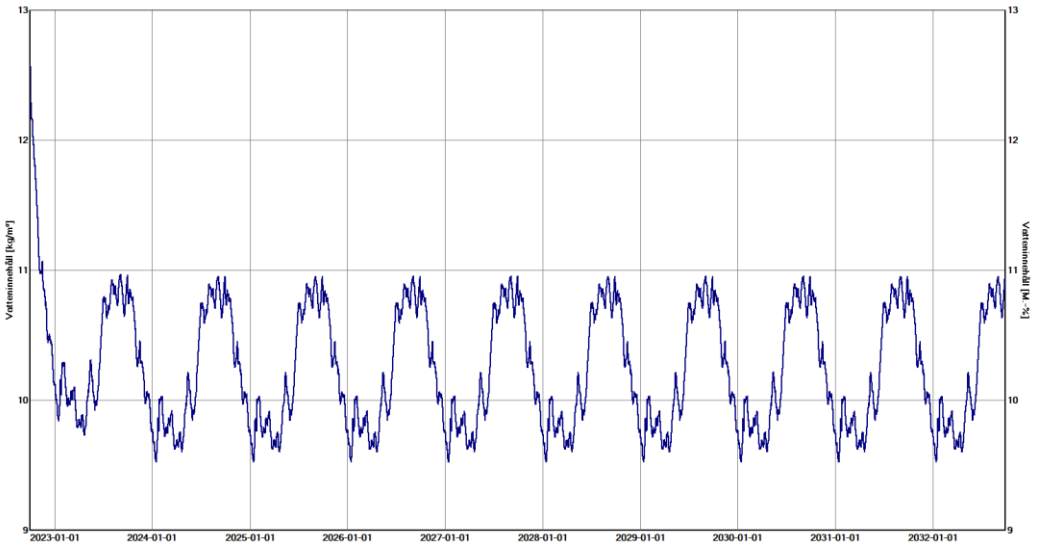
Single layers

Wood fibre behind the air gap:



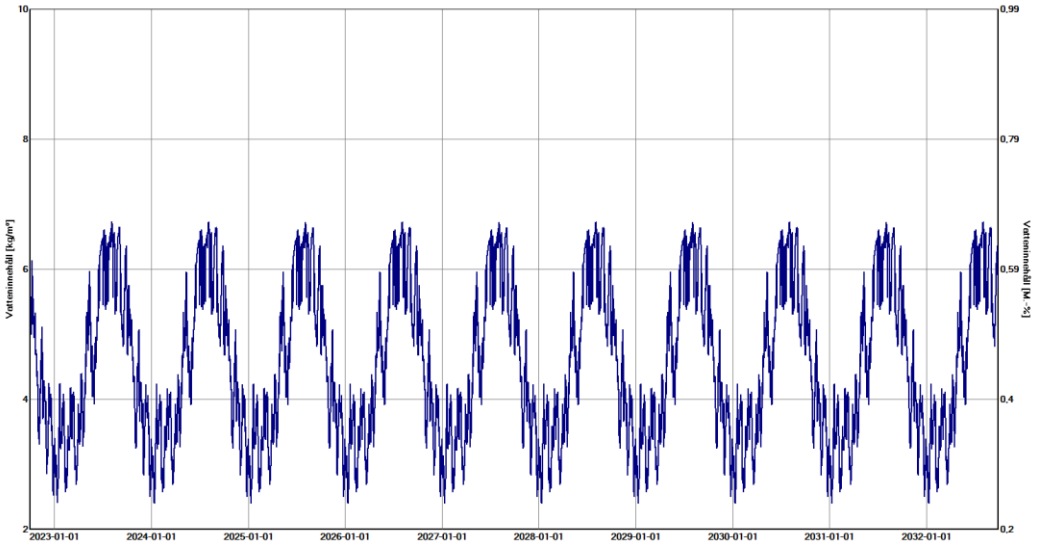
The asphalt fibreboard has the chance to dry out and the relative humidity is constantly below 16 M.-% and thus below the critical limit.

EcoCocon panel (straw):



After the deliberately high value at the beginning, the water content drops immediately and stays below 11 M.-% all the time.

