**Low energy windows**

Similar to the insulation of the external wall, the roof and the floor, the insulation of windows has a big impact on the thermal protection of a building. Although the development of the last years is characterised by a big improvement of the energetic quality, windows still have the lowest level of insulation of all external components of a building.

The reduction of the thermal transfer of windows has been reached, as especially the thermal properties of the glazing, which has the highest impact on the heat losses, were improved. Generally there are the following kinds of glazing:

| **Glazing** | **U-value for Glazing ($W/m^2K$)** | **U-value for Window (including frame) ($W/m^2K$)** |
|---|---|---|
| **Single** | 5,8 | 3-4 |
| **Double** | 3,2 | 2,8 |
| **Double low-Energy** | 1,1 | 1,5-1,7 |
| **Triple** | 2,5 | 2,2 |
| **Triple low-Energy** | 0,7 | 1,0-1,2 |
| **Passiv House (with insulated frame)** | 0,7 | 0,8 |

*Table: Overview of U-values for different types of glazing and for the whole window –including frame. The values are for standard windows (app. 1x0,7m).*

Single glazing (U-values up to 5,8 $W/m^2K$) are no longer common. In old buildings they might though be found and here it can be efficient to apply a secondary removable window – a so called double window or winter window – on the inside.

Efficient glazing consists of two or three layers pane, which are separated from each other by a layer of air. The heat losses due to transmission are reduced to the half of a single glazing, but they are still very high. That is for example the reason why since 1995 efficient glazing is not allowed any more in Germany to be implemented in a new building. A substantial improvement is the high-efficient glazing with U-values between 0,4 and 1,6 $W/m^2K$. The insulating properties are again 50 - 60 percent better than those of the efficient glazing. On the inner layer there is a very thin emission-reducing metal coating, which reflects the long-wave heat back to the room and lets the short-wave sunrays pass through the glazing. Moreover the space between the two layers of glazing is not filled with air but with a rare gas, which has lower heat conductivity. The gas used in most cases is Argon. The difference to the triple high-efficient glazing is, that here the heat losses can be reduced even more through the implementation of a third layer pane and a metal coating on two inner layers. The best thermal insulation can be reached, if one of the even better insulating rare gases Krypton or Xenon is used instead of Argon. Altogether the heat loss through a triple high-efficient glazing is only one eighth of the value of a single glazing. According to the Passive hous Institute, because of solar gains, the net heat losses through triple high-efficient glazing (south orientation) are the same as those through a wall.

As typical measures of windows consist to 15 – 35 percent of frame, the heat losses due to transmission in the frame are important to consider. Here it is both heat

losses through the frame (this is not the case for plastic windows) and heat losses through edges and thermal bridges in the frame. Frames are typically made of wood, synthetic material or aluminium. In new types of insulated frames the heat losses has been reduced by help of integrated parts of the construction which breaks the cold bridges.

Wood is the material, which is characterised by the longest lifespan and is best durability against influences from the outside. Usually, frames made of wood have very good thermal insulating properties. The kinds of wood that are used in most cases are spruce, pine and oak.

Frames made of synthetic material are mostly made of polyvinylchloride or polyurethane and can reach values of thermal insulation similar to wood-frames. All in all wood and synthetic materials are those that with a market share of 80 percent are sold in most of the cases.

The heat losses through the windows are also measured by the U-value. The U-value of the complete window is calculated in dependency of the U-values of the frame and the glass, whereby the frame-U-value mostly is the higher one. Another important value is the g-value. It indicates how many percent of the sun-rays with a vertical direction go through the glazing into the room.

| Technology | Relevant Indicators | Performance Requirements | | | Check Systems and standards |
|---|---|---|---|---|---|
| | | 2006 (Present situation) | Goal for next EPBD in 2011 | BAT (Best Available Technology) | |
| **Energy Windows** | U-value [W/m²K] Total: | I: 1,0-1,8<br>II: 0,8-1,5<br>III: 1,1-3,2 | I: 1,0-1,8<br>II: 0,5-1,2<br>III: 2,8 | I: 1,0-1,7<br>II: 0,6-1,2<br>III: 1,1-2,8 | Windows: DIN EN ISO 10077-1:2000-11; DIN 4108-4<br>Passivhaus-Institut<br><br>FENSA<br><br>Glass: DIN EN 673:2001-1; DIN EN 410:1998-12<br><br>Cold bridge coefficient: DIN EN 10211 + DIN 4108-2 |
| | Glass: | I:<br>II: 0,5-1,2<br>III: | I:<br>II: 0,4-1,1<br>III: | I:<br>II: 0,5-1,1<br>III: | |
| | Frame: | I:<br>II: 0,85-1,5<br>III: | I:<br>II: 0,75-1,3<br>III: | I:<br>II: 0,64-1,07<br>III: | |
| | g-value [%] | I:<br>II: 60-71<br>III: 58<br>GR: 77 | I:<br>II: 25-67<br>III: | I:<br>II: 50-58<br>III: 55-58<br>GR: 77 | |
| | Cold bridge coefficient glass: $\psi$ [W/mK] | I:<br>II: 0,06<br>III: | I:<br>II: 0,034<br>III: | I:<br>II: 0,017-0,022<br>III: 0,0-0,65 | |