## Overview

To supplement the completed Tremblay retrofit package, additional approaches and climatic considerations are provided to demonstrate the versatility and effectiveness of the Larsen Truss system for retrofits across Canada. This is a very condensed and brief introduction, with further in-depth investigation being encouraged. It is important to note that "ubakus," the primary tool used for analysis, is not dynamic and only models steady-state scenarios. However, it was found sufficient for assessing average conditions and overall performance, with extremes checked as needed. Therefore, all temperatures and humidities in the analysis reflect expected seasonal averages.

### Alberta

The first package mirrors the Tremblay retrofit under conditions similar to those in Red Deer, branching conditions of Calgary and Edmonton. This approach is applicable not only to Alberta's most populated areas but also to other locations in Climate Zone 7A, such as Regina, Winnipeg, and Quebec City. It may also be suitable for parts of Zone 7B, like Whitehorse, and some areas of Zone 6, such as Ottawa. While relative humidity is high, the colder air holds less moisture overall, making outward moisture drive the primary concern. This allows a more conventional control layer strategy to function effectively.

### Southern Ontario

The second package differs from the Tremblay retrofit by eliminating the interior vapour layer, using only a vapour-smart weather barrier. Based on Toronto's climate, this approach is ideal for Canada's warmest and most humid regions, particularly southern Ontario (especially the southwest). It is designed for Zone 5 and could also be applied to parts of southwestern British Columbia. Additionally, it may be feasible for Zone 4 (such as Vancouver), where it effectively manages mild temperatures and humidity. This approach relies on permeability for outward vapour drive but may experience moisture accumulation in extreme cold, making it unsuitable for harsher climates

### Iqaluit

The third package is designed for arctic conditions, particularly those in Iqaluit. While this approach offers the broadest potential applicability, it is also the most intensive. It features fibreboard sheathing over the Larsen Truss, instead of just an air barrier, increased insulation, a variable moisture barrier, and both interior and exterior plywood on the studs for enhanced performance. This system effectively handles the extreme cold and high humidity of Zone 8. Experimental testing found that it performs well under a wide range of extreme conditions. However, further optimization would be required to refine the balance between performance and cost-effectiveness for broader application across Canada.

# Calculations for thermal insulation, moisture protection and heat protection

created on 2.4.2025 20:11

## Content



## Comparison with different maximum values*

| Component | BEG Einzelmaßn. | GEG 2020/24 Bestand | GEG 2023/24 Neubau | DIN 4108 |
|---|---|---|---|---|
| Tremblay Wall (Winter, AB) | ✓ | ✓ | ✓ | ✓ |
| Tremblay Wall (Summer, AB) | ✓ | ✓ | ✓ | ✓ |

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

# Tremblay Wall (Winter, AB)

Exterior wall
created on 2.4.2025

## Thermal protection

U = 0,15 W/(m²K)

DIN 4108*: R>1,74 m²K/W + $R_{si}$ + $R_{se}$

excellent insufficient

## Moisture proofing

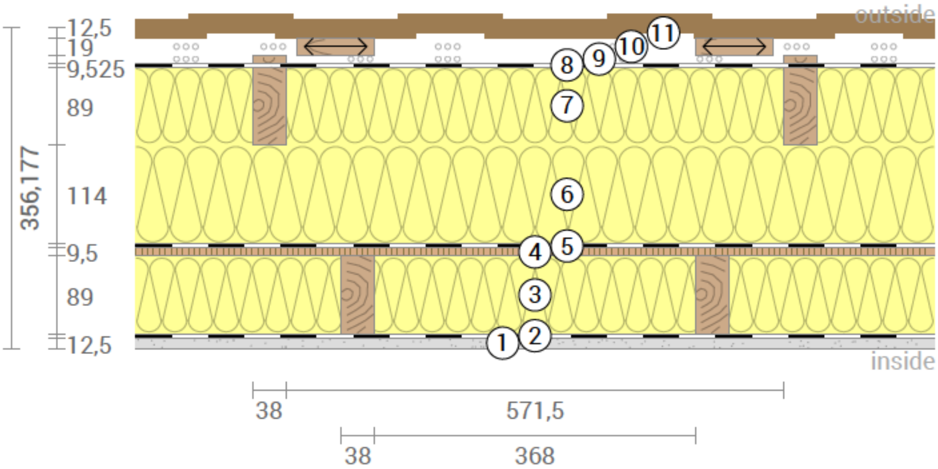
Drying reserve: 431 g/m²a
No condensate

excellent insufficient

## Heat protection

Temperature amplitude damping: 12
phase shift: 11,3 h
Thermal capacity inside: 26 kJ/m²K

excellent insufficient




1. Gypsum board (12,5 mm)
2. Foil, PE
3. Insulation, blanket and batt, rock or glass mineral fibre, R12, 89mm (89 mm)
4. Plywood - Douglas fir (9,5 mm)
5. Tyvek® HomeWrap®
6. Insulation, loose-fill insulation, cellulose (114 mm)
7. Insulation, loose-fill insulation, cellulose (89 mm)
8. Tyvek® HomeWrap®
9. Rear ventilated level (9,525 mm)
10. Rear ventilated level (19 mm)
11. Vertical cladding (12,5 mm)

<-> Layers marked by arrows are perpendicular to the main axis.

| | | | | |
|---|---|---|---|---|
| Inside air : | 23.0°C / 40% | | Thickness: | 35,6 cm |
| Outside air: | -14.0°C / 75% | sd-value: 17,4 m | Weight: | 36 kg/m² |
| Surface temperature.: | 21,4°C / -13,8°C | | Heat capacity: | 44 kJ/m²K |

☑ BEG Einzelmaßn. ☑ GEG 2020/24 Bestand ☑ GEG 2023/24 Neubau ☑ DIN 4108

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

Tremblay Wall (Winter, AB), U=0,15 W/(m²K)

# U-Value calculation according to DIN EN ISO 6946

| # | Material | Dicke [cm] | λ [W/mK] | R [m²K/W] |
|---|---|---|---|---|
| | Thermal contact resistance inside (Rsi) | | | 0,130 |
| 1 | Gypsum board | 1,25 | 0,250 | 0,050 |
| 2 | Foil, PE | 0,02 | 0,400 | 0,000 |
| 3 | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 8,90 | 0,055 | 1,618 |
| | Wood, structural framing (spruce-pine-fir) (9.4%) | 8,90 | 0,118 | 0,757 |
| 4 | Plywood - Douglas fir | 0,95 | 0,090 | 0,106 |
| 5 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| 6 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 11,40 | 0,040 | 2,850 |
| 7 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 8,90 | 0,040 | 2,225 |
| | Wood, structural framing (spruce-pine-fir) (6.2%) | 8,90 | 0,118 | 0,757 |
| 8 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| | Thermal contact resistance outside (Rse) | | | 0,130 |

Thermal contact resistances have been taken from DIN 6946 Table 7.
Rsi: heat flow direction horizontally
Rse: heat flow direction horizontally, outside: Ventilation level

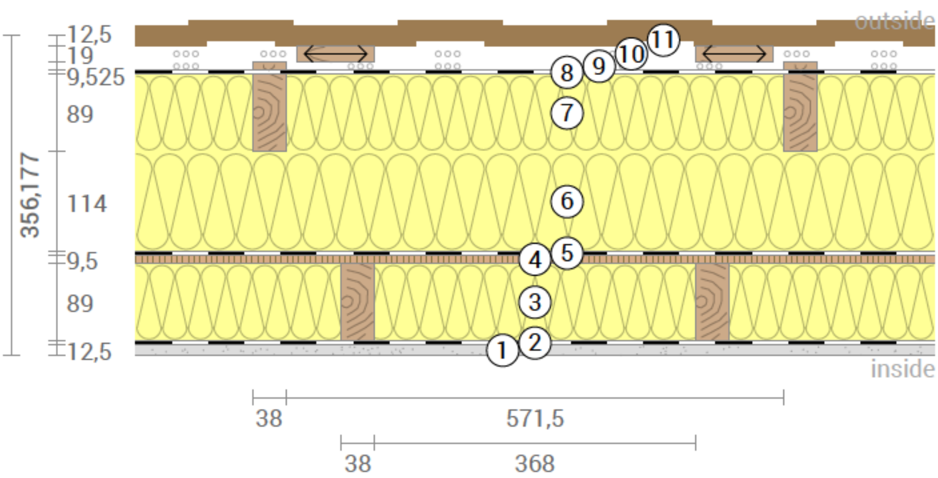
Upper limit of thermal resistance $R_{tot;upper}$ = 6,910 m²K/W.
Lower limit of thermal resistance $R_{tot;lower}$ = 6,714 m²K/W.
Check applicability: $R_{tot;upper}$ / $R_{tot;lower}$ = 1,029 (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance $R_{tot} = (R_{tot;upper} + R_{tot;lower})/2$ = 6.812 m²K/W
Estimated maximum relative uncertainty according to section 6.7.2.5: 1.4%

Heat transfer coefficient U = $1/R_{tot}$ = **0,15 W/(m²K)**

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 61 cm. This, however, is not true for at least layer 3 with a total width of 40,6 cm and can cause increased inaccuracy of the U-value.



Tremblay Wall (Winter, AB), U=0,15 W/(m²K)

## LCA

**Heat loss: 21 kWh/m² per heating season**

Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

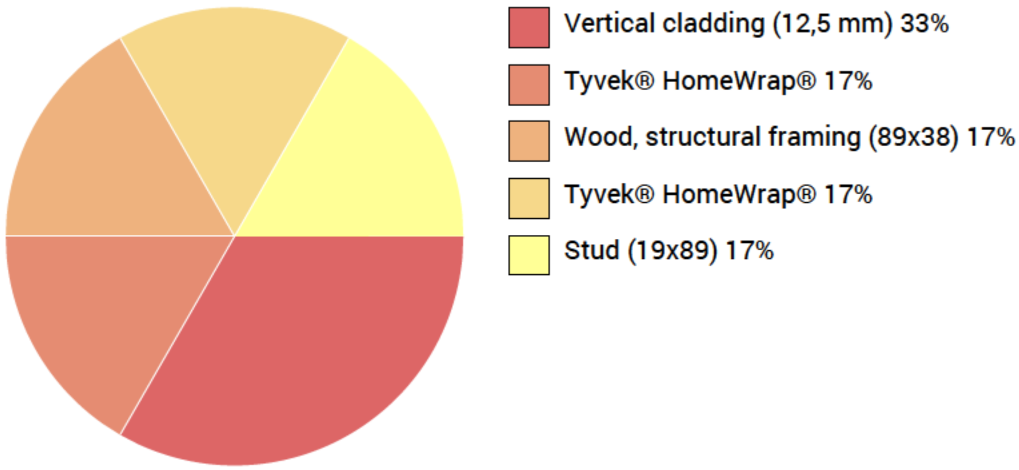
**Primary energy (non renewable): >6.1 kWh/m²**

Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

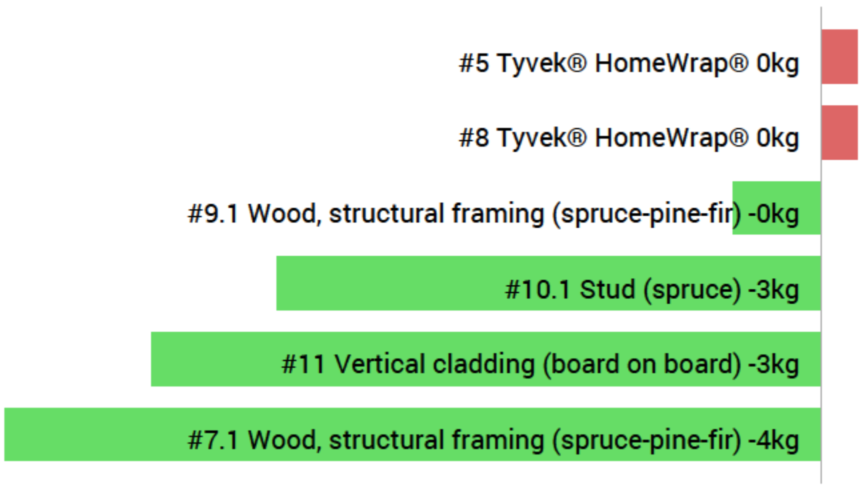
**Green house gas potential: -9.5 (?) kg CO2 Äqv./m²**

For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

### Composition of non-renewable primary energy of production:



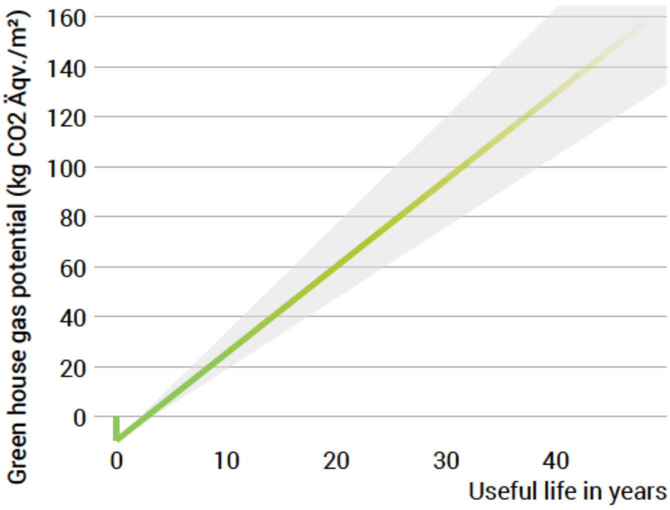

### Composition of the greenhouse potential of production:

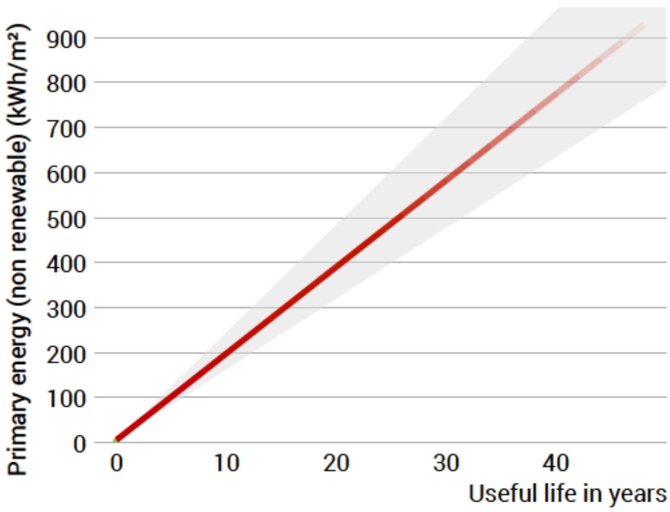



Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

Tremblay Wall (Winter, AB), U=0,15 W/(m²K)

## Global warming potential and primary energy for construction and use




The **left figure** shows the global warming potential of the production of the component in the vertical part of the curve. Greenhouse gas emissions (through heating) arising during use of the building are indicated by the upward curve.

The **figure at the bottom left** shows the non-renewable primary energy expenditure for the production of the component in the vertical part of the curve. The primary energy required during use of the building (through heating) is represented by the upward curve.

The longer the component is used unchanged, the more environmentally friendly it is, because the production costs contribute less to the total emissions (indicated by the color of the curve).

Due to unknown solar and internal gains, the heating demand can only be estimated. Accordingly, primary energy consumption and global warming potential during the use phase are only vaguely known. For the estimation it was assumed that solar and internal profits contribute with 4 kWh/a/m² component area. The light gray area indicates the area in which the curve is located with great certainty. For heat generation, a primary energy input of 1.2 kWh per kWh of heat and a global warming potential of 0.21 kg CO2 eqv/m² per kWh of heat was used. Heat source: Natural gas H.

### Hints

Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

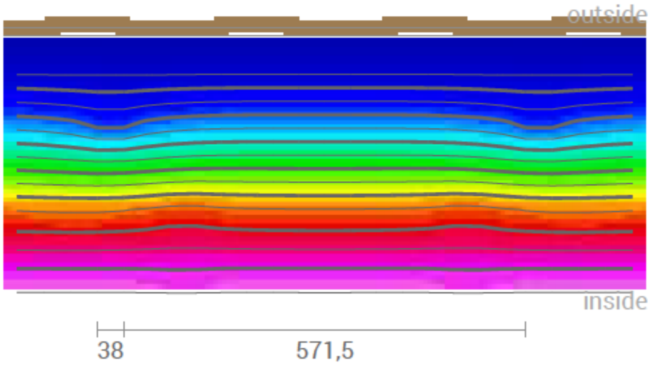
Calculated for the location AB:ABEE AGDM, heating period from Mid of October to End of April. The calculation is based on monthly average temperatures. Source: Canadian Weather Year for Energy Calculation (2016)

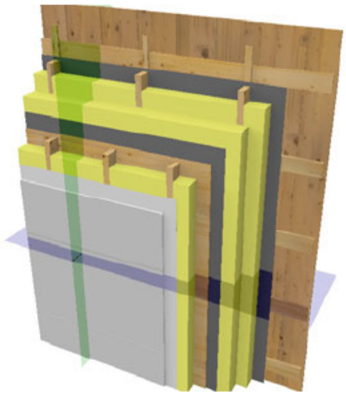
The climate and energy data on which this calculation is based can, in some cases, show considerable fluctuations and, in individual cases, deviate considerably from the actual value.

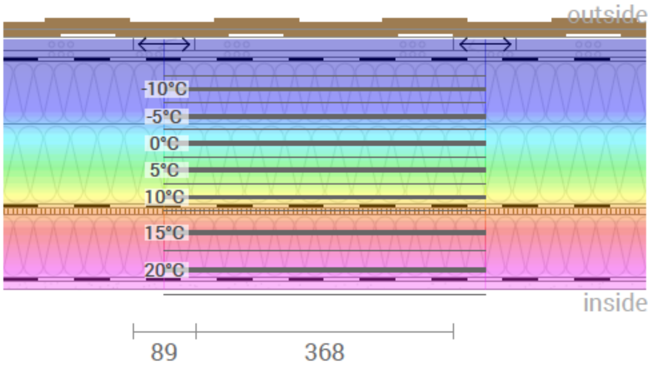
Note: The environmental product data for layer 6 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 7 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
The calculated amortization periods of primary energy and global warming potential are therefore too low.
Keine Berechnung möglich.

Tremblay Wall (Winter, AB), U=0,15 W/($m^2$K)

## Temperature profile






Top left: Temperature profile in the blue section (see right illustration). Bottom left: Temperature profile in the green section.

## Layers (from inside to outside)

| # | | Material | λ [W/mK] | RSI [$m^2$K/W] | Temperatur [°C] min | max | Weight [kg/$m^2$] |
|---|---|---|---|---|---|---|---|
| | | Thermal contact resistance* | | 0,250 | 21,4 | 23,0 | |
| 1 | 1,25 cm | Gypsum board | 0,250 | 0,050 | 21,0 | 21,7 | 8,5 |
| 2 | 0,015 cm | Foil, PE | 0,400 | 0,000 | 21,0 | 21,5 | 0,1 |
| 3 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,055 | 1,618 | 12,9 | 21,5 | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 0,118 | 0,757 | 14,4 | 21,2 | 3,8 |
| 4 | 0,95 cm | Plywood - Douglas fir | 0,090 | 0,106 | 12,3 | 14,4 | 2,9 |
| 5 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | 12,3 | 13,7 | 0,1 |
| 6 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,850 | -4,7 | 13,7 | 6,8 |
| 7 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,225 | -13,8 | -2,1 | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 0,118 | 0,757 | -13,7 | -4,7 | 2,5 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | -13,8 | -13,7 | 0,1 |
| | | Thermal contact resistance* | | 0,040 | -14,0 | -13,7 | |
| 9 | 0.9525 cm | Rear ventilated level (outside air) | | | -14,0 | -14,0 | 0,0 |
| 10 | 1.9 cm | Rear ventilated level (outside air) | | | -14,0 | -14,0 | 0,0 |
| 11 | 1.25 cm | Vertical cladding (board on board) | | | -14,0 | -14,0 | 2,2 |
| | 35.61774 cm | Whole component | | 6,812 | | | 36,4 |

*Thermal contact resistances according to DIN 4108-3 for moisture protection and temperature profile. The values for the U-value calculation can be found on the page 'U-value calculation'.

| | | | |
|---|---|---|---|
| Surface temperature inside (min / average / max): | 21,4°C | 21,6°C | 21,7°C |
| Surface temperature outside (min / average / max): | -13,8°C | -13,8°C | -13,7°C |

Tremblay Wall (Winter, AB), U=0,15 W/(m²K)

# Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 23°C und 40% Humidity; outside: -14°C und 75% Humidity (Climate according to user input).