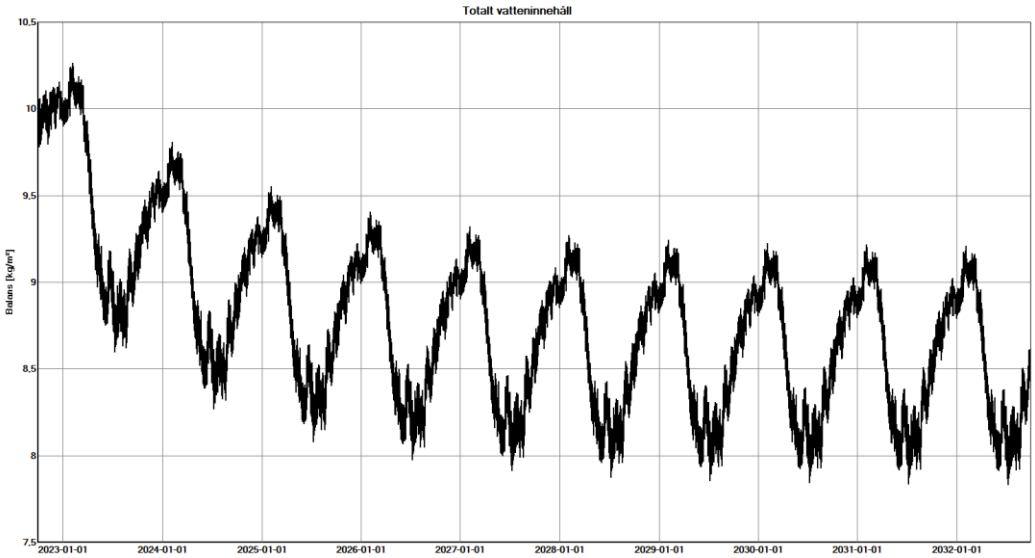
Plasterboard:



The moisture content does not take any harmful forms here.

Wall type M

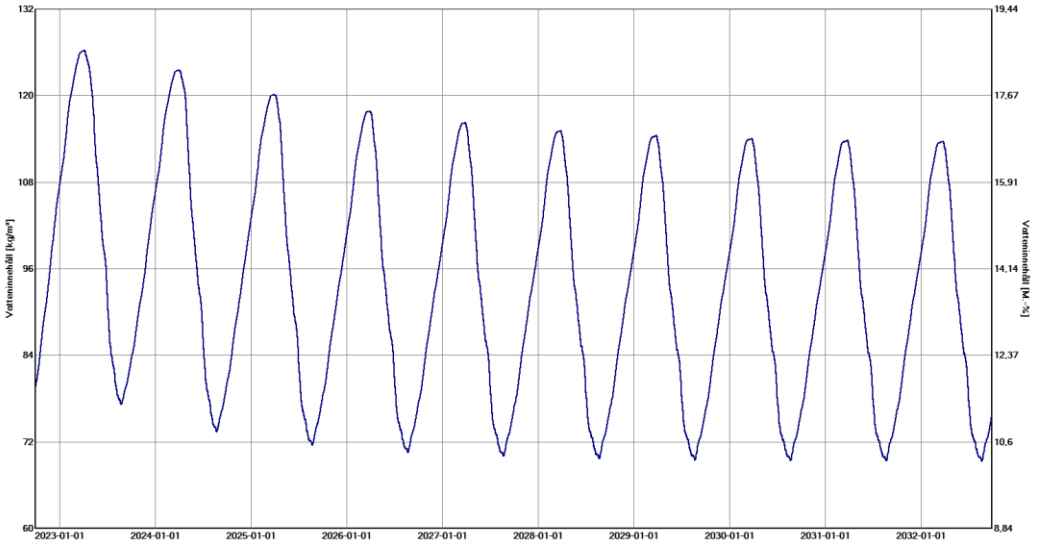
<u>The whole wall</u>



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 (unusually high assumed) built-in moisture. No risk of damage to the building fabric, or mould, can be expected if the work is carried out correctly.

