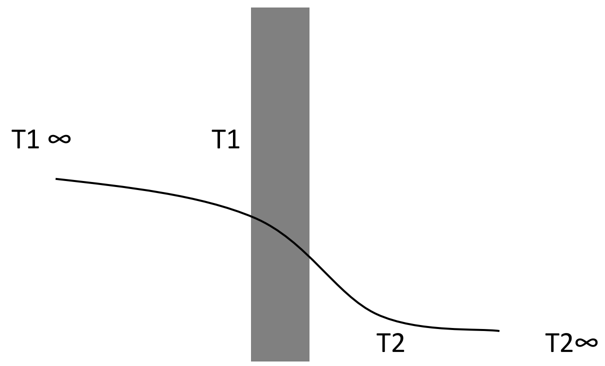
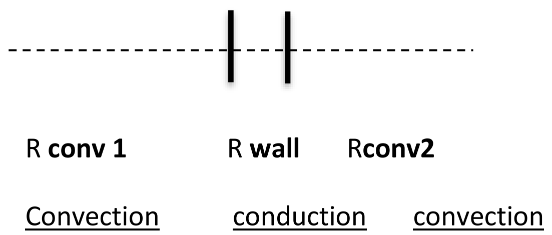
To define energy consumption through a wall, measuring the rate of heat transfer through it as a solid (conduction heat transfer) is not enough. We should as well measure temperature that goes from air to that solid. This could be done through calculating the convection rate of heat transfer (heat transfer through fluids, with air = fluid).

We have two convections : the natural one due to the considerable difference between the density of air and the density of solid ; and a second one due to external forces (wind for example). The convection happens because of the difference of temperature wich its flow always occur from the hottest to coolest : the hottest air affected by the solid goes up because it becomes less dense pushing the coolest one down since it has higher density.

Rate of convective heat transfer depends on : the difference of temperature, the velocity of fluid and the nature of this latter.

T∞ is the homogenous temperature of the space that is not affected by the solid. For the temperature inside the house, we choose T that fulfills a thermal confort (aroud 20°C). For the outside we choose T of the worst case scenario depending on the place's location.





why increasing the thickness of a single pane glass does not increase the total resistane ? Increasing the thickness of the pane L means increasing the conductive resistance as R = L/(k*A). But since the conductive resistance is neglected compared to the conductive resistances, the added value do not affect the total resistance. R **wall <<<<<<<<<** R **conv.**

Mistakes ? small differences of values because of too much rounding !

$$\begin{cases} \dot{Q} = \dfrac{T_{\infty 1} - T_{\infty 4}}{R_{TOTAL}} \\ R_{TOTAL} = R_{conv1} + (R_{glass} \times 2) + R_{cond} + R_{conv2} \end{cases}$$

* $R_{conv1} = 1/h_1 \times A = \dfrac{1}{10 \times 1{,}5 \times 0{,}8} = 0{,}0833\ °C/W$
* $R_{glass} = L/KA = \dfrac{6 \times 10^{-3}}{0{,}78 \times 1{,}5 \times 0{,}8} = 0{,}0064\ °C/W$
* $R_{cond} = L'/K'A = \dfrac{13 \times 10^{-3}}{0{,}026 \times 1{,}5 \times 0{,}8} = 0{,}4166\ °C/W$
* $R_{conv2} = 1/h_2 \times A = \dfrac{1}{40 \times 1{,}5 \times 0{,}8} = 0{,}0208\ °C/W$

$$\Rightarrow \boxed{\begin{aligned} R_{TOTAL} &= \Sigma R = 0{,}5271\ °C/W \\ \dot{Q} &= \frac{20-(-10)}{0{,}5271} = 56{,}9151\ W \end{aligned}}$$

$$\left\{ \dot{Q} \text{ steady} \Rightarrow \dot{Q} = \frac{T_{\infty 1} - T_1}{R_{conv1}} \right.$$

$$T_1 = T_{\infty 1} - \dot{Q} \times R_{conv1} = 20 - \begin{pmatrix} 0{,}0833 \\ \times 56{,}915 \end{pmatrix}$$

$$\Rightarrow \boxed{T_1 \approx 15{,}26\ °C}$$

Comment on results ?

- The resistance of the air gap space is signaficantly high compared to the other resistances
- The air gap space decreases significantly the rate of heat transfer
- The resistance of glass is almost neglicted !
- Increasing the thickness of the air gap distance from 10mm (previous example) to 13mm has decreased the value of the heat transfer by aroud 1/6

Q (L=10mm) = 69, 28 W

Q (L=13mm) = 56,91 W

(the increase of the thickness of the glass from 4mm to 6mm is not considered since the resistance of the glass is neglicted)

why we have an optimal range for the air-gap's distance ?

Increasing the air gap distance helps decreasing the rate of heat transfer. However, going beyong a certain value (around16mm) is impossible since considering the air gap space as a solid (stagnant air) will not be verified. This is due to its displacement generated because of the wide distance.