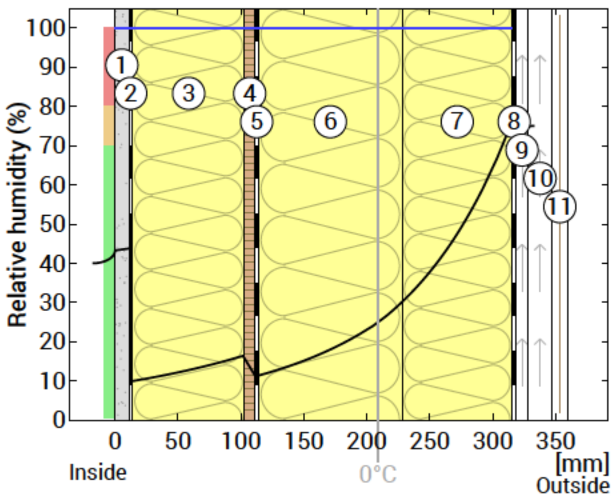
This component is free of condensate under the given climate conditions.

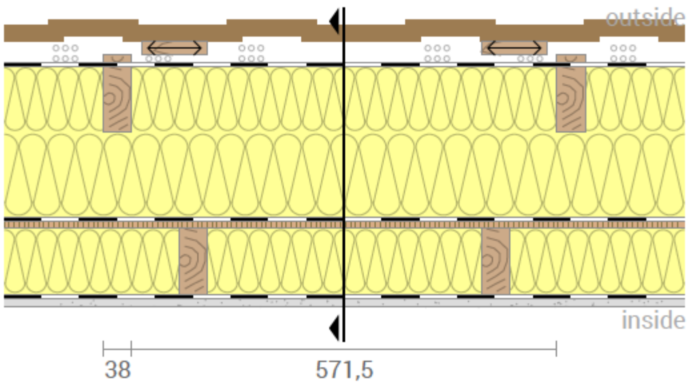
Drying reserve according to Ubakus 2D-FE method: 431 g/(m²a)
At least required by DIN 68800-2: 100 g/(m²a)

| # | | Material | sd-value [m] | Condensate [kg/m²] | Condensate [Gew.-%] | Weight [kg/m²] |
|---|---|---|---|---|---|---|
| 1 | 1,25 cm | Gypsum board | 0,05 | - | | 8,5 |
| 2 | 0,015 cm | Foil, PE | 15,24 | - | | 0,1 |
| 3 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,09 | - | | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 4,45 | - | - | 3,8 |
| 4 | 0,95 cm | Plywood - Douglas fir | 1,43 | - | - | 2,9 |
| 5 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| 6 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,23 | - | | 6,8 |
| 7 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,18 | - | | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 4,45 | - | - | 2,5 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| | 35.61774 cm | Whole component | 17,43 | 0 | | 36,4 |

## Humidity

The temperature of the inside surface is 21,4 °C leading to a relative humidity on the surface of 44%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



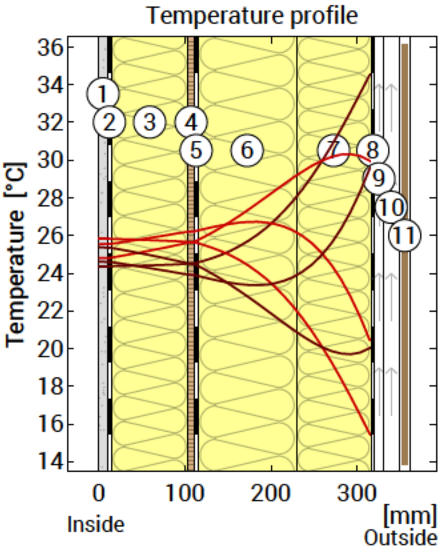

① Gypsum board (12,5 mm)
② Foil, PE
③ Insulation, blanket and batt, rock ...
④ Plywood - Douglas fir (9,5 mm)
⑤ Tyvek® HomeWrap®
⑥ Insulation, loose-fill insulation, ce...
⑦ Insulation, loose-fill insulation, ce...
⑧ Tyvek® HomeWrap®
⑨ Rear ventilated level (9,53 mm)
⑩ Rear ventilated level (19 mm)
⑪ Vertical cladding (12,5 mm)

Layers marked with <-> run parallel to the illustrated cutting plane and were not taken into account in the moisture protection calculation.
Notes: Calculation using the Ubakus 2D-FE method. Convection and the capillarity of the building materials were not considered. The drying time may take longer under unfavorable conditions (shading, damp / cool summers) than calculated here.

Tremblay Wall (Winter, AB), U=0,15 W/(m²K)

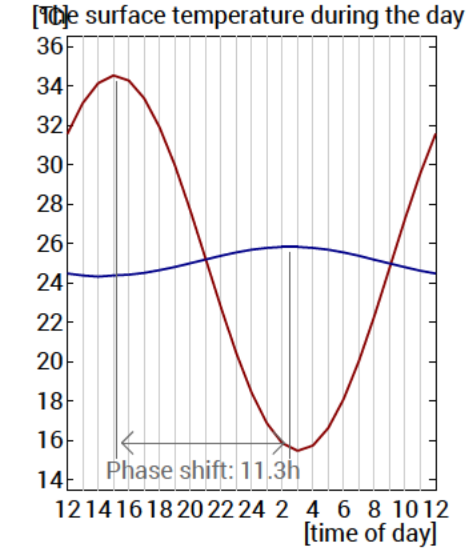
## Heat protection

The following results are properties of the tested component alone and do not make any statement about the heat protection of the entire room:




Temperature at 3pm, 11am and 7am
Temperature at 7pm, 11pm and 3am

1. Gypsum board (12,5 mm)
2. Foil, PE
3. Insulation, blanket and batt, rock or glass mineral fibre, R12, 89mm (89 mm)
4. Plywood - Douglas fir (9,5 mm)
5. Tyvek® HomeWrap®
6. Insulation, loose-fill insulation, cellulose (114 mm)
7. Insulation, loose-fill insulation, cellulose (89 mm)
8. Tyvek® HomeWrap®
9. Rear ventilated level (9,53 mm)
10. Rear ventilated level (19 mm)
11. Vertical cladding (12,5 mm)




Outside
Inside

**Top:**Temperature profile within the component at different times. From top to bottom, brown lines: at 3 pm, 11 am and 7 am and red lines at 7 pm , 11 pm and 3 am.
**Bottom:**Temperature on the outer ( red ) and inner ( blue ) surface in the course of a day. The arrows indicate the location of the temperature maximum values . The maximum of the inner surface temperature should preferably occur during the second half of the night.

| | | | |
|---|---|---|---|
| Phase shift* | 11,3 h | Heat storage capacity (whole component): | 44 kJ/m²K |
| Amplitude attenuation ** | 12,5 | Thermal capacity of inner layers: | 26 kJ/m²K |
| TAV *** | 0,080 | | |

* The phase shift is the time in hours after which the temperature peak of the afternoon reaches the component interior.
** The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 means that the temperature on the outside varies 10x stronger than on the inside, e.g. outside 15-35 °C, inside 24-26 °C.
*** The temperature amplitude ratio TAV is the reciprocal of the attenuation: TAV = 1 / amplitude attenuation

Note: The heat protection of a room is influenced by several factors, but essentially by the direct solar radiation through windows and the total amount of heat storage capacity (including floor, interior walls and furniture). A single component usually has only a very small influence on the heat protection of the room.

The calculations presented above have been created for a 1-dimensional cross-section of the component.

# Tremblay Wall (Summer, AB)

Exterior wall
created on 2.4.2025

## Thermal protection

U = 0,15 W/(m²K)

DIN 4108*: R>1,74 m²K/W + $R_{si}$ + $R_{se}$

excellent insufficient

## Moisture proofing

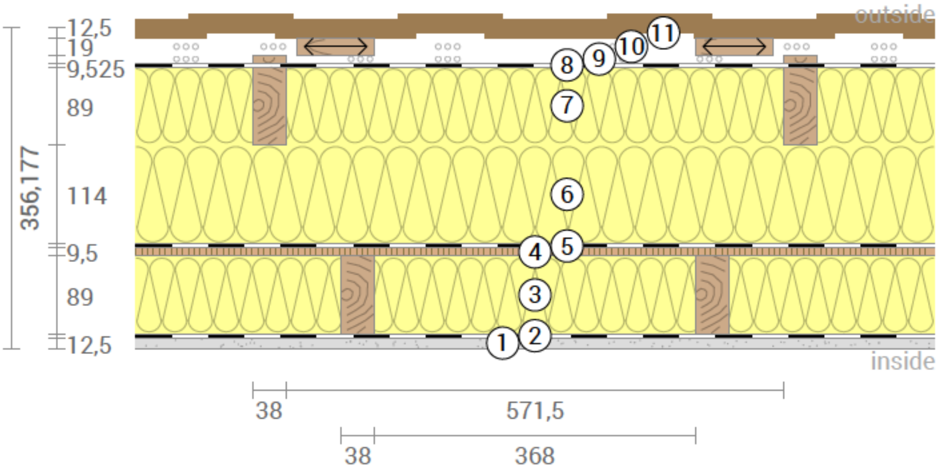
Drying reserve: 431 g/m²a
No condensate

excellent insufficient

## Heat protection

Temperature amplitude damping: 12
phase shift: 11,3 h
Thermal capacity inside: 26 kJ/m²K

excellent insufficient




1. Gypsum board (12,5 mm)
2. Foil, PE
3. Insulation, blanket and batt, rock or glass mineral fibre, R12, 89mm (89 mm)
4. Plywood - Douglas fir (9,5 mm)
5. Tyvek® HomeWrap®
6. Insulation, loose-fill insulation, cellulose (114 mm)
7. Insulation, loose-fill insulation, cellulose (89 mm)
8. Tyvek® HomeWrap®
9. Rear ventilated level (9,525 mm)
10. Rear ventilated level (19 mm)
11. Vertical cladding (12,5 mm)

<-> Layers marked by arrows are perpendicular to the main axis.

| | | | | |
|---|---|---|---|---|
| Inside air : | 21.0°C / 50% | | Thickness: | 35,6 cm |
| Outside air: | 18.0°C / 74% | sd-value: 17,4 m | Weight: | 36 kg/m² |
| Surface temperature.: | 20,9°C / 18,0°C | | Heat capacity: | 44 kJ/m²K |

☑ BEG Einzelmaßn. ☑ GEG 2020/24 Bestand ☑ GEG 2023/24 Neubau ☑ DIN 4108

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

# U-Value calculation according to DIN EN ISO 6946

| # | Material | Dicke [cm] | λ [W/mK] | R [m²K/W] |
|---|---|---|---|---|
| | Thermal contact resistance inside (Rsi) | | | 0,130 |
| 1 | Gypsum board | 1,25 | 0,250 | 0,050 |
| 2 | Foil, PE | 0,02 | 0,400 | 0,000 |
| 3 | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 8,90 | 0,055 | 1,618 |
| | Wood, structural framing (spruce-pine-fir) (9.4%) | 8,90 | 0,118 | 0,757 |
| 4 | Plywood - Douglas fir | 0,95 | 0,090 | 0,106 |
| 5 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| 6 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 11,40 | 0,040 | 2,850 |
| 7 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 8,90 | 0,040 | 2,225 |
| | Wood, structural framing (spruce-pine-fir) (6.2%) | 8,90 | 0,118 | 0,757 |
| 8 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| | Thermal contact resistance outside (Rse) | | | 0,130 |

Thermal contact resistances have been taken from DIN 6946 Table 7.
Rsi: heat flow direction horizontally
Rse: heat flow direction horizontally, outside: Ventilation level

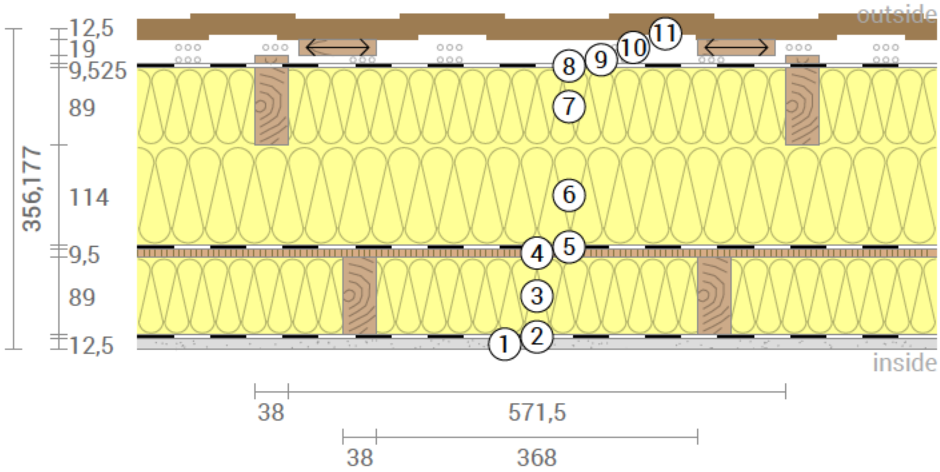
Upper limit of thermal resistance $R_{tot;upper}$ = 6,910 m²K/W.
Lower limit of thermal resistance $R_{tot;lower}$ = 6,714 m²K/W.
Check applicability: $R_{tot;upper}$ / $R_{tot;lower}$ = 1,029 (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance $R_{tot} = (R_{tot;upper} + R_{tot;lower})/2$ = 6.812 m²K/W
Estimated maximum relative uncertainty according to section 6.7.2.5: 1.4%

Heat transfer coefficient $U = 1/R_{tot}$ = **0,15 W/(m²K)**

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 61 cm. This, however, is not true for at least layer 3 with a total width of 40,6 cm and can cause increased inaccuracy of the U-value.



Tremblay Wall (Summer, AB), U=0,15 W/(m²K)

## LCA

**Heat loss: 19 kWh/m² per heating season**

Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

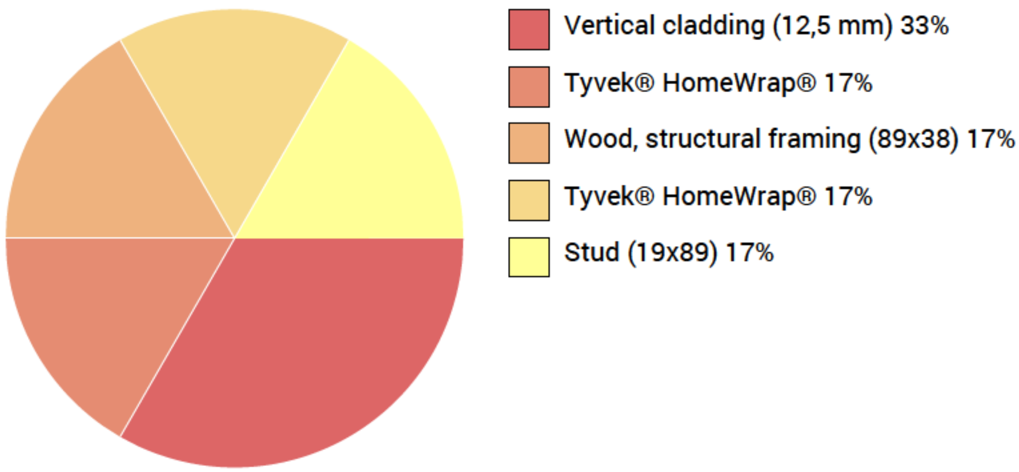
**Primary energy (non renewable): >6.1 kWh/m²**

Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

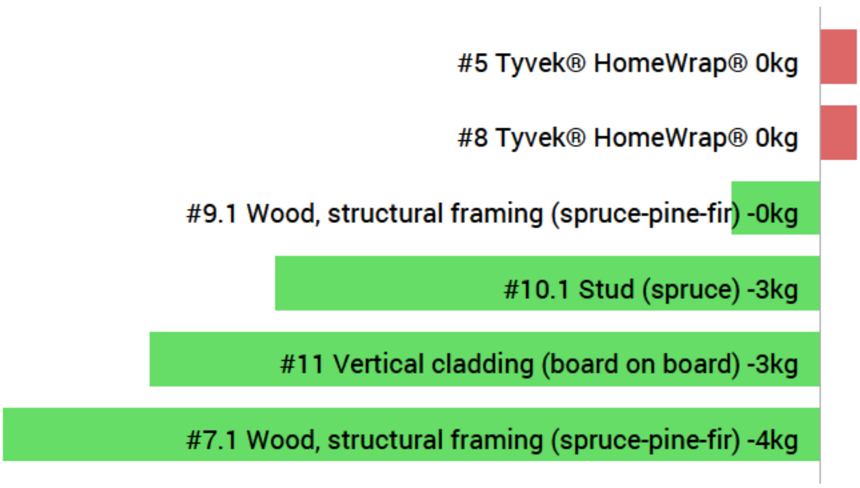
**Green house gas potential: -9.5 (?) kg CO2 Äqv./m²**

For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

### Composition of non-renewable primary energy of production:



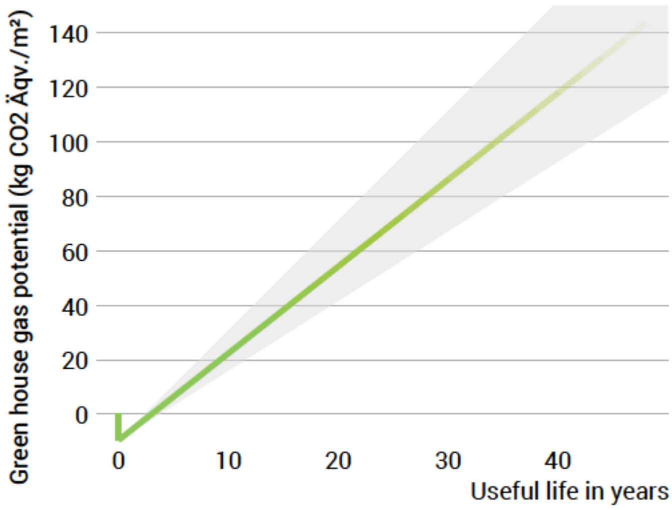

### Composition of the greenhouse potential of production:

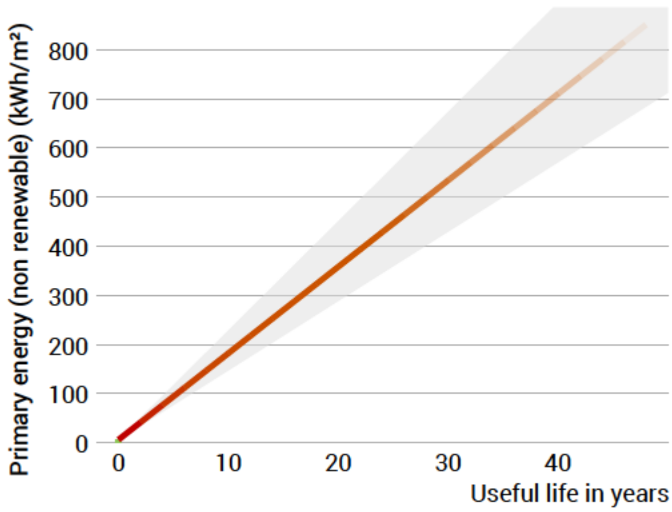



Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

Tremblay Wall (Summer, AB), U=0,15 W/(m²K)

# Global warming potential and primary energy for construction and use




The **left figure** shows the global warming potential of the production of the component in the vertical part of the curve. Greenhouse gas emissions (through heating) arising during use of the building are indicated by the upward curve.

The **figure at the bottom left** shows the non-renewable primary energy expenditure for the production of the component in the vertical part of the curve. The primary energy required during use of the building (through heating) is represented by the upward curve.

The longer the component is used unchanged, the more environmentally friendly it is, because the production costs contribute less to the total emissions (indicated by the color of the curve).

Due to unknown solar and internal gains, the heating demand can only be estimated. Accordingly, primary energy consumption and global warming potential during the use phase are only vaguely known. For the estimation it was assumed that solar and internal profits contribute with 4 kWh/a/m² component area. The light gray area indicates the area in which the curve is located with great certainty. For heat generation, a primary energy input of 1.2 kWh per kWh of heat and a global warming potential of 0.21 kg CO2 eqv/m² per kWh of heat was used. Heat source: Natural gas H.

## Hints

Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

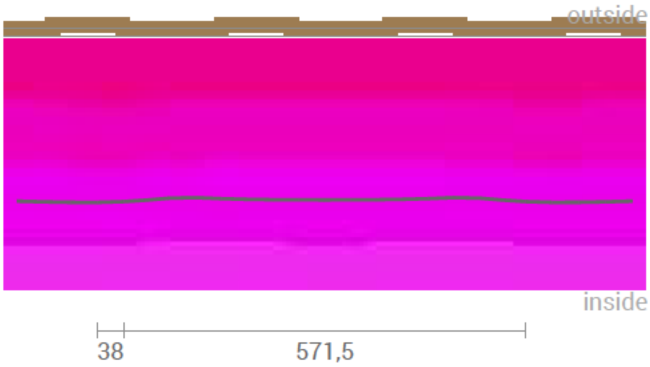
Calculated for the location AB:ABEE AGDM, heating period from Mid of October to End of April. The calculation is based on monthly average temperatures. Source: Canadian Weather Year for Energy Calculation (2016)

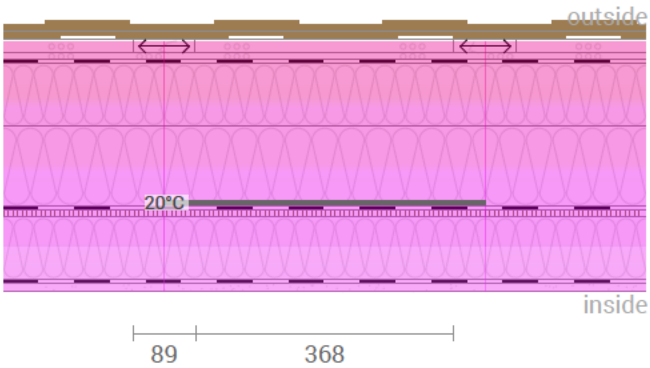
The climate and energy data on which this calculation is based can, in some cases, show considerable fluctuations and, in individual cases, deviate considerably from the actual value.