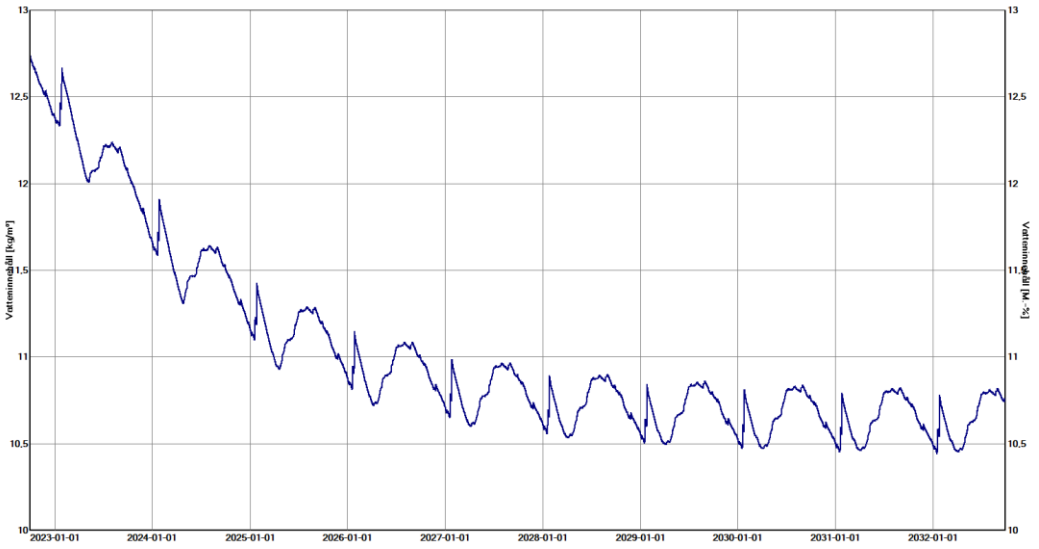
Single layers

The OSB board towards the outside:



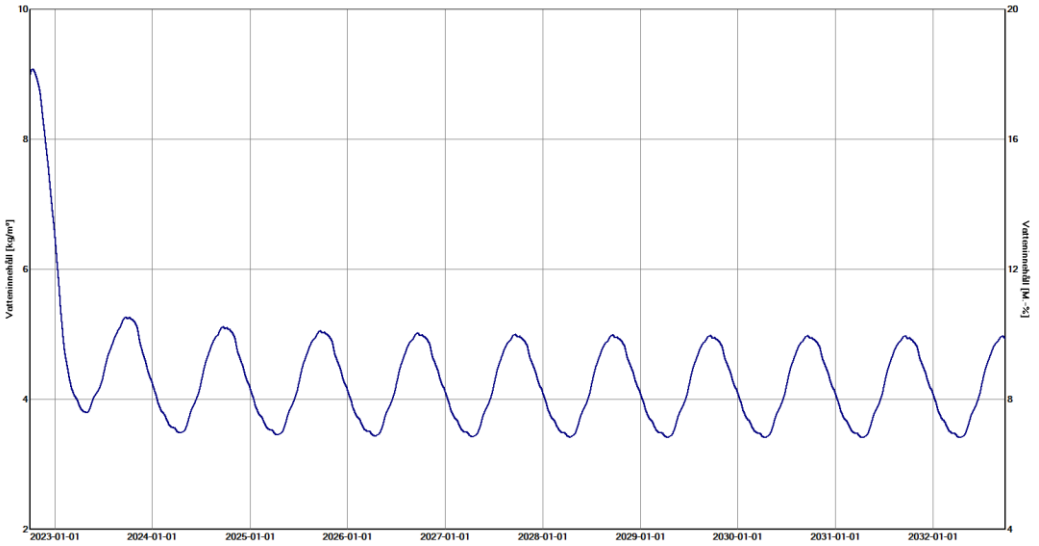
After a few seasons of drying out, the water content is permanently below 17 M.-%.

EcoCocon panel (straw):



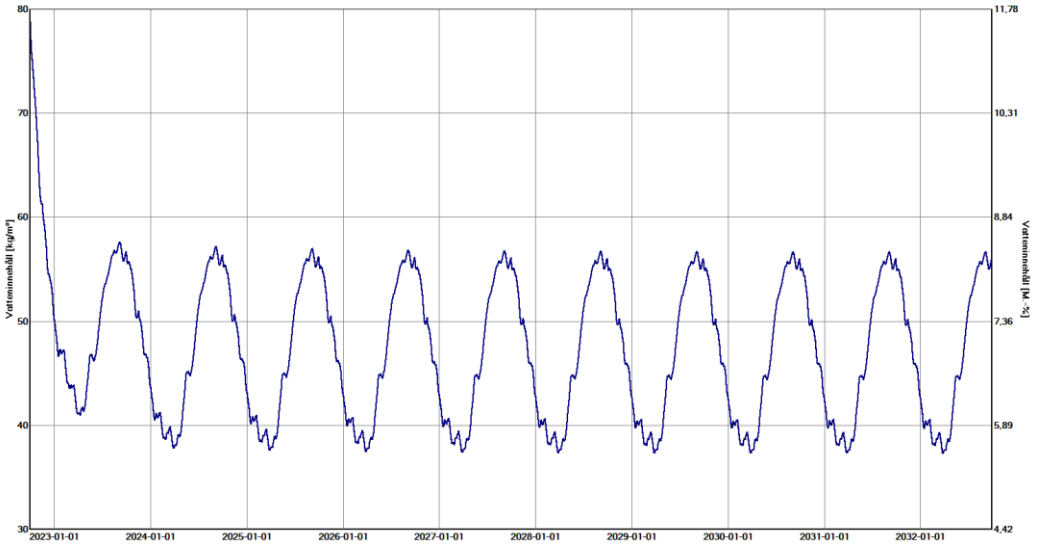
Again, it takes several seasons to come down to a lower level, but even after the intentionally high value at the beginning, the water content drops over time and is below 13 M.-% all the time.