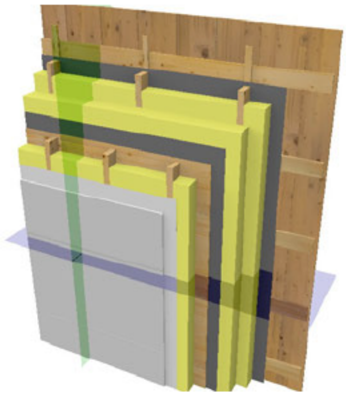
Note: The environmental product data for layer 6 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 7 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
The calculated amortization periods of primary energy and global warming potential are therefore too low.
Keine Berechnung möglich.

Tremblay Wall (Summer, AB), U=0,15 W/(m²K)

## Temperature profile



Top left: Temperature profile in the blue section (see right illustration). Bottom left: Temperature profile in the green section.

## Layers (from inside to outside)

| # | | Material | λ [W/mK] | RSI [m²K/W] | Temperatur [°C] min | Temperatur [°C] max | Weight [kg/m²] |
|---|---|---|---|---|---|---|---|
| | | Thermal contact resistance* | | 0,250 | 20,9 | 21,0 | |
| 1 | 1,25 cm | Gypsum board | 0,250 | 0,050 | 20,8 | 20,9 | 8,5 |
| 2 | 0,015 cm | Foil, PE | 0,400 | 0,000 | 20,8 | 20,9 | 0,1 |
| 3 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,055 | 1,618 | 20,2 | 20,9 | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 0,118 | 0,757 | 20,3 | 20,9 | 3,8 |
| 4 | 0,95 cm | Plywood - Douglas fir | 0,090 | 0,106 | 20,1 | 20,3 | 2,9 |
| 5 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | 20,1 | 20,2 | 0,1 |
| 6 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,850 | 18,8 | 20,2 | 6,8 |
| 7 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,225 | 18,0 | 19,0 | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 0,118 | 0,757 | 18,0 | 18,8 | 2,5 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | 18,0 | 18,0 | 0,1 |
| | | Thermal contact resistance* | | 0,040 | 18,0 | 18,0 | |
| 9 | 0.9525 cm | Rear ventilated level (outside air) | | | 18,0 | 18,0 | 0,0 |
| 10 | 1.9 cm | Rear ventilated level (outside air) | | | 18,0 | 18,0 | 0,0 |
| 11 | 1.25 cm | Vertical cladding (board on board) | | | 18,0 | 18,0 | 2,2 |
| | 35.61774 cm | Whole component | | 6,812 | | | 36,4 |

*Thermal contact resistances according to DIN 4108-3 for moisture protection and temperature profile. The values for the U-value calculation can be found on the page 'U-value calculation'.

| | | | |
|---|---|---|---|
| Surface temperature inside (min / average / max): | 20,9°C | 20,9°C | 20,9°C |
| Surface temperature outside (min / average / max): | 18,0°C | 18,0°C | 18,0°C |

Tremblay Wall (Summer, AB), U=0,15 W/(m²K)

# Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 21°C und 50% Humidity; outside: 18°C und 74% Humidity (Climate according to user input).

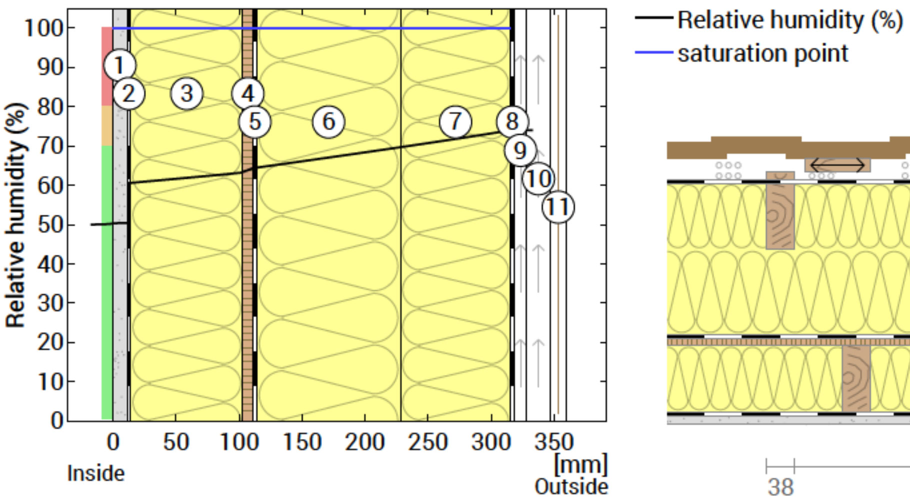
This component is free of condensate under the given climate conditions.

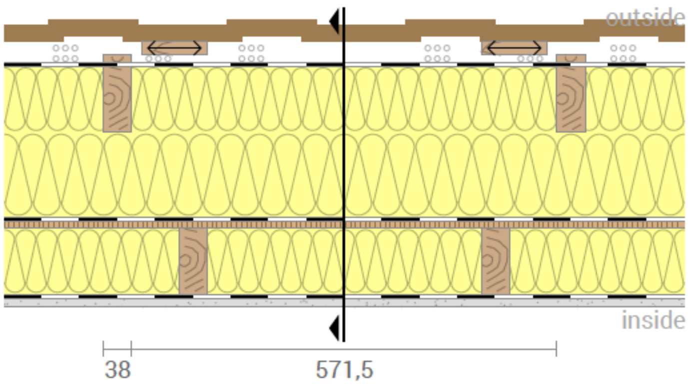
Drying reserve according to Ubakus 2D-FE method: 431 g/(m²a)
At least required by DIN 68800-2: 100 g/(m²a)

| # | | Material | sd-value [m] | Condensate [kg/m²] | Condensate [Gew.-%] | Weight [kg/m²] |
|---|---|---|---|---|---|---|
| 1 | 1,25 cm | Gypsum board | 0,05 | - | | 8,5 |
| 2 | 0,015 cm | Foil, PE | 15,24 | - | | 0,1 |
| 3 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,09 | - | | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 4,45 | - | - | 3,8 |
| 4 | 0,95 cm | Plywood - Douglas fir | 1,43 | - | - | 2,9 |
| 5 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| 6 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,23 | - | | 6,8 |
| 7 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,18 | - | | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 4,45 | - | - | 2,5 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| | 35.61774 cm | Whole component | 17,43 | 0 | | 36,4 |

## Humidity

The temperature of the inside surface is 20,9 °C leading to a relative humidity on the surface of 50%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



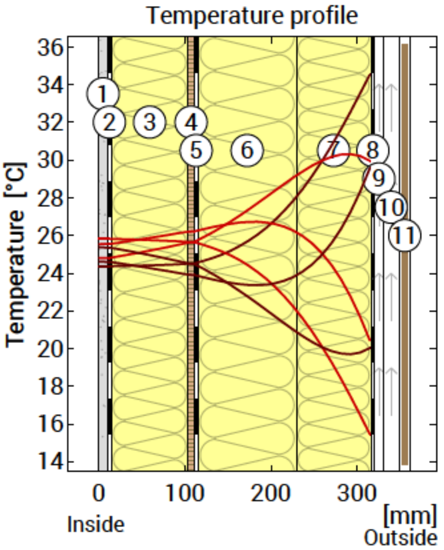

① Gypsum board (12,5 mm)
② Foil, PE
③ Insulation, blanket and batt, rock ...
④ Plywood - Douglas fir (9,5 mm)
⑤ Tyvek® HomeWrap®
⑥ Insulation, loose-fill insulation, ce...
⑦ Insulation, loose-fill insulation, ce...
⑧ Tyvek® HomeWrap®
⑨ Rear ventilated level (9,53 mm)
⑩ Rear ventilated level (19 mm)
⑪ Vertical cladding (12,5 mm)

Layers marked with <-> run parallel to the illustrated cutting plane and were not taken into account in the moisture protection calculation.
Notes: Calculation using the Ubakus 2D-FE method. Convection and the capillarity of the building materials were not considered. The drying time may take longer under unfavorable conditions (shading, damp / cool summers) than calculated here.

Tremblay Wall (Summer, AB), U=0,15 W/(m²K)

## Heat protection

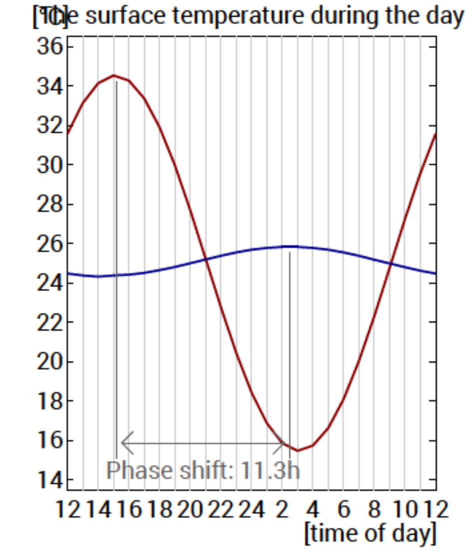
The following results are properties of the tested component alone and do not make any statement about the heat protection of the entire room:




Temperature at 3pm, 11am and 7am

Temperature at 7pm, 11pm and 3am

1. Gypsum board (12,5 mm)
2. Foil, PE
3. Insulation, blanket and batt, rock or glass mineral fibre, R12, 89mm (89 mm)
4. Plywood - Douglas fir (9,5 mm)
5. Tyvek® HomeWrap®
6. Insulation, loose-fill insulation, cellulose (114 mm)
7. Insulation, loose-fill insulation, cellulose (89 mm)
8. Tyvek® HomeWrap®
9. Rear ventilated level (9,53 mm)
10. Rear ventilated level (19 mm)
11. Vertical cladding (12,5 mm)




**Top:**Temperature profile within the component at different times. From top to bottom, brown lines: at 3 pm, 11 am and 7 am and red lines at 7 pm , 11 pm and 3 am.
**Bottom:**Temperature on the outer ( red ) and inner ( blue ) surface in the course of a day. The arrows indicate the location of the temperature maximum values . The maximum of the inner surface temperature should preferably occur during the second half of the night.

| | | | |
|---|---|---|---|
| Phase shift* | 11,3 h | Heat storage capacity (whole component): | 44 kJ/m²K |
| Amplitude attenuation ** | 12,5 | Thermal capacity of inner layers: | 26 kJ/m²K |
| TAV *** | 0,080 | | |

* The phase shift is the time in hours after which the temperature peak of the afternoon reaches the component interior.
** The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 means that the temperature on the outside varies 10x stronger than on the inside, e.g. outside 15-35 °C, inside 24-26 °C.
*** The temperature amplitude ratio TAV is the reciprocal of the attenuation: TAV = 1 / amplitude attenuation

Note: The heat protection of a room is influenced by several factors, but essentially by the direct solar radiation through windows and the total amount of heat storage capacity (including floor, interior walls and furniture). A single component usually has only a very small influence on the heat protection of the room.

The calculations presented above have been created for a 1-dimensional cross-section of the component.

# Calculations for thermal insulation, moisture protection and heat protection

created on 2.4.2025 20:06

## Content



## Comparison with different maximum values*

| Component | BEG Einzelmaßn. | GEG 2020/24 Bestand | GEG 2023/24 Neubau | DIN 4108 |
|---|---|---|---|---|
| Tremblay Wall (Winter, S-ON) | ✓ | ✓ | ✓ | ✓ |
| Tremblay Wall (Summer, S-ON) | ✓ | ✓ | ✓ | ✓ |

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

# Tremblay Wall (Winter, S-ON)

Exterior wall
created on 2.4.2025

## Thermal protection

U = 0,15 W/(m²K)

DIN 4108*: R>1,74 m²K/W + $R_{si}$ + $R_{se}$

excellent insufficient

## Moisture proofing

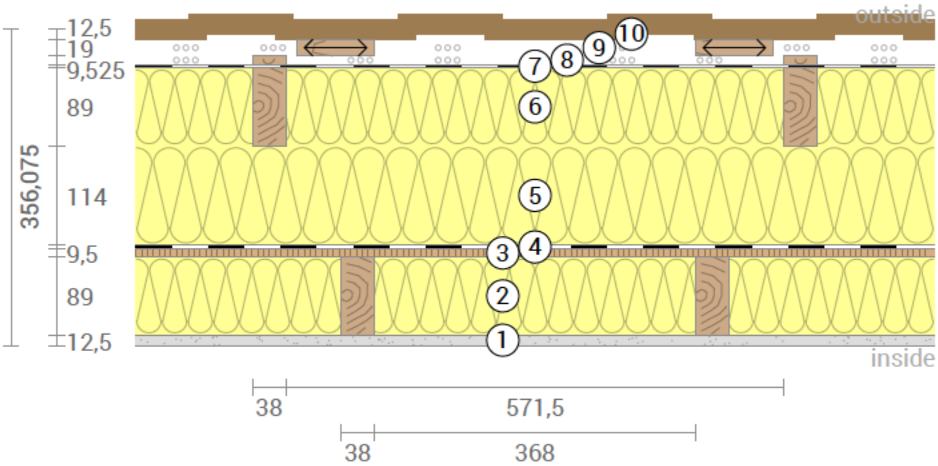
Drying reserve: 1541 g/m²a
No condensate

excellent insufficient

## Heat protection

Temperature amplitude damping: 12
phase shift: 11,3 h
Thermal capacity inside: 26 kJ/m²K

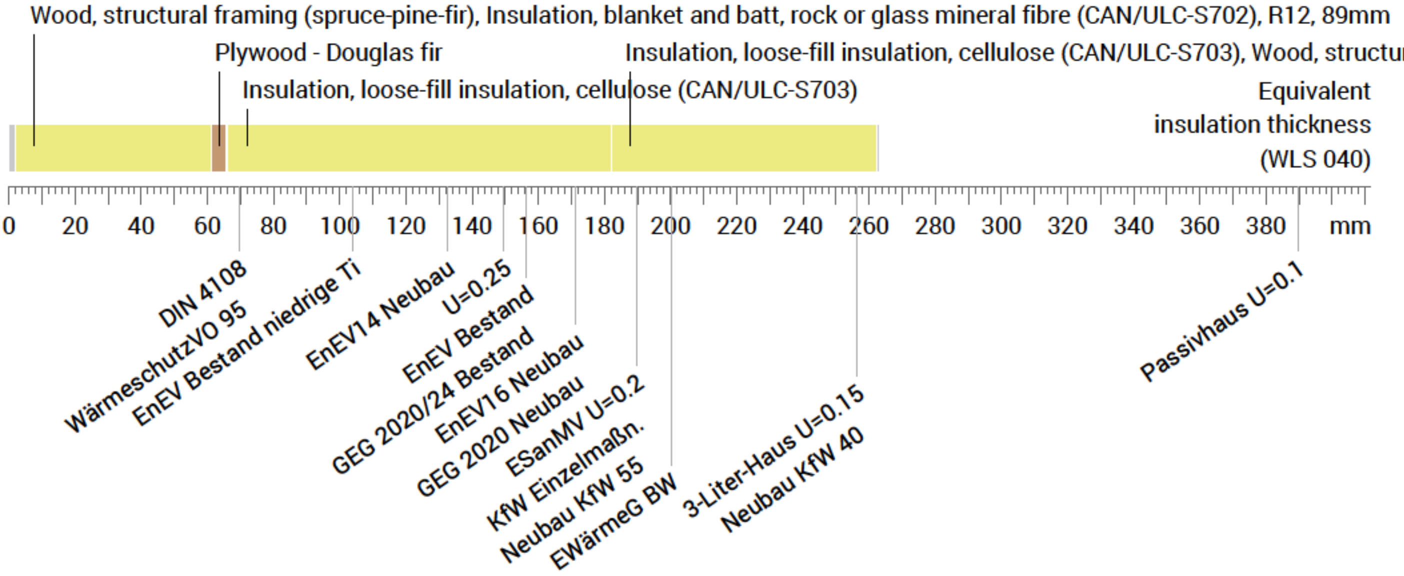
excellent insufficient




1. Gypsum board (12,5 mm)
2. Insulation, blanket and batt, rock or glass mineral fibre, R12, 89mm (89 mm)
3. Plywood - Douglas fir (9,5 mm)
4. pro clima SOLITEX® ADHERO 1000
5. Insulation, loose-fill insulation, cellulose (114 mm)
6. Insulation, loose-fill insulation, cellulose (89 mm)
7. Tyvek® HomeWrap®
8. Rear ventilated level (9,525 mm)
9. Rear ventilated level (19 mm)
10. Vertical cladding (12,5 mm)

<-> Layers marked by arrows are perpendicular to the main axis.

## Impact of each layer and comparison to reference values




| | | | | |
|---|---|---|---|---|
| Inside air : | 23.0°C / 40% | | Thickness: | 35,6 cm |
| Outside air: | -6.0°C / 74% | sd-value: 2,4 m | Weight: | 36 kg/m² |
| Surface temperature.: | 21,7°C / -5,8°C | | Heat capacity: | 44 kJ/m²K |

☑ BEG Einzelmaßn. ☑ GEG 2020/24 Bestand ☑ GEG 2023/24 Neubau ☑ DIN 4108

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

Tremblay Wall (Winter, S-ON), U=0,15 W/(m²K)

# U-Value calculation according to DIN EN ISO 6946

| # | Material | Dicke [cm] | λ [W/mK] | R [m²K/W] |
|---|---|---|---|---|
| | Thermal contact resistance inside (Rsi) | | | 0,130 |
| 1 | Gypsum board | 1,25 | 0,250 | 0,050 |
| 2 | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 8,90 | 0,055 | 1,618 |
| | Wood, structural framing (spruce-pine-fir) (9.4%) | 8,90 | 0,118 | 0,757 |
| 3 | Plywood - Douglas fir | 0,95 | 0,090 | 0,106 |
| 4 | pro clima SOLITEX® ADHERO 1000 | 0,06 | 0,040 | 0,014 |
| 5 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 11,40 | 0,040 | 2,850 |
| 6 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 8,90 | 0,040 | 2,225 |
| | Wood, structural framing (spruce-pine-fir) (6.2%) | 8,90 | 0,118 | 0,757 |
| 7 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| | Thermal contact resistance outside (Rse) | | | 0,130 |

Thermal contact resistances have been taken from DIN 6946 Table 7.
Rsi: heat flow direction horizontally
Rse: heat flow direction horizontally, outside: Ventilation level

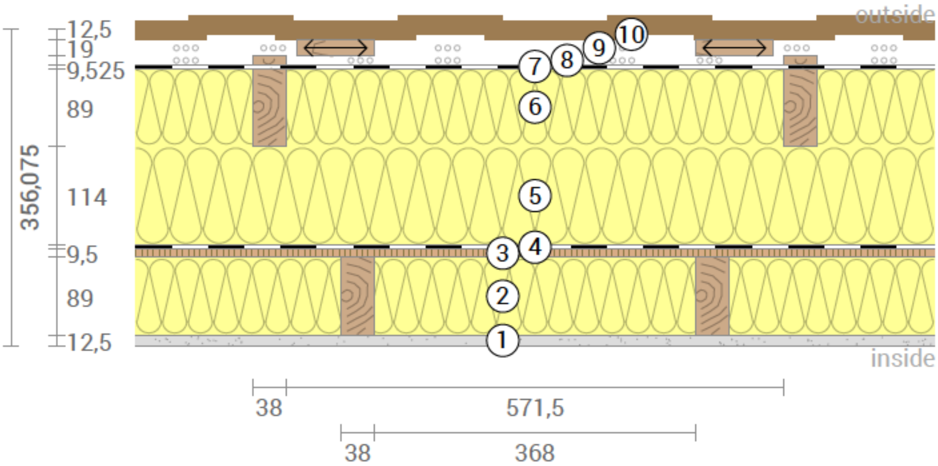
Upper limit of thermal resistance $R_{tot;upper}$ = 6,922 m²K/W.
Lower limit of thermal resistance $R_{tot;lower}$ = 6,727 m²K/W.
Check applicability: $R_{tot;upper}$ / $R_{tot;lower}$ = 1,029 (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance $R_{tot}$ = ($R_{tot;upper}$ + $R_{tot;lower}$)/2 = 6.824 m²K/W
Estimated maximum relative uncertainty according to section 6.7.2.5: 1.4%

Heat transfer coefficient U = 1/$R_{tot}$ = **0,15 W/(m²K)**

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 61 cm. This, however, is not true for at least layer 2 with a total width of 40,6 cm and can cause increased inaccuracy of the U-value.



Tremblay Wall (Winter, S-ON), U=0,15 W/(m²K)

# LCA

**Heat loss: 21 kWh/m² per heating season**

Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

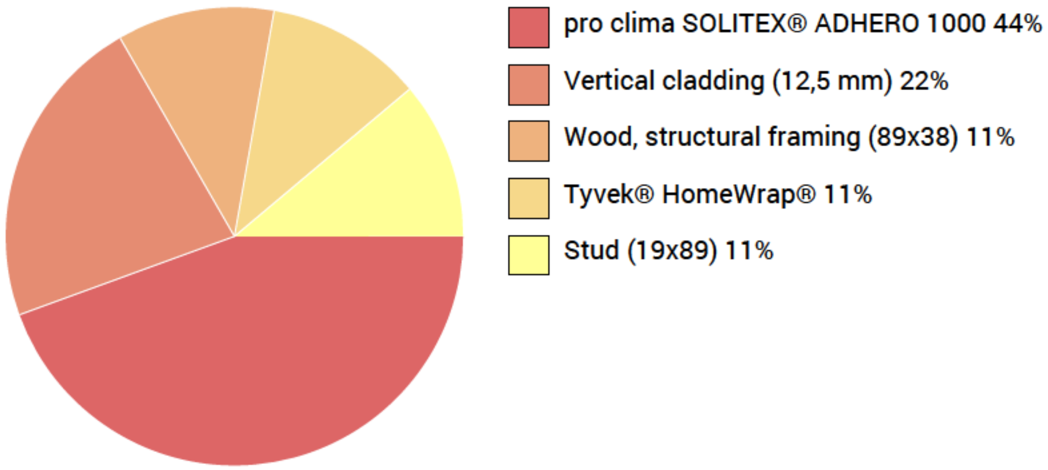
**Primary energy (non renewable): >8.6 kWh/m²**

Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

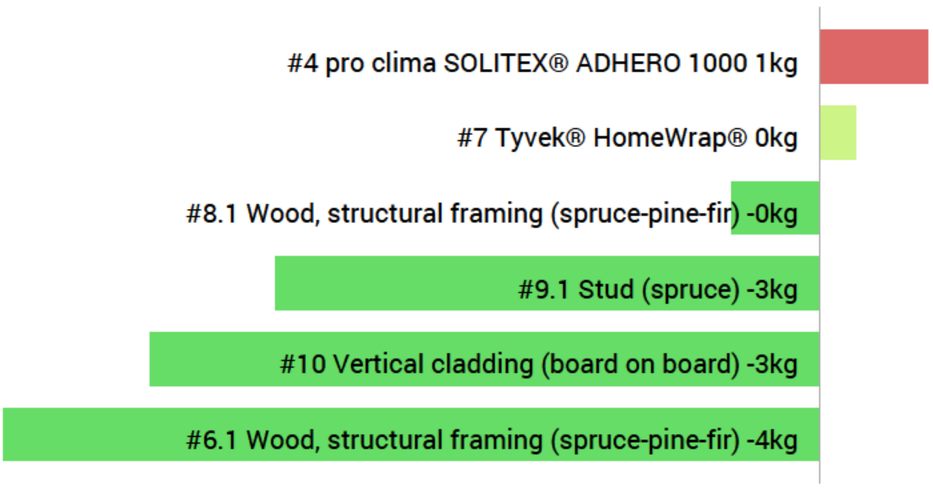
**Green house gas potential: -9.2 (?) kg CO2 Äqv./m²**

For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

## Composition of non-renewable primary energy of production:



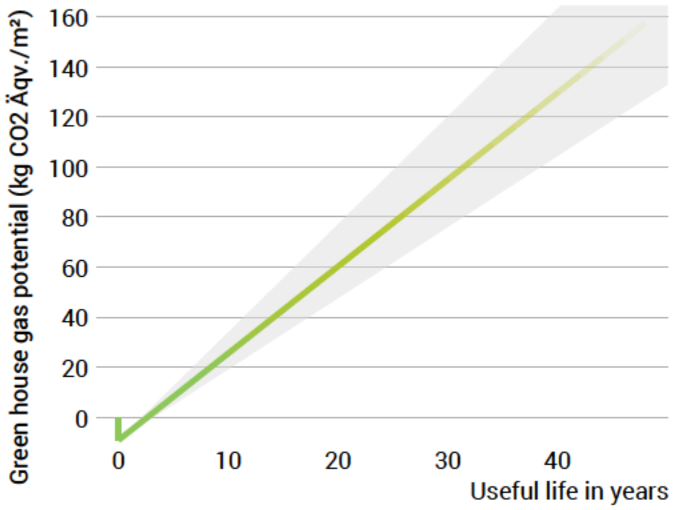

## Composition of the greenhouse potential of production:

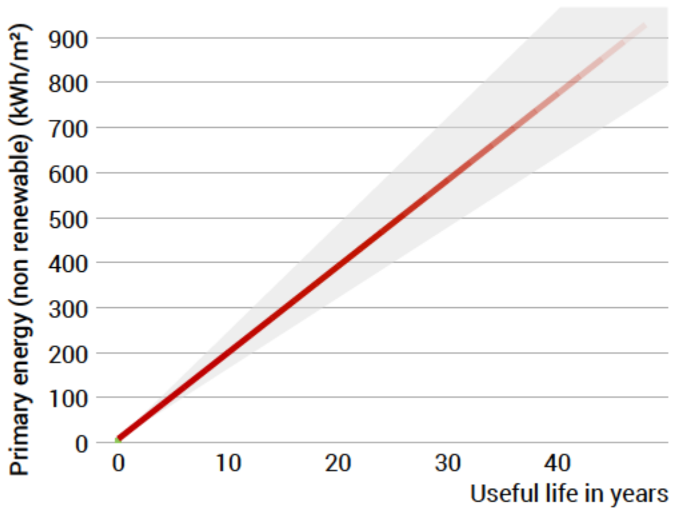



Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

Tremblay Wall (Winter, S-ON), U=0,15 W/(m²K)

# Global warming potential and primary energy for construction and use




The **left figure** shows the global warming potential of the production of the component in the vertical part of the curve. Greenhouse gas emissions (through heating) arising during use of the building are indicated by the upward curve.

The **figure at the bottom left** shows the non-renewable primary energy expenditure for the production of the component in the vertical part of the curve. The primary energy required during use of the building (through heating) is represented by the upward curve.

The longer the component is used unchanged, the more environmentally friendly it is, because the production costs contribute less to the total emissions (indicated by the color of the curve).

Due to unknown solar and internal gains, the heating demand can only be estimated. Accordingly, primary energy consumption and global warming potential during the use phase are only vaguely known. For the estimation it was assumed that solar and internal profits contribute with 4 kWh/a/m² component area. The light gray area indicates the area in which the curve is located with great certainty. For heat generation, a primary energy input of 1.2 kWh per kWh of heat and a global warming potential of 0.21 kg $CO_2$ eqv/m² per kWh of heat was used. Heat source: Natural gas H.

## Hints

Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

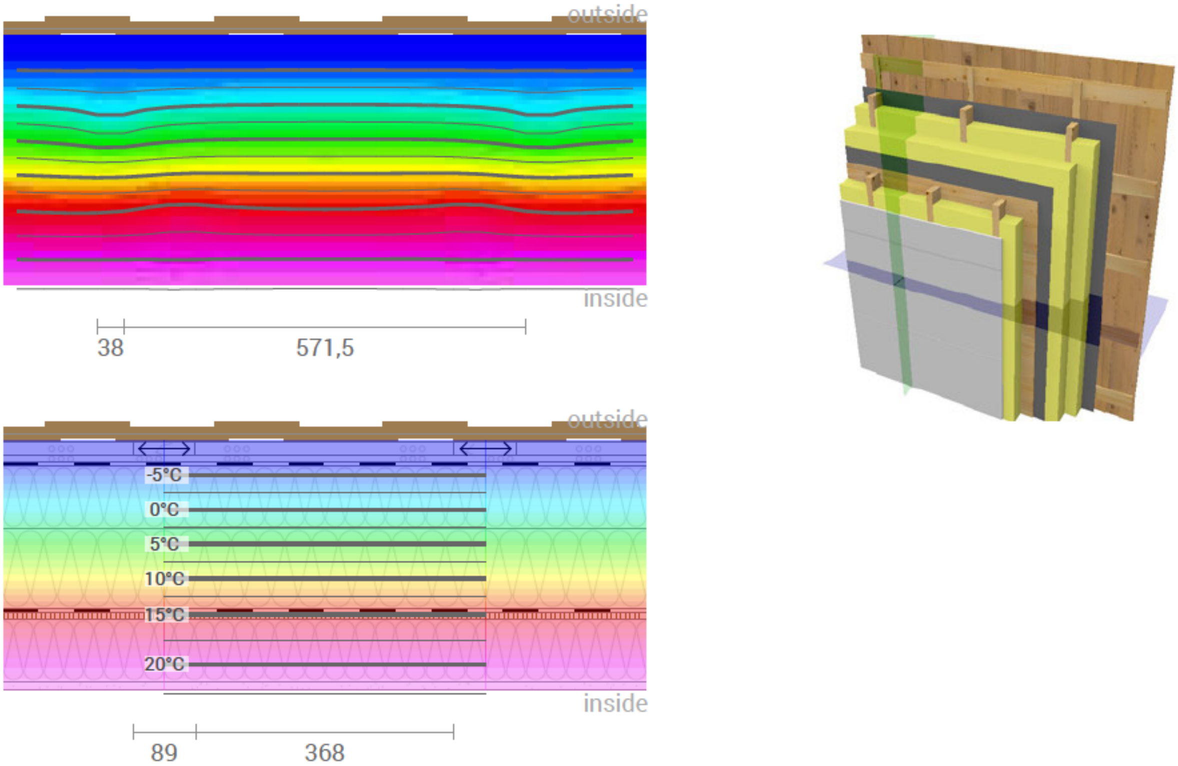
Calculated for the location AB:ABEE AGDM, heating period from Mid of October to End of April. The calculation is based on monthly average temperatures. Source: Canadian Weather Year for Energy Calculation (2016)

The climate and energy data on which this calculation is based can, in some cases, show considerable fluctuations and, in individual cases, deviate considerably from the actual value.

Note: The environmental product data for layer 5 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 6 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
The calculated amortization periods of primary energy and global warming potential are therefore too low.
Keine Berechnung möglich.

Tremblay Wall (Winter, S-ON), U=0,15 W/(m²K)

## Temperature profile




Top left: Temperature profile in the blue section (see right illustration). Bottom left: Temperature profile in the green section.

## Layers (from inside to outside)

| # | | Material | λ [W/mK] | RSI [m²K/W] | Temperatur [°C] min | max | Weight [kg/m²] |
|---|---|---|---|---|---|---|---|
| | | Thermal contact resistance* | | 0,250 | 21,7 | 23,0 | |
| 1 | 1,25 cm | Gypsum board | 0,250 | 0,050 | 21,5 | 22,0 | 8,5 |
| 2 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,055 | 1,618 | 15,1 | 21,8 | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 0,118 | 0,757 | 16,3 | 21,6 | 3,8 |
| 3 | 0,95 cm | Plywood - Douglas fir | 0,090 | 0,106 | 14,6 | 16,3 | 2,9 |
| 4 | 0,055 cm | pro clima SOLITEX® ADHERO 1000 | 0,040 | 0,014 | 14,5 | 15,7 | 0,2 |
| 5 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,850 | 1,2 | 15,7 | 6,8 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,225 | -5,8 | 3,3 | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 0,118 | 0,757 | -5,7 | 1,2 | 2,5 |
| 7 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | -5,9 | -5,7 | 0,1 |
| | | Thermal contact resistance* | | 0,040 | -6,0 | -5,7 | |
| 8 | 0.9525 cm | Rear ventilated level (outside air) | | | -6,0 | -6,0 | 0,0 |
| 9 | 1.9 cm | Rear ventilated level (outside air) | | | -6,0 | -6,0 | 0,0 |
| 10 | 1.25 cm | Vertical cladding (board on board) | | | -6,0 | -6,0 | 2,2 |
| | 35.6075 cm | Whole component | | 6,824 | | | 36,4 |

*Thermal contact resistances according to DIN 4108-3 for moisture protection and temperature profile. The values for the U-value calculation can be found on the page 'U-value calculation'.

| | | | |
|---|---|---|---|
| Surface temperature inside (min / average / max): | 21,7°C | 21,9°C | 22,0°C |
| Surface temperature outside (min / average / max): | -5,9°C | -5,8°C | -5,7°C |

Tremblay Wall (Winter, S-ON), U=0,15 W/(m²K)

# Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 23°C und 40% Humidity; outside: -6°C und 74% Humidity (Climate according to user input).

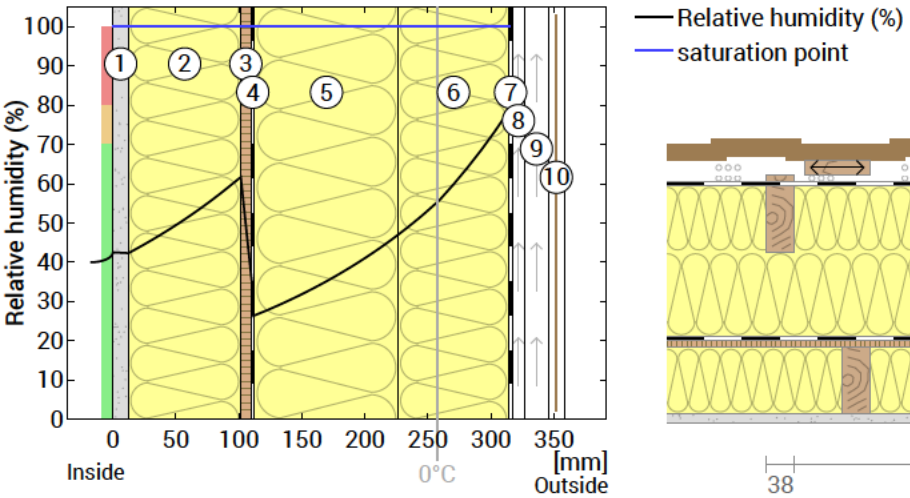
This component is free of condensate under the given climate conditions.

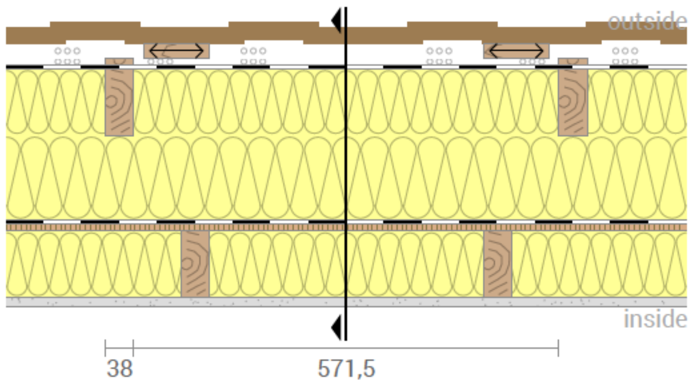
Drying reserve according to Ubakus 2D-FE method: 1541 g/(m²a)
At least required by DIN 68800-2: 100 g/(m²a)

| # | | Material | sd-value [m] | Condensate [kg/m²] | [Gew.-%] | Weight [kg/m²] |
|---|---|---|---|---|---|---|
| 1 | 1,25 cm | Gypsum board | 0,05 | - | | 8,5 |
| 2 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,09 | - | | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 1,78 | - | - | 3,8 |
| 3 | 0,95 cm | Plywood - Douglas fir | 1,43 | - | - | 2,9 |
| 4 | 0,055 cm | pro clima SOLITEX® ADHERO 1000 | 0,30 | - | | 0,2 |
| 5 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,23 | - | | 6,8 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,18 | - | | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 4,45 | - | - | 2,5 |
| 7 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| | 35.6075 cm | Whole component | 2,38 | 0 | | 36,4 |

## Humidity

The temperature of the inside surface is 21,7 °C leading to a relative humidity on the surface of 43%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



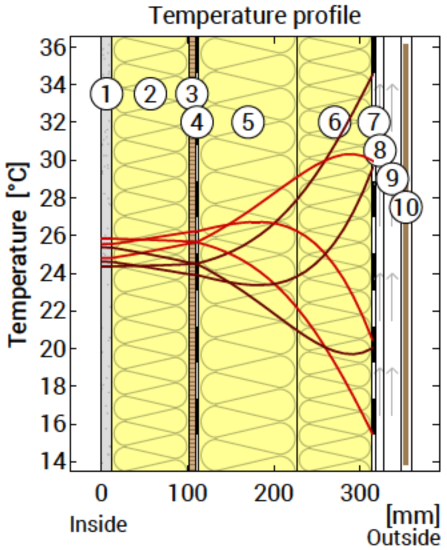

① Gypsum board (12,5 mm)
② Insulation, blanket and batt, rock ...
③ Plywood - Douglas fir (9,5 mm)
④ pro clima SOLITEX® ADHERO 1000
⑤ Insulation, loose-fill insulation, ce...
⑥ Insulation, loose-fill insulation, ce...
⑦ Tyvek® HomeWrap®
⑧ Rear ventilated level (9,53 mm)
⑨ Rear ventilated level (19 mm)
⑩ Vertical cladding (12,5 mm)

Layers marked with <-> run parallel to the illustrated cutting plane and were not taken into account in the moisture protection calculation.
Notes: Calculation using the Ubakus 2D-FE method. Convection and the capillarity of the building materials were not considered. The drying time may take longer under unfavorable conditions (shading, damp / cool summers) than calculated here.

Tremblay Wall (Winter, S-ON), U=0,15 W/(m²K)

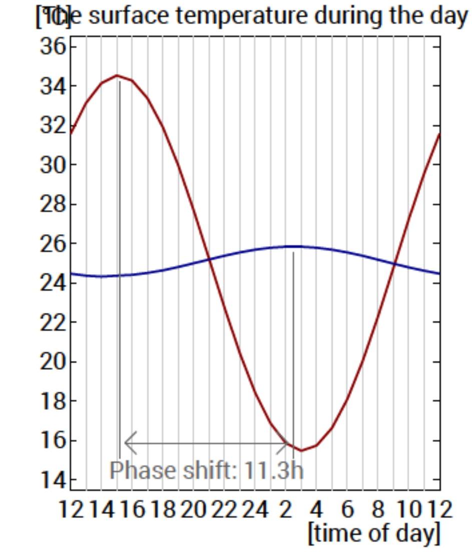
# Heat protection

The following results are properties of the tested component alone and do not make any statement about the heat protection of the entire room:




Temperature at 3pm, 11am and 7am
Temperature at 7pm, 11pm and 3am

1. Gypsum board (12,5 mm)
2. Insulation, blanket and batt, rock or glass mineral fibre, R12, 89mm (89 mm)
3. Plywood - Douglas fir (9,5 mm)
4. pro clima SOLITEX® ADHERO 1000
5. Insulation, loose-fill insulation, cellulose (114 mm)
6. Insulation, loose-fill insulation, cellulose (89 mm)
7. Tyvek® HomeWrap®
8. Rear ventilated level (9,53 mm)
9. Rear ventilated level (19 mm)
10. Vertical cladding (12,5 mm)




Outside
Inside

**Top:**Temperature profile within the component at different times. From top to bottom, brown lines: at 3 pm, 11 am and 7 am and red lines at 7 pm , 11 pm and 3 am.
**Bottom:**Temperature on the outer ( red ) and inner ( blue ) surface in the course of a day. The arrows indicate the location of the temperature maximum values . The maximum of the inner surface temperature should preferably occur during the second half of the night.

| | | | |
|---|---|---|---|
| Phase shift* | 11,3 h | Heat storage capacity (whole component): | 44 kJ/m²K |
| Amplitude attenuation ** | 12,4 | Thermal capacity of inner layers: | 26 kJ/m²K |
| TAV *** | 0,081 | | |

* The phase shift is the time in hours after which the temperature peak of the afternoon reaches the component interior.
** The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 means that the temperature on the outside varies 10x stronger than on the inside, e.g. outside 15-35 °C, inside 24-26 °C.
*** The temperature amplitude ratio TAV is the reciprocal of the attenuation: TAV = 1 / amplitude attenuation

Note: The heat protection of a room is influenced by several factors, but essentially by the direct solar radiation through windows and the total amount of heat storage capacity (including floor, interior walls and furniture). A single component usually has only a very small influence on the heat protection of the room.

The calculations presented above have been created for a 1-dimensional cross-section of the component.