The fibreboard:



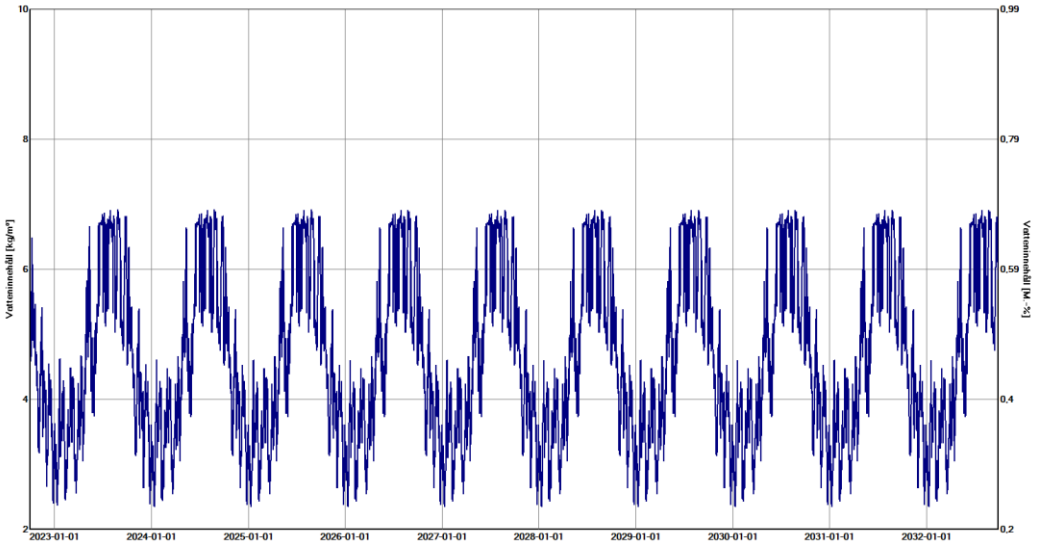
A low moisture level is reached after only a few months. Even with the intentionally high value at the beginning, the water content drops quickly and stays below 12 M.-%.

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.

Summary

The simulation shows that all examined wall types in all locations - except externally rendered facades in Bergen - dry out quickly, even if they have 80% moisture content at the start of construction. Of course, there is a periodic accumulation and reduction of moisture in the individual layers, but this never reaches alarming proportions.

The straw panels themselves and the inner layer (plaster or plasterboard) do not present any problems, but the wood fibre board is more sensitive - especially in the case of walls with external plaster. For walls with external plaster in the Bergen climate, the simulation shows that the moisture content of the wood fibre layer is too high for a long time, i.e. even at temperatures that can favour mould growth. It is therefore recommended that in the Bergen area only exterior walls with ventilated facades are used.

The rendered facades have been simulated with exterior plasters that have a water absorption coefficient of 0.1 kg/(m²·h$^{0.5}$). If the value is higher, it is a major hazard for the structure. The external plaster must also be carefully selected and maintained.

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 necessary, airtightness testing are prerequisites.
4) The specified moisture content of the materials, specific to wood or wood-based products, must not be exceeded. Careful, clean and dry storage must be a prerequisite.

Tvärred, 14 February 2023

Ingo Theoboldt
Building physicist, accredited certifier and designer for passive houses

Passivhusbyrån Ingo Theoboldt
Tel: 0762-874024
Address: Vasared 301, 523 94 Tvärred
E-mail: info@passivhusbyran.se