# Tremblay Wall (Summer, S-ON)

Exterior wall
created on 2.4.2025

## Thermal protection

U = 0,15 W/(m²K)

DIN 4108*: R>1,74 m²K/W + $R_{si}$ + $R_{se}$

excellent — insufficient

## Moisture proofing

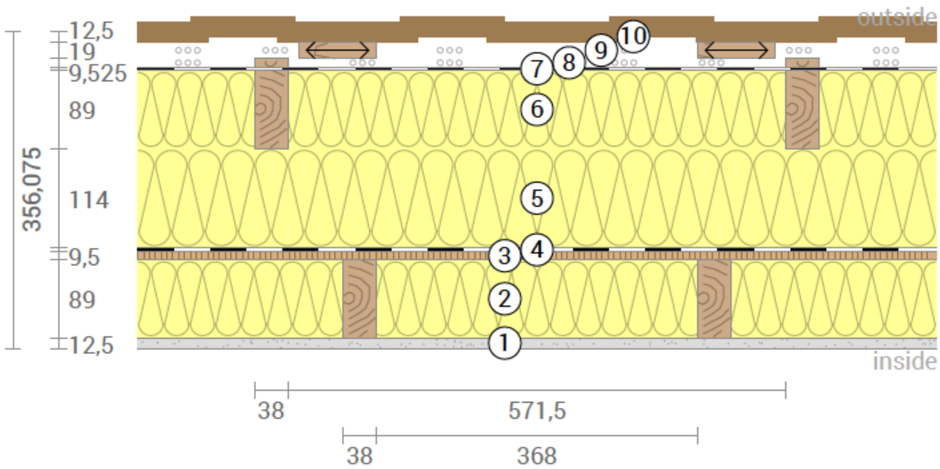
Drying reserve: 1541 g/m²a
No condensate

excellent — insufficient

## Heat protection

Temperature amplitude damping: 12
phase shift: 11,3 h
Thermal capacity inside: 26 kJ/m²K

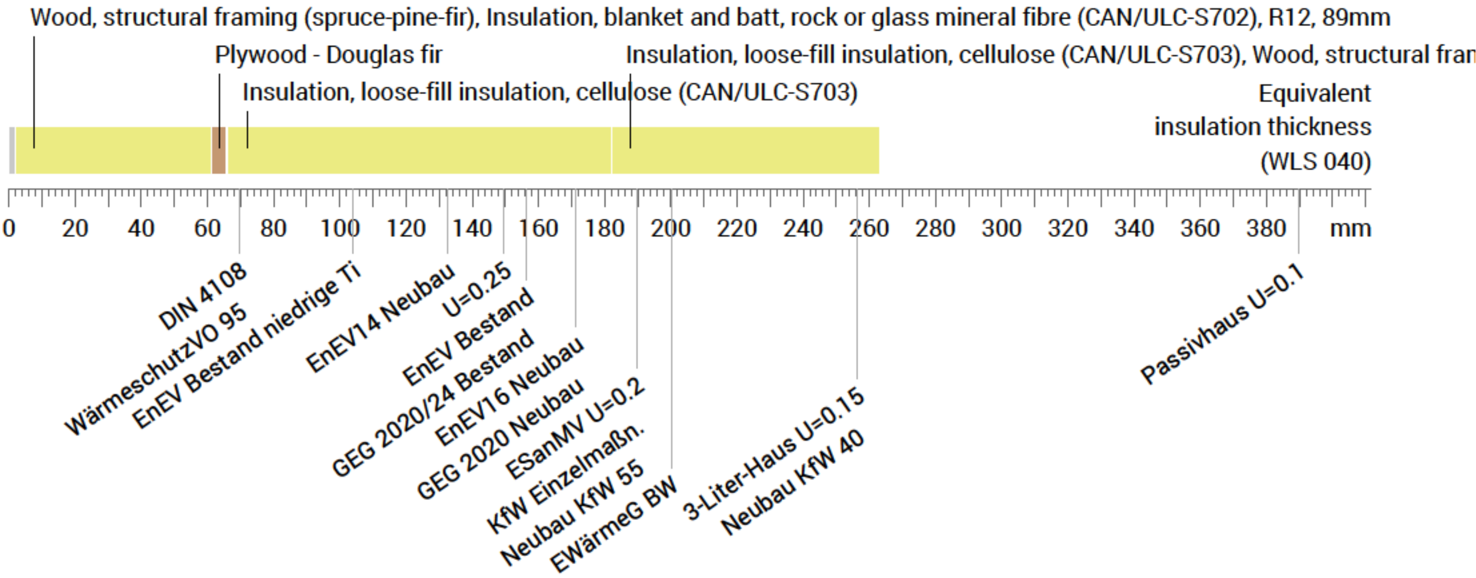
excellent — insufficient




1. Gypsum board (12,5 mm)
2. Insulation, blanket and batt, rock or glass mineral fibre, R12, 89mm (89 mm)
3. Plywood - Douglas fir (9,5 mm)
4. pro clima SOLITEX® ADHERO 1000
5. Insulation, loose-fill insulation, cellulose (114 mm)
6. Insulation, loose-fill insulation, cellulose (89 mm)
7. Tyvek® HomeWrap®
8. Rear ventilated level (9,525 mm)
9. Rear ventilated level (19 mm)
10. Vertical cladding (12,5 mm)

<-> Layers marked by arrows are perpendicular to the main axis.

## Impact of each layer and comparison to reference values




| | | | |
|---|---|---|---|
| Inside air : | 21.0°C / 50% | | Thickness: 35,6 cm |
| Outside air: | 24.0°C / 70% | sd-value: 2,4 m | Weight: 36 kg/m² |
| Surface temperature.: | 21,1°C / 24,0°C | | Heat capacity: 44 kJ/m²K |

☑ BEG Einzelmaßn. ☑ GEG 2020/24 Bestand ☑ GEG 2023/24 Neubau ☑ DIN 4108

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

Tremblay Wall (Summer, S-ON), U=0,15 W/(m²K)

# U-Value calculation according to DIN EN ISO 6946

| # | Material | Dicke [cm] | λ [W/mK] | R [m²K/W] |
|---|---|---|---|---|
| | Thermal contact resistance inside (Rsi) | | | 0,130 |
| 1 | Gypsum board | 1,25 | 0,250 | 0,050 |
| 2 | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 8,90 | 0,055 | 1,618 |
| | Wood, structural framing (spruce-pine-fir) (9.4%) | 8,90 | 0,118 | 0,757 |
| 3 | Plywood - Douglas fir | 0,95 | 0,090 | 0,106 |
| 4 | pro clima SOLITEX® ADHERO 1000 | 0,06 | 0,040 | 0,014 |
| 5 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 11,40 | 0,040 | 2,850 |
| 6 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 8,90 | 0,040 | 2,225 |
| | Wood, structural framing (spruce-pine-fir) (6.2%) | 8,90 | 0,118 | 0,757 |
| 7 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| | Thermal contact resistance outside (Rse) | | | 0,130 |

Thermal contact resistances have been taken from DIN 6946 Table 7.
Rsi: heat flow direction horizontally
Rse: heat flow direction horizontally, outside: Ventilation level

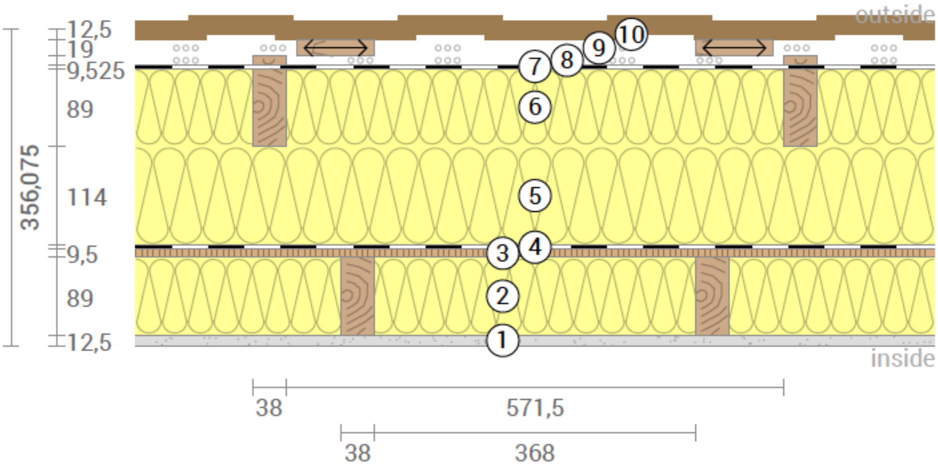
Upper limit of thermal resistance $R_{tot;upper}$ = 6,922 m²K/W.
Lower limit of thermal resistance $R_{tot;lower}$ = 6,727 m²K/W.
Check applicability: $R_{tot;upper}$ / $R_{tot;lower}$ = 1,029 (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance $R_{tot} = (R_{tot;upper} + R_{tot;lower})/2$ = 6.824 m²K/W
Estimated maximum relative uncertainty according to section 6.7.2.5: 1.4%

Heat transfer coefficient U = $1/R_{tot}$ = **0,15 W/(m²K)**

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 61 cm. This, however, is not true for at least layer 2 with a total width of 40,6 cm and can cause increased inaccuracy of the U-value.



# LCA

**Heat loss: 19 kWh/m² per heating season**

Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

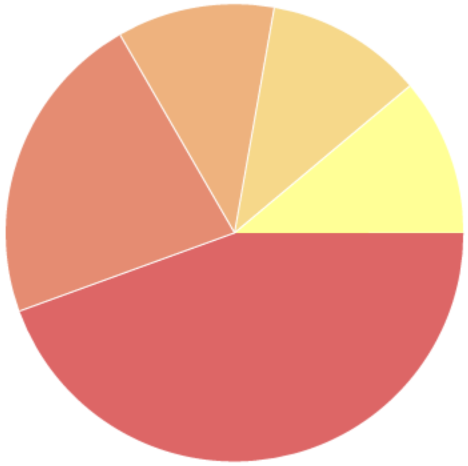
**Primary energy (non renewable): >8.6 kWh/m²**

Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

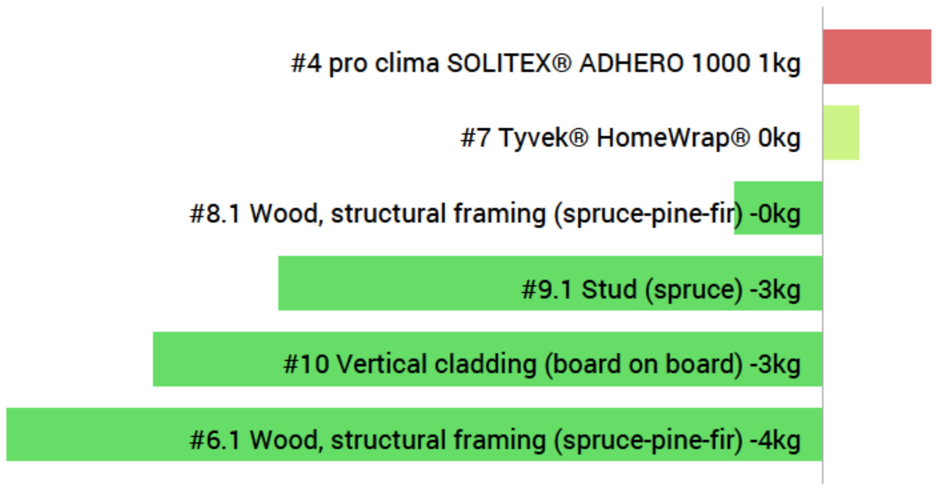
**Green house gas potential: -9.2 (?) kg CO2 Äqv./m²**

For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

## Composition of non-renewable primary energy of production:



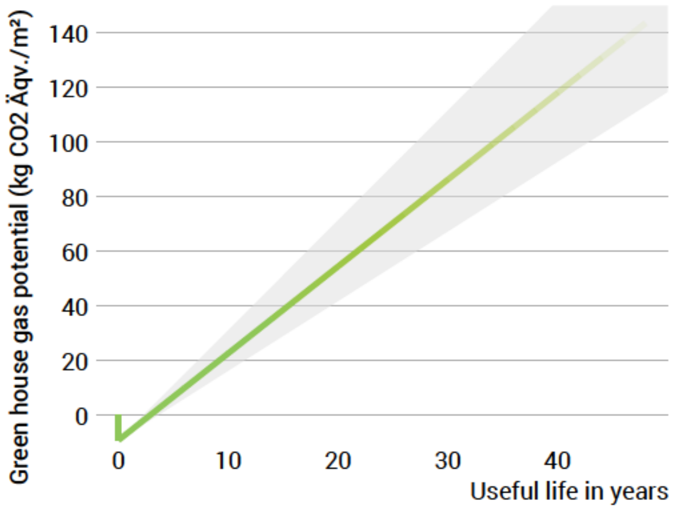

## Composition of the greenhouse potential of production:

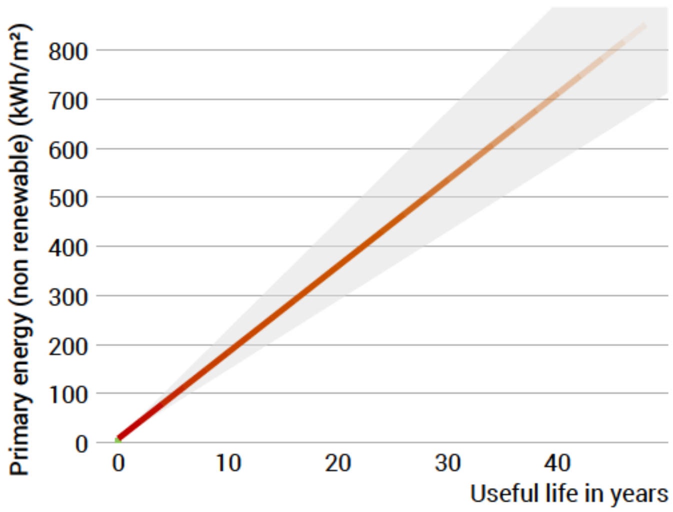



Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

Tremblay Wall (Summer, S-ON), U=0,15 W/(m²K)

# Global warming potential and primary energy for construction and use




The **left figure** shows the global warming potential of the production of the component in the vertical part of the curve. Greenhouse gas emissions (through heating) arising during use of the building are indicated by the upward curve.

The **figure at the bottom left** shows the non-renewable primary energy expenditure for the production of the component in the vertical part of the curve. The primary energy required during use of the building (through heating) is represented by the upward curve.

The longer the component is used unchanged, the more environmentally friendly it is, because the production costs contribute less to the total emissions (indicated by the color of the curve).

Due to unknown solar and internal gains, the heating demand can only be estimated. Accordingly, primary energy consumption and global warming potential during the use phase are only vaguely known. For the estimation it was assumed that solar and internal profits contribute with 4 kWh/a/m² component area. The light gray area indicates the area in which the curve is located with great certainty. For heat generation, a primary energy input of 1.2 kWh per kWh of heat and a global warming potential of 0.21 kg CO2 eqv/m² per kWh of heat was used. Heat source: Natural gas H.

## Hints

Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

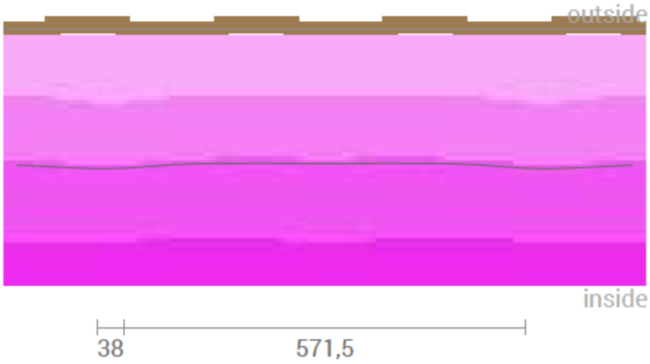
Calculated for the location AB:ABEE AGDM, heating period from Mid of October to End of April. The calculation is based on monthly average temperatures. Source: Canadian Weather Year for Energy Calculation (2016)

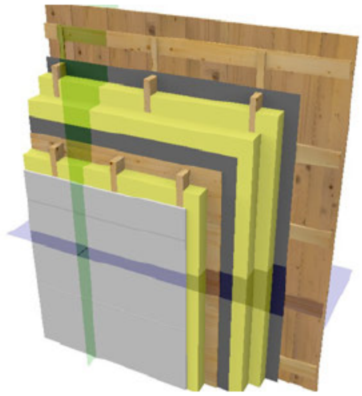
The climate and energy data on which this calculation is based can, in some cases, show considerable fluctuations and, in individual cases, deviate considerably from the actual value.

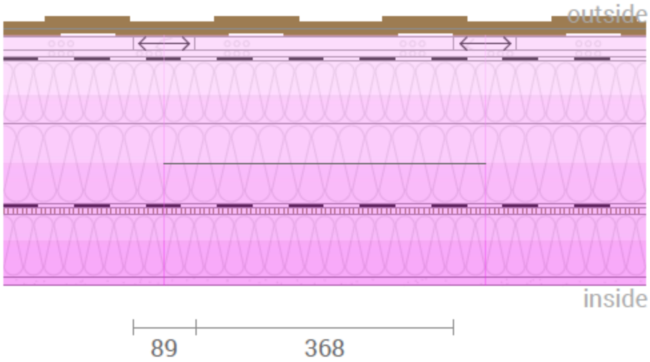
Note: The environmental product data for layer 5 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 6 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
The calculated amortization periods of primary energy and global warming potential are therefore too low.
Keine Berechnung möglich.

Tremblay Wall (Summer, S-ON), U=0,15 W/(m²K)

## Temperature profile






Top left: Temperature profile in the blue section (see right illustration). Bottom left: Temperature profile in the green section.

## Layers (from inside to outside)

| # | | Material | λ [W/mK] | RSI [m²K/W] | Temperatur [°C] min | Temperatur [°C] max | Weight [kg/m²] |
|---|---|---|---|---|---|---|---|
| | | Thermal contact resistance* | | 0,250 | 21,0 | 21,1 | |
| 1 | 1,25 cm | Gypsum board | 0,250 | 0,050 | 21,1 | 21,2 | 8,5 |
| 2 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,055 | 1,618 | 21,1 | 21,8 | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 0,118 | 0,757 | 21,1 | 21,7 | 3,8 |
| 3 | 0,95 cm | Plywood - Douglas fir | 0,090 | 0,106 | 21,7 | 21,9 | 2,9 |
| 4 | 0,055 cm | pro clima SOLITEX® ADHERO 1000 | 0,040 | 0,014 | 21,8 | 21,9 | 0,2 |
| 5 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,850 | 21,8 | 23,3 | 6,8 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,225 | 23,0 | 24,0 | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 0,118 | 0,757 | 23,3 | 24,0 | 2,5 |
| 7 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | 24,0 | 24,0 | 0,1 |
| | | Thermal contact resistance* | | 0,040 | 24,0 | 24,0 | |
| 8 | 0.9525 cm | Rear ventilated level (outside air) | | | 24,0 | 24,0 | 0,0 |
| 9 | 1.9 cm | Rear ventilated level (outside air) | | | 24,0 | 24,0 | 0,0 |
| 10 | 1.25 cm | Vertical cladding (board on board) | | | 24,0 | 24,0 | 2,2 |
| | 35.6075 cm | Whole component | | 6,824 | | | 36,4 |

*Thermal contact resistances according to DIN 4108-3 for moisture protection and temperature profile. The values for the U-value calculation can be found on the page 'U-value calculation'.

| | | | |
|---|---|---|---|
| Surface temperature inside (min / average / max): | 21,1°C | 21,1°C | 21,1°C |
| Surface temperature outside (min / average / max): | 24,0°C | 24,0°C | 24,0°C |

Tremblay Wall (Summer, S-ON), U=0,15 W/(m²K)

## Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 21°C und 50% Humidity; outside: 24°C und 70% Humidity (Climate according to user input).

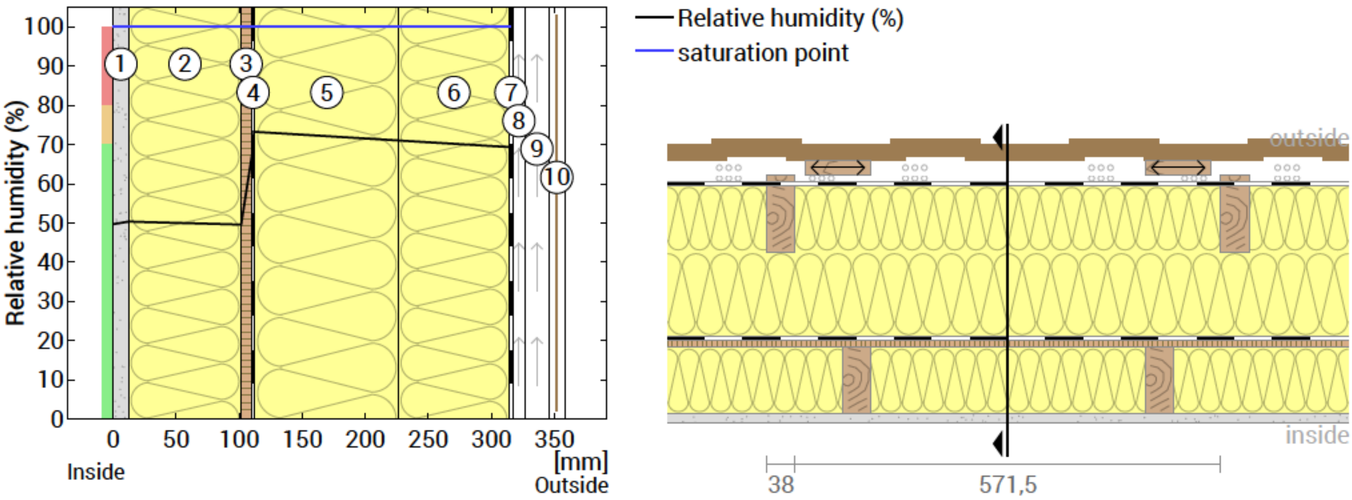
This component is free of condensate under the given climate conditions.

Drying reserve according to Ubakus 2D-FE method: 1541 g/(m²a)
At least required by DIN 68800-2: 100 g/(m²a)

| # | | Material | sd-value [m] | Condensate [kg/m²] | [Gew.-%] | Weight [kg/m²] |
|---|---|---|---|---|---|---|
| 1 | 1,25 cm | Gypsum board | 0,05 | - | | 8,5 |
| 2 | 8,9 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R12, 89mm | 0,09 | - | | 2,6 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 1,78 | - | - | 3,8 |
| 3 | 0,95 cm | Plywood - Douglas fir | 1,43 | - | - | 2,9 |
| 4 | 0,055 cm | pro clima SOLITEX® ADHERO 1000 | 0,30 | - | | 0,2 |
| 5 | 11,4 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,23 | - | | 6,8 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,18 | - | | 5,0 |
| | 8,9 cm | Wood, structural framing (spruce-pine-fir) (6.2%) | 4,45 | - | - | 2,5 |
| 7 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| | 35.6075 cm | Whole component | 2,38 | 0 | | 36,4 |

## Humidity

The temperature of the inside surface is 21,0 °C leading to a relative humidity on the surface of 50%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.

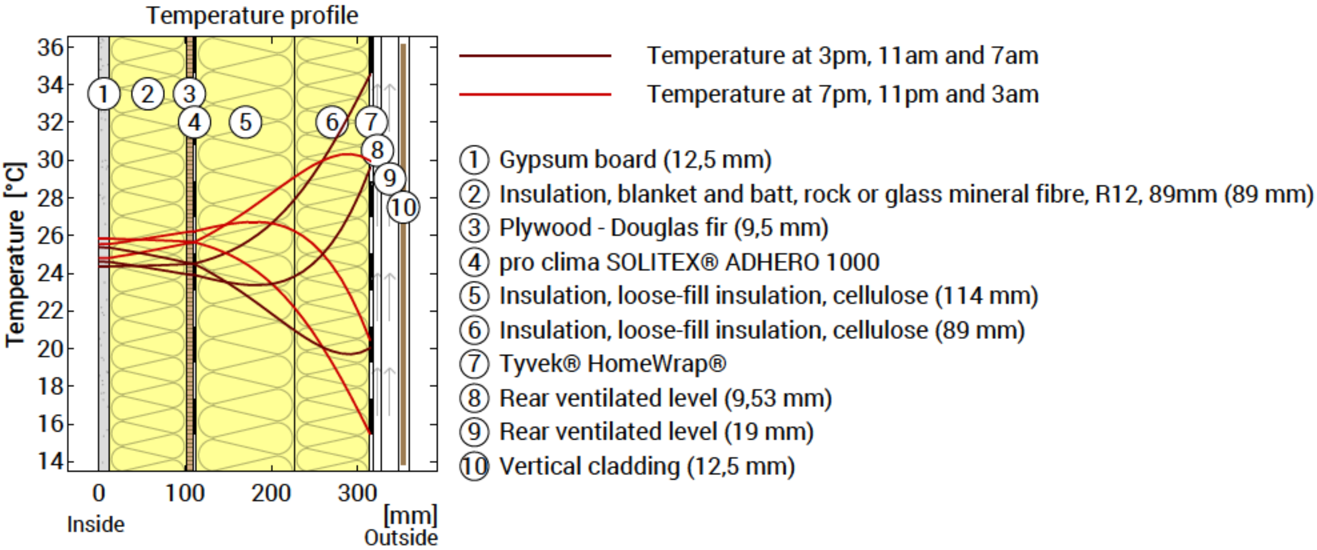


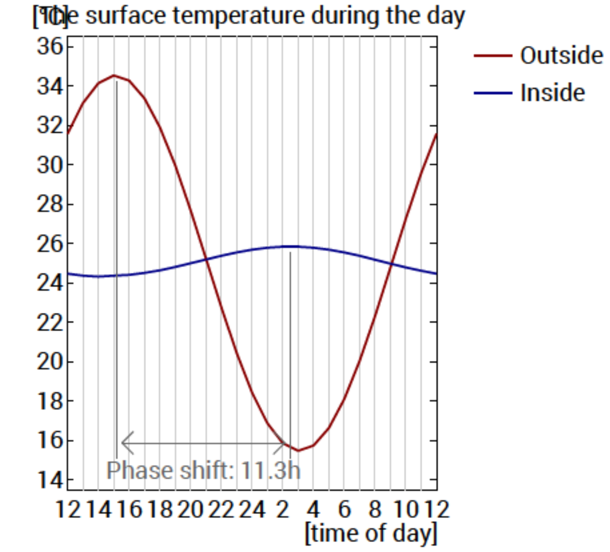

① Gypsum board (12,5 mm)
② Insulation, blanket and batt, rock ...
③ Plywood - Douglas fir (9,5 mm)
④ pro clima SOLITEX® ADHERO 1000
⑤ Insulation, loose-fill insulation, ce...
⑥ Insulation, loose-fill insulation, ce...
⑦ Tyvek® HomeWrap®
⑧ Rear ventilated level (9,53 mm)
⑨ Rear ventilated level (19 mm)
⑩ Vertical cladding (12,5 mm)

Layers marked with <-> run parallel to the illustrated cutting plane and were not taken into account in the moisture protection calculation.
Notes: Calculation using the Ubakus 2D-FE method. Convection and the capillarity of the building materials were not considered. The drying time may take longer under unfavorable conditions (shading, damp / cool summers) than calculated here.

## Heat protection

The following results are properties of the tested component alone and do not make any statement about the heat protection of the entire room:




**Top:**Temperature profile within the component at different times. From top to bottom, brown lines: at 3 pm, 11 am and 7 am and red lines at 7 pm , 11 pm and 3 am.
**Bottom:**Temperature on the outer ( red ) and inner ( blue ) surface in the course of a day. The arrows indicate the location of the temperature maximum values . The maximum of the inner surface temperature should preferably occur during the second half of the night.

| | | | |
|---|---|---|---|
| Phase shift* | 11,3 h | Heat storage capacity (whole component): | 44 kJ/m²K |
| Amplitude attenuation ** | 12,4 | Thermal capacity of inner layers: | 26 kJ/m²K |
| TAV *** | 0,081 | | |

* The phase shift is the time in hours after which the temperature peak of the afternoon reaches the component interior.
** The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 means that the temperature on the outside varies 10x stronger than on the inside, e.g. outside 15-35 °C, inside 24-26 °C.
*** The temperature amplitude ratio TAV is the reciprocal of the attenuation: TAV = 1 / amplitude attenuation

Note: The heat protection of a room is influenced by several factors, but essentially by the direct solar radiation through windows and the total amount of heat storage capacity (including floor, interior walls and furniture). A single component usually has only a very small influence on the heat protection of the room.

The calculations presented above have been created for a 1-dimensional cross-section of the component.

# Calculations for thermal insulation, moisture protection and heat protection

created on 2.4.2025 19:59

## Content



## Comparison with different maximum values*

| Component | BEG Einzelmaßn. | GEG 2020/24 Bestand | GEG 2023/24 Neubau | DIN 4108 |
|---|---|---|---|---|
| Tremblay Wall (Winter, Iqaluit) | ✓ | ✓ | ✓ | ✓ |
| Tremblay Wall (Summer, Iqaluit) | ✓ | ✓ | ✓ | ✓ |

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

# Tremblay Wall (Winter, Iqaluit)

Exterior wall
created on 2.4.2025

## Thermal protection

U = 0,09 W/(m²K)

DIN 4108*: R>1,74 m²K/W + $R_{si}$ + $R_{se}$

excellent insufficient

## Moisture proofing

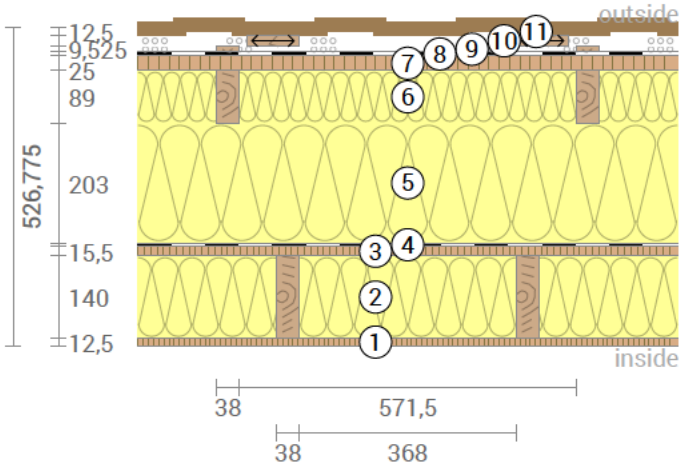
Drying reserve: 579 g/m²a
Dries 1 days
Wood moisture: +0,1%

excellent insufficient

## Heat protection

Temperature amplitude damping: 53
phase shift: 17,0 h
Thermal capacity inside: 33 kJ/m²K

excellent insufficient




1. Plywood - Douglas fir (12,5 mm)
2. Insulation, blanket and batt, rock or glass mineral fibre, R19, 140mm (140 mm)
3. Plywood - Douglas fir (15,5 mm)
4. pro clima INTELLO®
5. Insulation, loose-fill insulation, cellulose (203 mm)
6. Insulation, loose-fill insulation, cellulose (89 mm)
7. Insulating fibreboard (25 mm)
8. Tyvek® HomeWrap®
9. Rear ventilated level (9,525 mm)
10. Rear ventilated level (19 mm)
11. Vertical cladding (12,5 mm)

<-> Layers marked by arrows are perpendicular to the main axis.

| | | | | |
|---|---|---|---|---|
| Inside air : | 23.0°C / 40% | | Thickness: | 52,7 cm |
| Outside air: | -28.0°C / 60% | sd-value: 8,0 m | Weight: | 49 kg/m² |
| Surface temperature.: | 21,4°C / -27,8°C | | Heat capacity: | 69 kJ/m²K |

☑ BEG Einzelmaßn. ☑ GEG 2020/24 Bestand ☑ GEG 2023/24 Neubau ☑ DIN 4108

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

# U-Value calculation according to DIN EN ISO 6946

| # | Material | Dicke [cm] | λ [W/mK] | R [m²K/W] |
|---|---|---|---|---|
| | Thermal contact resistance inside (Rsi) | | | 0,130 |
| 1 | Plywood - Douglas fir | 1,25 | 0,090 | 0,139 |
| 2 | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm | 14,00 | 0,042 | 3,333 |
| | Wood, structural framing (spruce-pine-fir) (9.4%) | 14,00 | 0,118 | 1,190 |
| 3 | Plywood - Douglas fir | 1,55 | 0,090 | 0,172 |
| 4 | pro clima INTELLO® | 0,03 | 0,040 | 0,006 |
| 5 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 20,30 | 0,040 | 5,075 |
| 6 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 8,90 | 0,040 | 2,225 |
| | Stud (spruce) (6.2%) | 8,90 | 0,130 | 0,685 |
| 7 | Insulating fibreboard | 2,50 | 0,063 | 0,400 |
| 8 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| | Thermal contact resistance outside (Rse) | | | 0,130 |

Thermal contact resistances have been taken from DIN 6946 Table 7.
Rsi: heat flow direction horizontally
Rse: heat flow direction horizontally, outside: Ventilation level

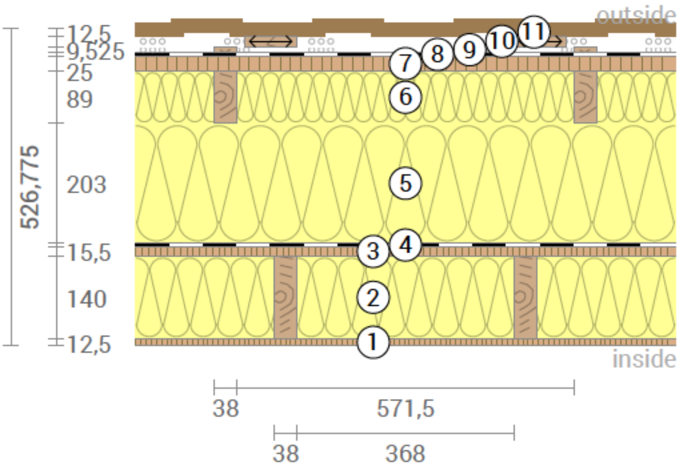
Upper limit of thermal resistance $R_{tot;upper}$ = 11,264 m²K/W.
Lower limit of thermal resistance $R_{tot;lower}$ = 10,854 m²K/W.
Check applicability: $R_{tot;upper}$ / $R_{tot;lower}$ = 1,038 (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance $R_{tot} = (R_{tot;upper} + R_{tot;lower})/2$ = 11.06 m²K/W
Estimated maximum relative uncertainty according to section 6.7.2.5: 1.9%

Heat transfer coefficient $U = 1/R_{tot}$ = **0,09 W/(m²K)**

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 61 cm. This, however, is not true for at least layer 2 with a total width of 40,6 cm and can cause increased inaccuracy of the U-value.



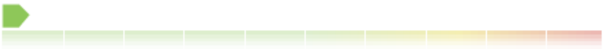
Tremblay Wall (Winter, Iqaluit), U=0,09 W/(m²K)

# LCA

## Heat loss: 13 kWh/m² per heating season

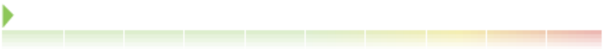
Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

## Primary energy (non renewable): >9.2 kWh/m²



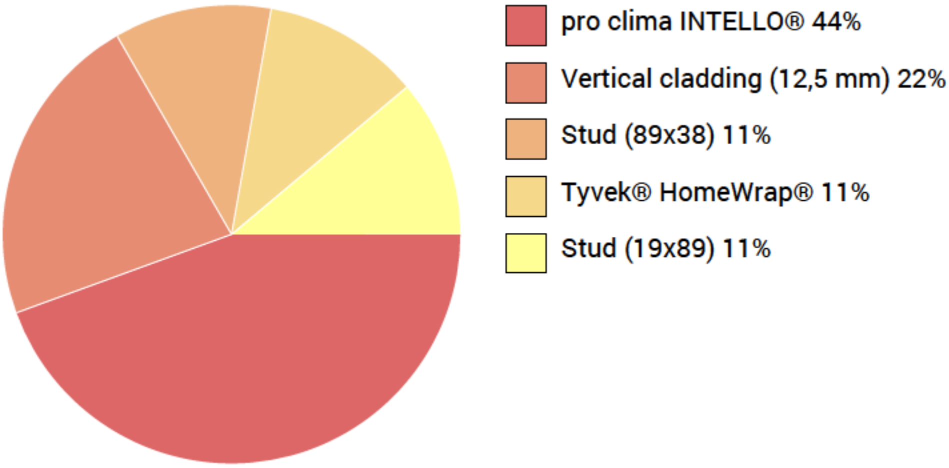
Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

## Green house gas potential: -8.8 (?) kg CO2 Äqv./m²

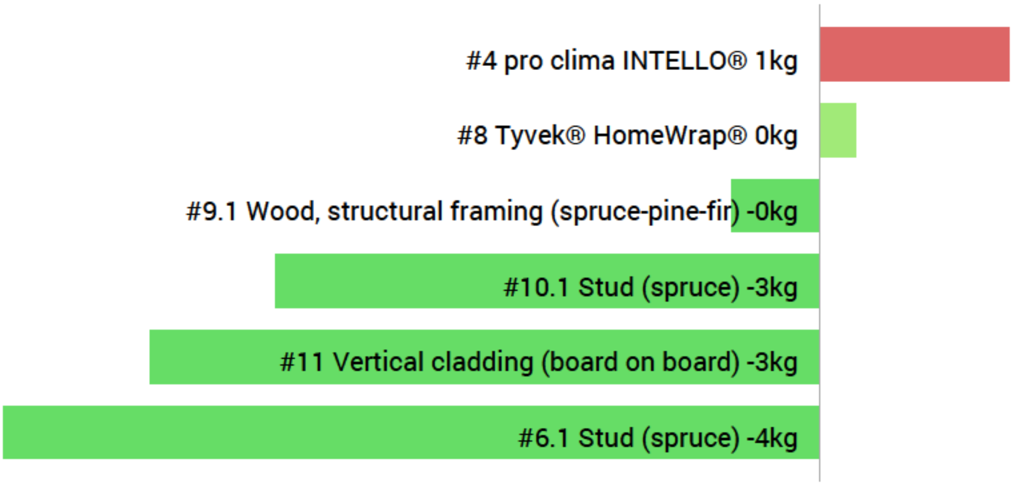


For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

## Composition of non-renewable primary energy of production:



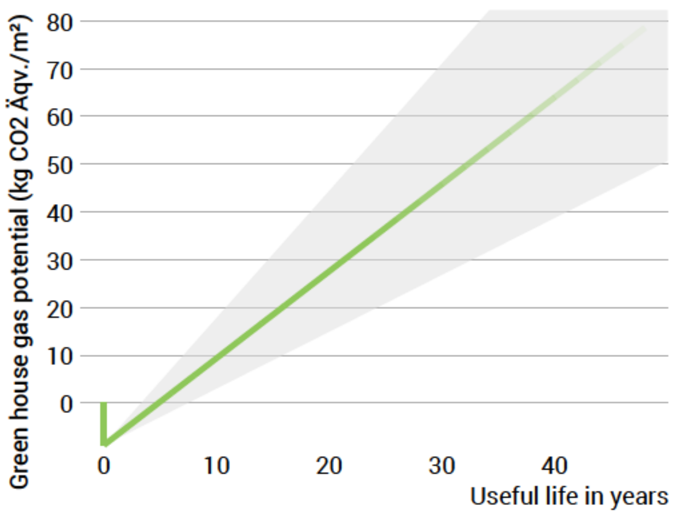

## Composition of the greenhouse potential of production:

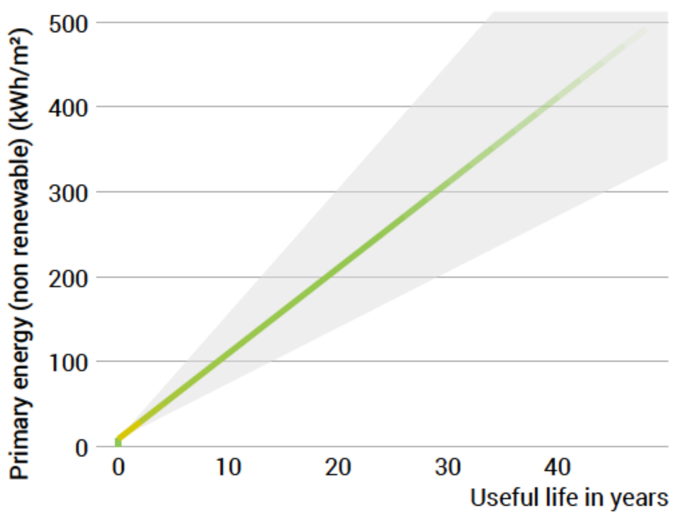



Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

Tremblay Wall (Winter, Iqaluit), U=0,09 W/(m²K)

# Global warming potential and primary energy for construction and use




The **left figure** shows the global warming potential of the production of the component in the vertical part of the curve. Greenhouse gas emissions (through heating) arising during use of the building are indicated by the upward curve.

The **figure at the bottom left** shows the non-renewable primary energy expenditure for the production of the component in the vertical part of the curve. The primary energy required during use of the building (through heating) is represented by the upward curve.

The longer the component is used unchanged, the more environmentally friendly it is, because the production costs contribute less to the total emissions (indicated by the color of the curve).

Due to unknown solar and internal gains, the heating demand can only be estimated. Accordingly, primary energy consumption and global warming potential during the use phase are only vaguely known. For the estimation it was assumed that solar and internal profits contribute with 4 kWh/a/m² component area. The light gray area indicates the area in which the curve is located with great certainty. For heat generation, a primary energy input of 1.2 kWh per kWh of heat and a global warming potential of 0.21 kg $CO_2$ eqv/m² per kWh of heat was used. Heat source: Natural gas H.

## Hints

Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

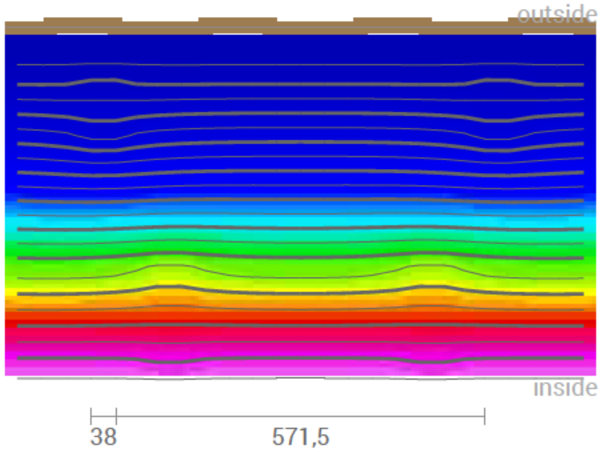
Calculated for the location AB:ABEE AGDM, heating period from Mid of October to End of April. The calculation is based on monthly average temperatures. Source: Canadian Weather Year for Energy Calculation (2016)

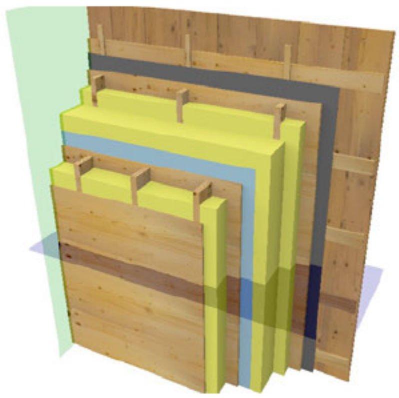
The climate and energy data on which this calculation is based can, in some cases, show considerable fluctuations and, in individual cases, deviate considerably from the actual value.

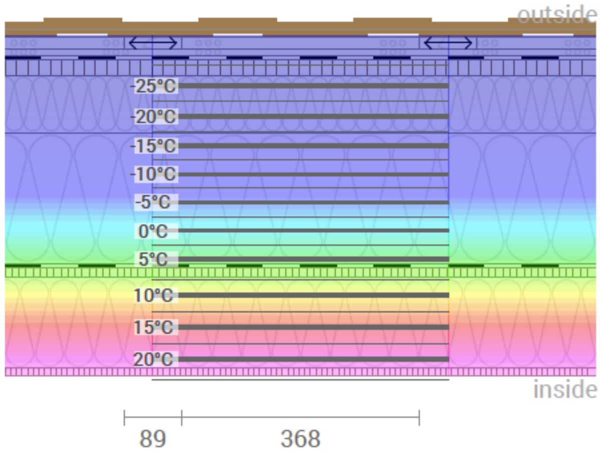
Note: The environmental product data for layer 1 (Plywood - Douglas fir) is yet unknown.
Note: The environmental product data for layer 2 (Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm) is yet unknown.
Note: The environmental product data for layer 5 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 6 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 7 (Insulating fibreboard) is yet unknown.
The calculated amortization periods of primary energy and global warming potential are therefore too low.
Keine Berechnung möglich.

Tremblay Wall (Winter, Iqaluit), U=0,09 W/(m²K)

## Temperature profile






Top left: Temperature profile in the blue section (see right illustration). Bottom left: Temperature profile in the green section.

## Layers (from inside to outside)

| # | | Material | λ [W/mK] | RSI [m²K/W] | Temperatur [°C] min | max | Weight [kg/m²] |
|---|---|---|---|---|---|---|---|
| | | Thermal contact resistance* | | 0,250 | 21,4 | 23,0 | |
| 1 | 1,25 cm | Plywood - Douglas fir | 0,090 | 0,139 | 20,4 | 22,0 | 3,8 |
| 2 | 14 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm | 0,042 | 3,333 | 7,2 | 21,4 | 4,1 |
| | 14 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 0,118 | 1,190 | 9,1 | 20,7 | 5,9 |
| 3 | 1,55 cm | Plywood - Douglas fir | 0,090 | 0,172 | 6,4 | 9,1 | 4,7 |
| 4 | 0,025 cm | pro clima INTELLO® | 0,040 | 0,006 | 6,4 | 8,0 | 0,1 |
| 5 | 20,3 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 5,075 | -18,3 | 8,0 | 12,2 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,225 | -26,1 | -16,1 | 5,0 |
| | 8,9 cm | Stud (spruce) (6.2%) | 0,130 | 0,685 | -25,3 | -18,3 | 2,5 |
| 7 | 2,5 cm | Insulating fibreboard | 0,063 | 0,400 | -27,8 | -25,2 | 6,3 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | -27,8 | -27,7 | 0,1 |
| | | Thermal contact resistance* | | 0,040 | -28,0 | -27,8 | |
| 9 | 0.9525 cm | Rear ventilated level (outside air) | | | -28,0 | -28,0 | 0,0 |
| 10 | 1.9 cm | Rear ventilated level (outside air) | | | -28,0 | -28,0 | 0,0 |
| 11 | 1.25 cm | Vertical cladding (board on board) | | | -28,0 | -28,0 | 2,2 |
| | 52.6775 cm | Whole component | | 11,059 | | | 48,6 |

*Thermal contact resistances according to DIN 4108-3 for moisture protection and temperature profile. The values for the U-value calculation can be found on the page 'U-value calculation'.

| | | | |
|---|---|---|---|
| Surface temperature inside (min / average / max): | 21,4°C | 21,8°C | 22,0°C |
| Surface temperature outside (min / average / max): | -27,8°C | -27,8°C | -27,8°C |

Tremblay Wall (Winter, Iqaluit), U=0,09 W/(m²K)

# Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 23°C und 40% Humidity; outside: -28°C und 60% Humidity (Climate according to user input).

Under these conditions, a total of 0.0025 kg of condensation water per square meter is accumulated.This quantity dries in summer in 1 days (Drying season according to DIN 4108-3:2018-10).

Drying reserve according to Ubakus 2D-FE method: 579 g/(m²a)
At least required by DIN 68800-2: 100 g/(m²a)

| # | | Material | sd-value [m] | Condensate [kg/m²] | Condensate [Gew.-%] | Weight [kg/m²] |
|---|---|---|---|---|---|---|
| 1 | 1,25 cm | Plywood - Douglas fir | 0,63 | - | - | 3,8 |
| 2 | 14 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm | 0,14 | 0.0025 | | 4,1 |
| | 14 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 2,80 | - | - | 5,9 |
| 3 | 1,55 cm | Plywood - Douglas fir | 0,78 | 0.0025 | 0,1 | 4,7 |
| 4 | 0,025 cm | pro clima INTELLO® | 5,96 | - | | 0,1 |
| 5 | 20,3 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,20 | - | | 12,2 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,09 | - | | 5,0 |
| | 8,9 cm | Stud (spruce) (6.2%) | 4,45 | - | - | 2,5 |
| 7 | 2,5 cm | Insulating fibreboard | 0,13 | - | - | 6,3 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| | 52.6775 cm | Whole component | 8,04 | 0.0025 | | 48,6 |

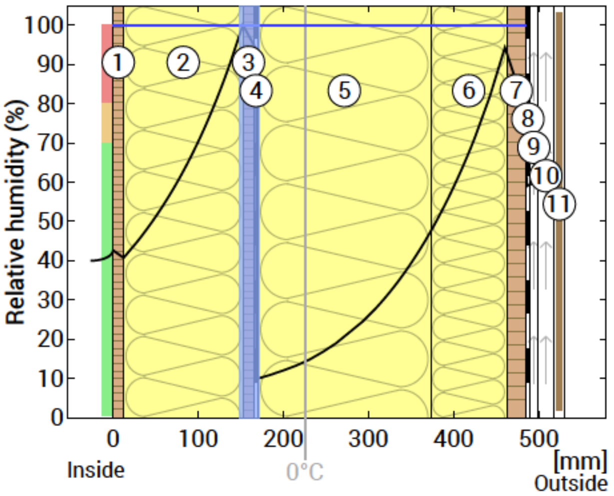
## Condensation areas

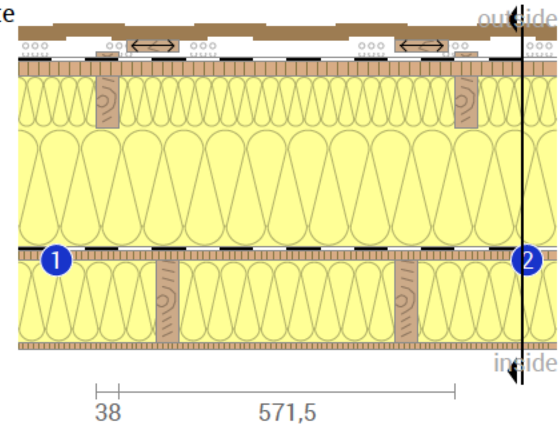
1. Condensate: 0,001 kg/m² Affected layers: Plywood - Douglas fir, Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm
2. Condensate: 0,001 kg/m² Affected layers: Plywood - Douglas fir, Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm

Tremblay Wall (Winter, Iqaluit), U=0,09 W/(m²K)

## Humidity

The temperature of the inside surface is 21,4 °C leading to a relative humidity on the surface of 44%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



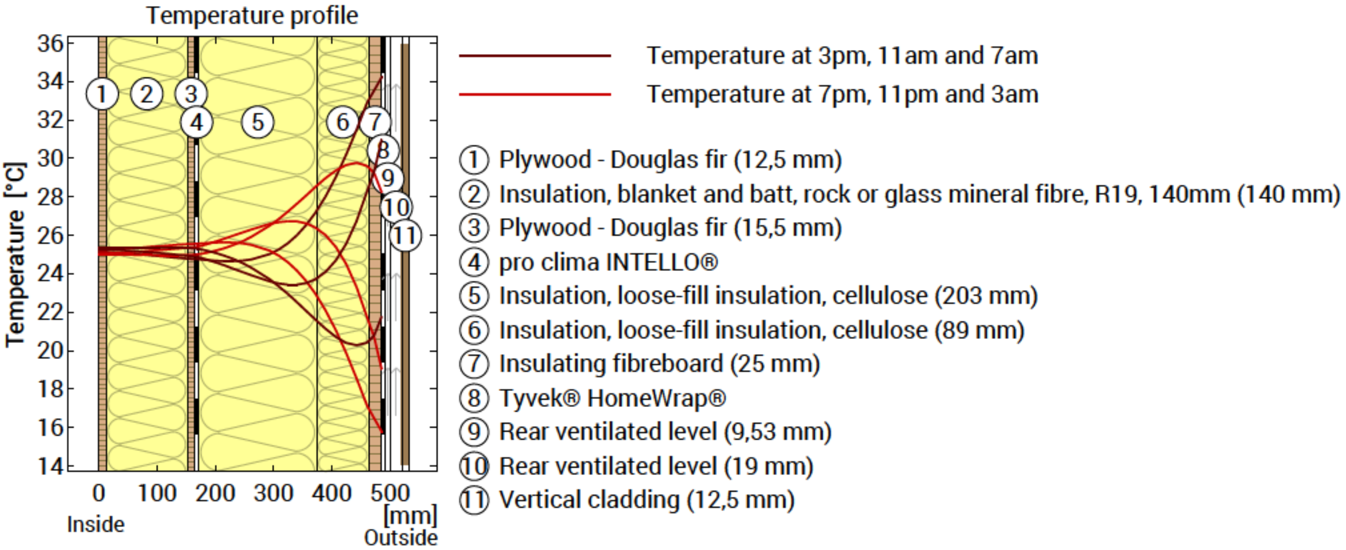

① Plywood - Douglas fir (12,5 mm)
② Insulation, blanket and batt, rock ...
③ Plywood - Douglas fir (15,5 mm)
④ pro clima INTELLO®
⑤ Insulation, loose-fill insulation, ce...
⑥ Insulation, loose-fill insulation, ce...
⑦ Insulating fibreboard (25 mm)
⑧ Tyvek® HomeWrap®
⑨ Rear ventilated level (9,53 mm)
⑩ Rear ventilated level (19 mm)
⑪ Vertical cladding (12,5 mm)

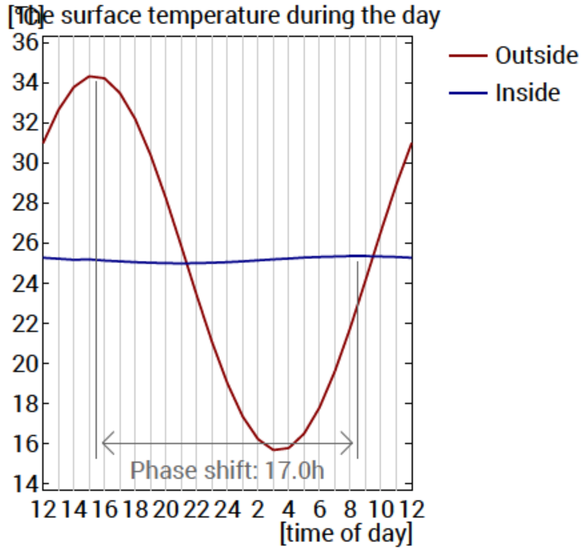
Layers marked with <-> run parallel to the illustrated cutting plane and were not taken into account in the moisture protection calculation.
Notes: Calculation using the Ubakus 2D-FE method. Convection and the capillarity of the building materials were not considered. The drying time may take longer under unfavorable conditions (shading, damp / cool summers) than calculated here.

Tremblay Wall (Winter, Iqaluit), U=0,09 W/(m²K)

# Heat protection

The following results are properties of the tested component alone and do not make any statement about the heat protection of the entire room:




**Top:** Temperature profile within the component at different times. From top to bottom, brown lines: at 3 pm, 11 am and 7 am and red lines at 7 pm , 11 pm and 3 am.
**Bottom:** Temperature on the outer ( red ) and inner ( blue ) surface in the course of a day. The arrows indicate the location of the temperature maximum values . The maximum of the inner surface temperature should preferably occur during the second half of the night.

| | | | |
|---|---|---|---|
| Phase shift* | 17,0 h | Heat storage capacity (whole component): | 69 kJ/m²K |
| Amplitude attenuation ** | 52,6 | Thermal capacity of inner layers: | 33 kJ/m²K |
| TAV *** | 0,019 | | |

* The phase shift is the time in hours after which the temperature peak of the afternoon reaches the component interior.
** The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 means that the temperature on the outside varies 10x stronger than on the inside, e.g. outside 15-35 °C, inside 24-26 °C.
*** The temperature amplitude ratio TAV is the reciprocal of the attenuation: TAV = 1 / amplitude attenuation

Note: The heat protection of a room is influenced by several factors, but essentially by the direct solar radiation through windows and the total amount of heat storage capacity (including floor, interior walls and furniture). A single component usually has only a very small influence on the heat protection of the room.

The calculations presented above have been created for a 1-dimensional cross-section of the component.

# Tremblay Wall (Summer, Iqaluit)

Exterior wall
created on 2.4.2025

## Thermal protection

U = 0,09 W/(m²K)

DIN 4108*: R>1,74 m²K/W + $R_{si}$ + $R_{se}$

excellent insufficient

## Moisture proofing

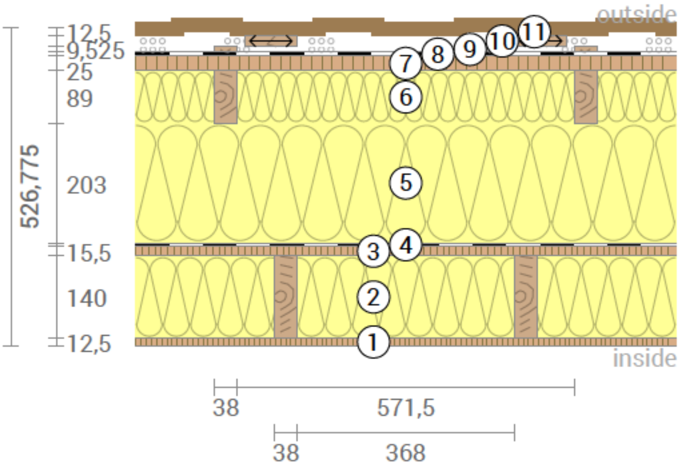
Drying reserve: 1468 g/m²a
No condensate

excellent insufficient

## Heat protection

Temperature amplitude damping: 53
phase shift: 17,0 h
Thermal capacity inside: 33 kJ/m²K

excellent insufficient




1. Plywood - Douglas fir (12,5 mm)
2. Insulation, blanket and batt, rock or glass mineral fibre, R19, 140mm (140 mm)
3. Plywood - Douglas fir (15,5 mm)
4. pro clima INTELLO®
5. Insulation, loose-fill insulation, cellulose (203 mm)
6. Insulation, loose-fill insulation, cellulose (89 mm)
7. Insulating fibreboard (25 mm)
8. Tyvek® HomeWrap®
9. Rear ventilated level (9,525 mm)
10. Rear ventilated level (19 mm)
11. Vertical cladding (12,5 mm)

<-> Layers marked by arrows are perpendicular to the main axis.

| | | | | |
|---|---|---|---|---|
| Inside air : | 21.0°C / 50% | | Thickness: | 52,7 cm |
| Outside air: | 8.0°C / 80% | sd-value: 7,8 m | Weight: | 49 kg/m² |
| Surface temperature.: | 20,6°C / 8,0°C | | Heat capacity: | 69 kJ/m²K |

☑ BEG Einzelmaßn. ☑ GEG 2020/24 Bestand ☑ GEG 2023/24 Neubau ☑ DIN 4108

*Comparison of the U-value with den techn. Mindestanforderungen für BEG Einzelmaßnahmen; den Höchstwerten aus GEG Anlage 7 (GEG 2020-2024 Bestand); 70% des U-Werts der Referenzausführung aus GEG 2023/2024 Anlage 1 (GEG Neubau); den R-Werten aus DIN 4108-2 Tabelle 3

Tremblay Wall (Summer, Iqaluit), U=0,09 W/(m²K)

# U-Value calculation according to DIN EN ISO 6946

| # | Material | Dicke [cm] | λ [W/mK] | R [m²K/W] |
|---|---|---|---|---|
| | Thermal contact resistance inside (Rsi) | | | 0,130 |
| 1 | Plywood - Douglas fir | 1,25 | 0,090 | 0,139 |
| 2 | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm | 14,00 | 0,042 | 3,333 |
| | Wood, structural framing (spruce-pine-fir) (9.4%) | 14,00 | 0,118 | 1,190 |
| 3 | Plywood - Douglas fir | 1,55 | 0,090 | 0,172 |
| 4 | pro clima INTELLO® | 0,03 | 0,040 | 0,006 |
| 5 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 20,30 | 0,040 | 5,075 |
| 6 | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 8,90 | 0,040 | 2,225 |
| | Stud (spruce) (6.2%) | 8,90 | 0,130 | 0,685 |
| 7 | Insulating fibreboard | 2,50 | 0,063 | 0,400 |
| 8 | Tyvek® HomeWrap® | 0,05 | 0,400 | 0,001 |
| | Thermal contact resistance outside (Rse) | | | 0,130 |

Thermal contact resistances have been taken from DIN 6946 Table 7.
Rsi: heat flow direction horizontally
Rse: heat flow direction horizontally, outside: Ventilation level

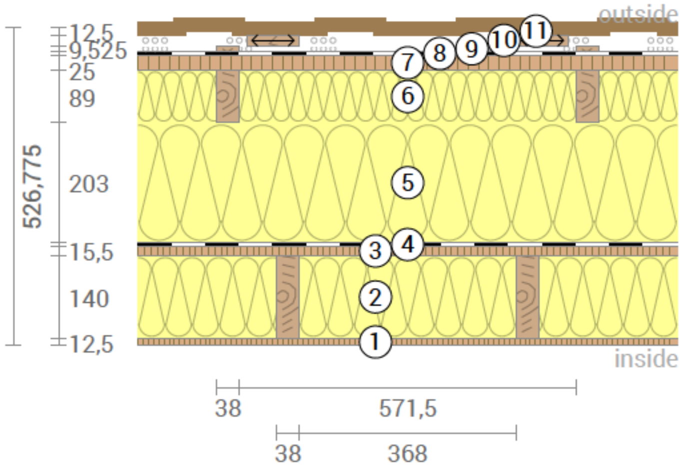
Upper limit of thermal resistance $R_{tot;upper}$ = 11,264 m²K/W.
Lower limit of thermal resistance $R_{tot;lower}$ = 10,854 m²K/W.
Check applicability: $R_{tot;upper}$ / $R_{tot;lower}$ = 1,038 (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance $R_{tot} = (R_{tot;upper} + R_{tot;lower})/2$ = 11.06 m²K/W
Estimated maximum relative uncertainty according to section 6.7.2.5: 1.9%

Heat transfer coefficient $U = 1/R_{tot}$ = **0,09 W/(m²K)**

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 61 cm. This, however, is not true for at least layer 2 with a total width of 40,6 cm and can cause increased inaccuracy of the U-value.



Tremblay Wall (Summer, Iqaluit), U=0,09 W/(m²K)

# LCA

**Heat loss: 12 kWh/m² per heating season**

Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

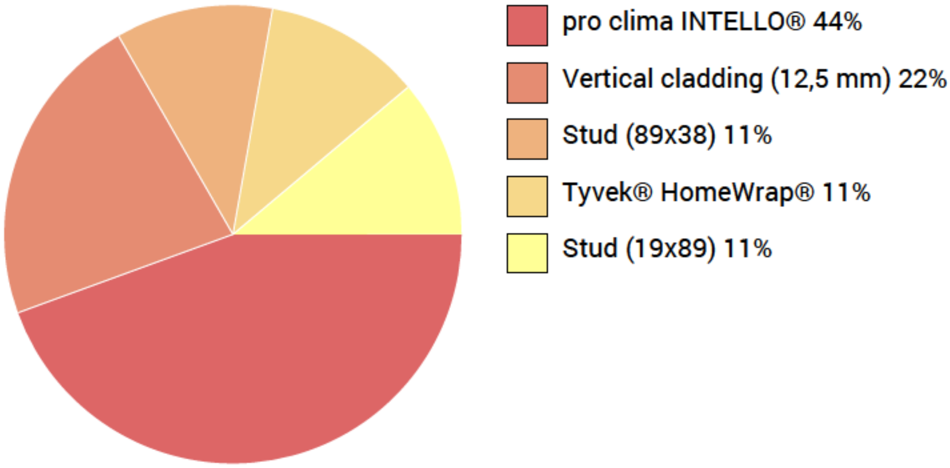
**Primary energy (non renewable): >9.2 kWh/m²**

Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

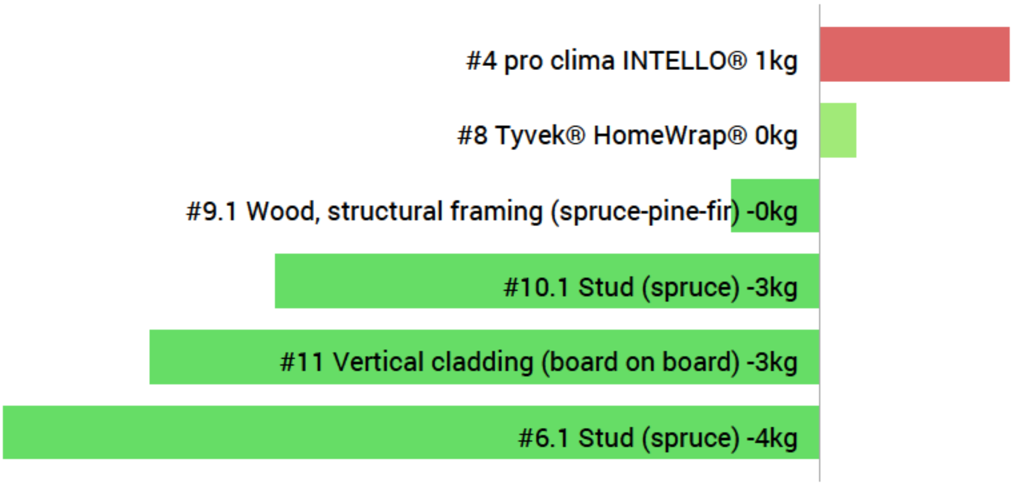
**Green house gas potential: -8.8 (?) kg $CO_2$ Äqv./m²**

For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

## Composition of non-renewable primary energy of production:



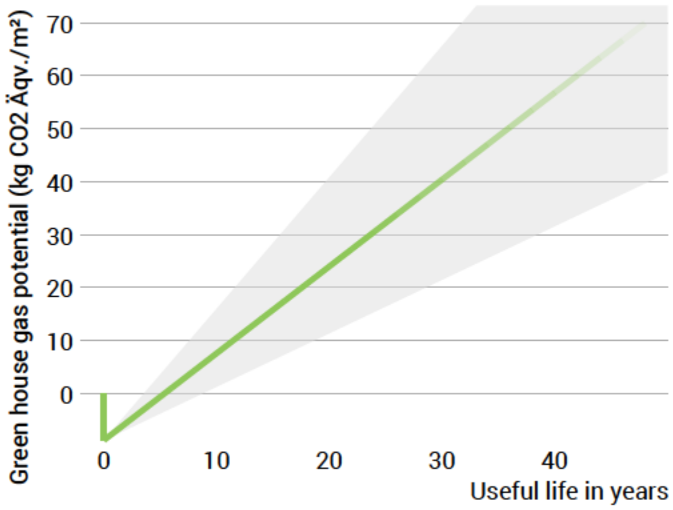

## Composition of the greenhouse potential of production:

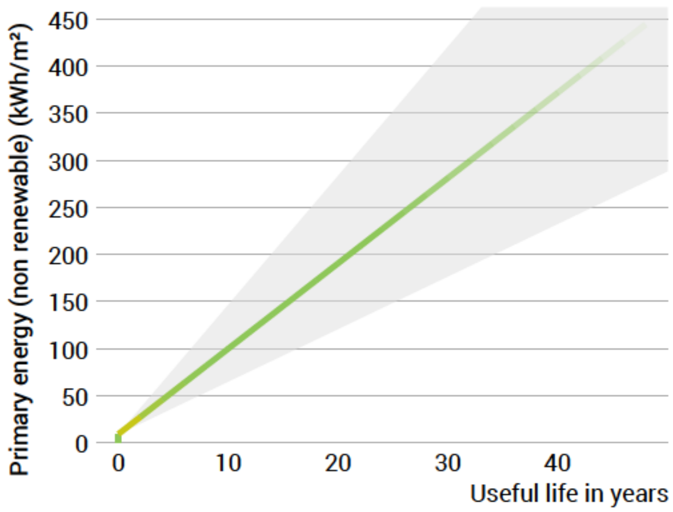



Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

Tremblay Wall (Summer, Iqaluit), U=0,09 W/(m²K)

# Global warming potential and primary energy for construction and use




The **left figure** shows the global warming potential of the production of the component in the vertical part of the curve. Greenhouse gas emissions (through heating) arising during use of the building are indicated by the upward curve.

The **figure at the bottom left** shows the non-renewable primary energy expenditure for the production of the component in the vertical part of the curve. The primary energy required during use of the building (through heating) is represented by the upward curve.

The longer the component is used unchanged, the more environmentally friendly it is, because the production costs contribute less to the total emissions (indicated by the color of the curve).

Due to unknown solar and internal gains, the heating demand can only be estimated. Accordingly, primary energy consumption and global warming potential during the use phase are only vaguely known. For the estimation it was assumed that solar and internal profits contribute with 4 kWh/a/m² component area. The light gray area indicates the area in which the curve is located with great certainty. For heat generation, a primary energy input of 1.2 kWh per kWh of heat and a global warming potential of 0.21 kg $CO_2$ eqv/m² per kWh of heat was used. Heat source: Natural gas H.

## Hints

Attention: At least one layer could not be considered because its primary energy content and / or global warming potential is unknown.

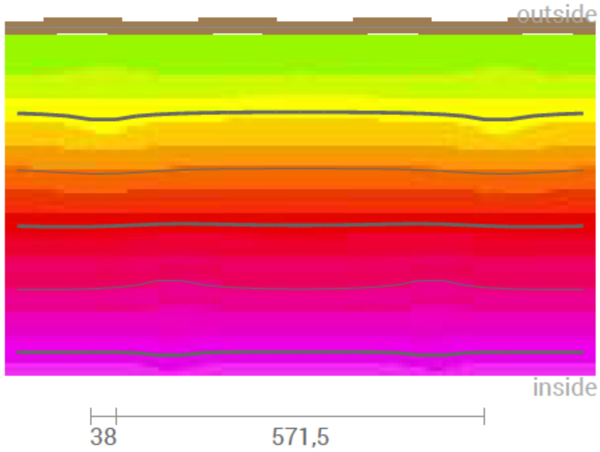
Calculated for the location AB:ABEE AGDM, heating period from Mid of October to End of April. The calculation is based on monthly average temperatures. Source: Canadian Weather Year for Energy Calculation (2016)

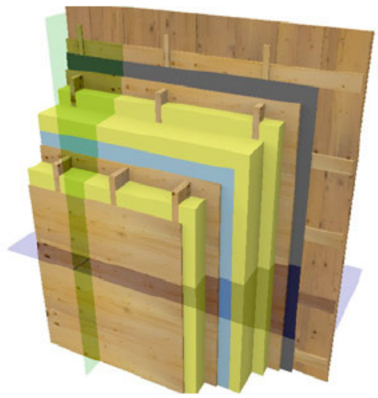
The climate and energy data on which this calculation is based can, in some cases, show considerable fluctuations and, in individual cases, deviate considerably from the actual value.

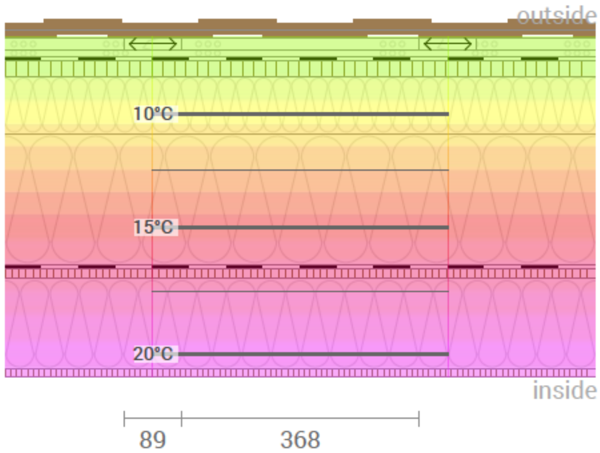
Note: The environmental product data for layer 1 (Plywood - Douglas fir) is yet unknown.
Note: The environmental product data for layer 2 (Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm) is yet unknown.
Note: The environmental product data for layer 5 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 6 (Insulation, loose-fill insulation, cellulose (CAN/ULC-S703)) is yet unknown.
Note: The environmental product data for layer 7 (Insulating fibreboard) is yet unknown.
The calculated amortization periods of primary energy and global warming potential are therefore too low.
Keine Berechnung möglich.

Tremblay Wall (Summer, Iqaluit), U=0,09 W/(m²K)

## Temperature profile






Top left: Temperature profile in the blue section (see right illustration). Bottom left: Temperature profile in the green section.

## Layers (from inside to outside)

| # | | Material | λ [W/mK] | RSI [m²K/W] | Temperatur [°C] min | max | Weight [kg/m²] |
|---|---|---|---|---|---|---|---|
| | | Thermal contact resistance* | | 0,250 | 20,6 | 21,0 | |
| 1 | 1,25 cm | Plywood - Douglas fir | 0,090 | 0,139 | 20,3 | 20,7 | 3,8 |
| 2 | 14 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm | 0,042 | 3,333 | 17,0 | 20,6 | 4,1 |
| | 14 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 0,118 | 1,190 | 17,5 | 20,4 | 5,9 |
| 3 | 1,55 cm | Plywood - Douglas fir | 0,090 | 0,172 | 16,8 | 17,5 | 4,7 |
| 4 | 0,025 cm | pro clima INTELLO® | 0,040 | 0,006 | 16,8 | 17,2 | 0,1 |
| 5 | 20,3 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 5,075 | 10,5 | 17,2 | 12,2 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,040 | 2,225 | 8,5 | 11,0 | 5,0 |
| | 8,9 cm | Stud (spruce) (6.2%) | 0,130 | 0,685 | 8,7 | 10,5 | 2,5 |
| 7 | 2,5 cm | Insulating fibreboard | 0,063 | 0,400 | 8,0 | 8,7 | 6,3 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,400 | 0,001 | 8,0 | 8,1 | 0,1 |
| | | Thermal contact resistance* | | 0,040 | 8,0 | 8,1 | |
| 9 | 0.9525 cm | Rear ventilated level (outside air) | | | 8,0 | 8,0 | 0,0 |
| 10 | 1.9 cm | Rear ventilated level (outside air) | | | 8,0 | 8,0 | 0,0 |
| 11 | 1.25 cm | Vertical cladding (board on board) | | | 8,0 | 8,0 | 2,2 |
| | 52.6775 cm | Whole component | | 11,059 | | | 48,6 |

*Thermal contact resistances according to DIN 4108-3 for moisture protection and temperature profile. The values for the U-value calculation can be found on the page 'U-value calculation'.

| | | | |
|---|---|---|---|
| Surface temperature inside (min / average / max): | 20,6°C | 20,7°C | 20,7°C |
| Surface temperature outside (min / average / max): | 8,0°C | 8,0°C | 8,1°C |

Tremblay Wall (Summer, Iqaluit), U=0,09 W/(m²K)

## Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 21°C und 50% Humidity; outside: 8°C und 80% Humidity (Climate according to user input).

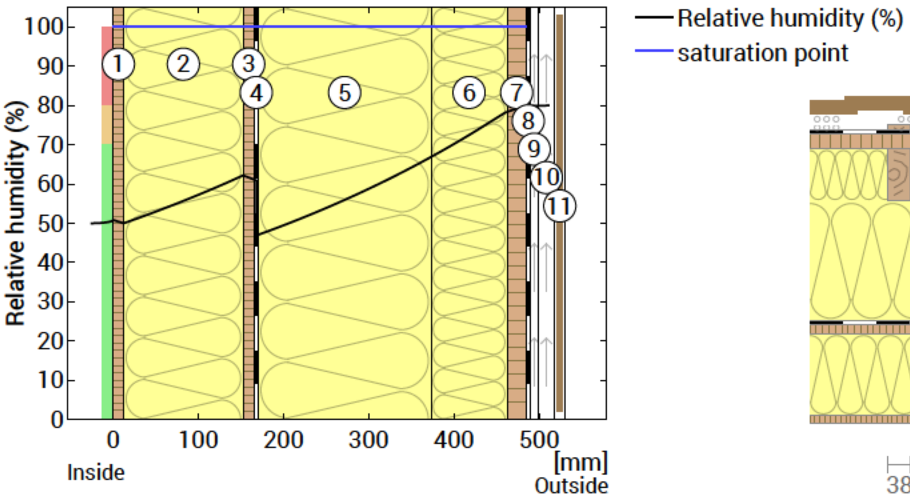
This component is free of condensate under the given climate conditions.

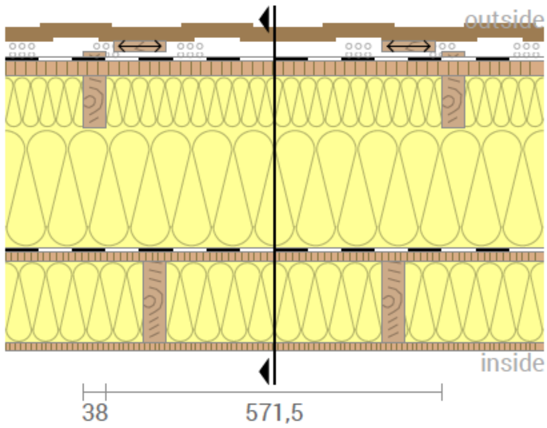
Drying reserve according to Ubakus 2D-FE method: 1468 g/(m²a)
At least required by DIN 68800-2: 100 g/(m²a)

| # | | Material | sd-value [m] | Condensate [kg/m²] | [Gew.-%] | Weight [kg/m²] |
|---|---|---|---|---|---|---|
| 1 | 1,25 cm | Plywood - Douglas fir | 0,63 | - | - | 3,8 |
| 2 | 14 cm | Insulation, blanket and batt, rock or glass mineral fibre (CAN/ULC-S702), R19, 140mm | 0,14 | - | | 4,1 |
| | 14 cm | Wood, structural framing (spruce-pine-fir) (9.4%) | 2,80 | - | - | 5,9 |
| 3 | 1,55 cm | Plywood - Douglas fir | 0,78 | - | - | 4,7 |
| 4 | 0,025 cm | pro clima INTELLO® | 5,40 | - | | 0,1 |
| 5 | 20,3 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,41 | - | | 12,2 |
| 6 | 8,9 cm | Insulation, loose-fill insulation, cellulose (CAN/ULC-S703) | 0,18 | - | | 5,0 |
| | 8,9 cm | Stud (spruce) (6.2%) | 4,45 | - | - | 2,5 |
| 7 | 2,5 cm | Insulating fibreboard | 0,13 | - | - | 6,3 |
| 8 | 0,05 cm | Tyvek® HomeWrap® | 0,06 | - | | 0,1 |
| | 52.6775 cm | Whole component | 7,79 | 0 | | 48,6 |

## Humidity

The temperature of the inside surface is 20,6 °C leading to a relative humidity on the surface of 51%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



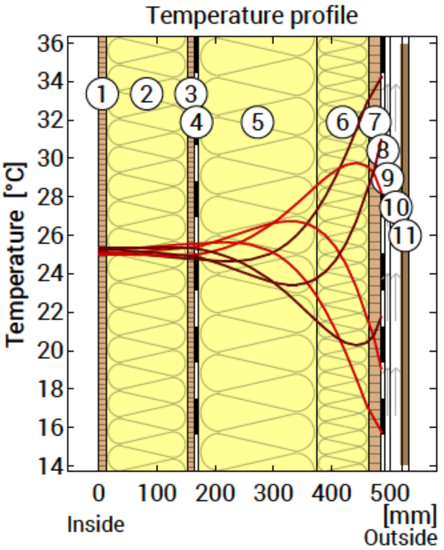

① Plywood - Douglas fir (12,5 mm)
② Insulation, blanket and batt, rock ...
③ Plywood - Douglas fir (15,5 mm)
④ pro clima INTELLO®
⑤ Insulation, loose-fill insulation, ce...
⑥ Insulation, loose-fill insulation, ce...
⑦ Insulating fibreboard (25 mm)
⑧ Tyvek® HomeWrap®
⑨ Rear ventilated level (9,53 mm)
⑩ Rear ventilated level (19 mm)
⑪ Vertical cladding (12,5 mm)

Layers marked with <-> run parallel to the illustrated cutting plane and were not taken into account in the moisture protection calculation.
Notes: Calculation using the Ubakus 2D-FE method. Convection and the capillarity of the building materials were not considered. The drying time may take longer under unfavorable conditions (shading, damp / cool summers) than calculated here.

Tremblay Wall (Summer, Iqaluit), U=0,09 W/(m²K)

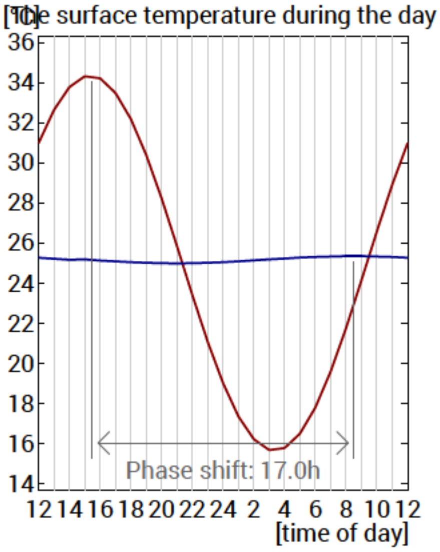
# Heat protection

The following results are properties of the tested component alone and do not make any statement about the heat protection of the entire room:




Temperature at 3pm, 11am and 7am
Temperature at 7pm, 11pm and 3am

① Plywood - Douglas fir (12,5 mm)
② Insulation, blanket and batt, rock or glass mineral fibre, R19, 140mm (140 mm)
③ Plywood - Douglas fir (15,5 mm)
④ pro clima INTELLO®
⑤ Insulation, loose-fill insulation, cellulose (203 mm)
⑥ Insulation, loose-fill insulation, cellulose (89 mm)
⑦ Insulating fibreboard (25 mm)
⑧ Tyvek® HomeWrap®
⑨ Rear ventilated level (9,53 mm)
⑩ Rear ventilated level (19 mm)
⑪ Vertical cladding (12,5 mm)




**Top:**Temperature profile within the component at different times. From top to bottom, brown lines: at 3 pm, 11 am and 7 am and red lines at 7 pm , 11 pm and 3 am.
**Bottom:**Temperature on the outer ( red ) and inner ( blue ) surface in the course of a day. The arrows indicate the location of the temperature maximum values . The maximum of the inner surface temperature should preferably occur during the second half of the night.

| | | | |
|---|---|---|---|
| Phase shift* | 17,0 h | Heat storage capacity (whole component): | 69 kJ/m²K |
| Amplitude attenuation ** | 52,6 | Thermal capacity of inner layers: | 33 kJ/m²K |
| TAV *** | 0,019 | | |

* The phase shift is the time in hours after which the temperature peak of the afternoon reaches the component interior.
** The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 means that the temperature on the outside varies 10x stronger than on the inside, e.g. outside 15-35 °C, inside 24-26 °C.
*** The temperature amplitude ratio TAV is the reciprocal of the attenuation: TAV = 1 / amplitude attenuation

Note: The heat protection of a room is influenced by several factors, but essentially by the direct solar radiation through windows and the total amount of heat storage capacity (including floor, interior walls and furniture). A single component usually has only a very small influence on the heat protection of the room.

The calculations presented above have been created for a 1-dimensional cross-section of the component.