Patrycja Kochaniuk, July 2012
Adapted from: 'A Methodology for Evaluation of an Energy Efficient Refurbishment of a Typical 1960's semi-detached Dublin House in Line with Ireland's 2020 National Goals', Graduate School of the Environment, Centre for Alternative Technology, MSc Architecture: AEES

Windows and doors replacement

Correctly installed energy efficient windows not only reduce the use of energy in the house due to smaller heat losses and greater solar gains, but also improve occupants' thermal comfort (Feist, no date). The performance of a window is determined by:

a. U-value and the solar transmittance of the glazing, which is influenced by the number of panes (two or three), width of the gap between them, low-e coatings helping to reflect the heat back to the house, the gas filling the gap and level of iron content in glass, as it influences light and solar transmittance (EST, 2011);
b. U-value of the frames, which depends on the material they are made of and its insulation. It is important the frame size is as small as possible, as it always has bigger thermal transmittance then the glazing;
c. The performance of the spacer – spacer thermal bridge should be minimized;
d. The performance of the installation – to achieve the lowest thermal bridge, windows should be fitted in the depth of the insulation (Fig. 1).

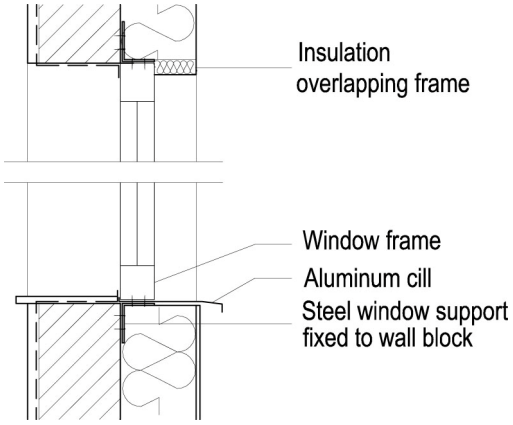


Figure 1. Window installation with minimised thermal bridge

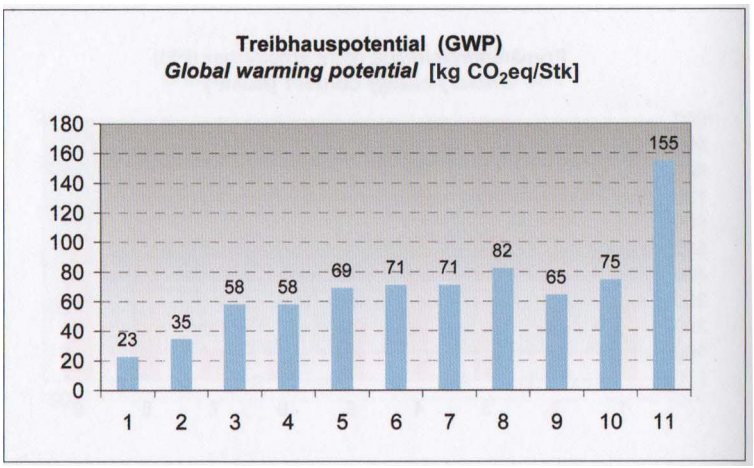
a. Window rating

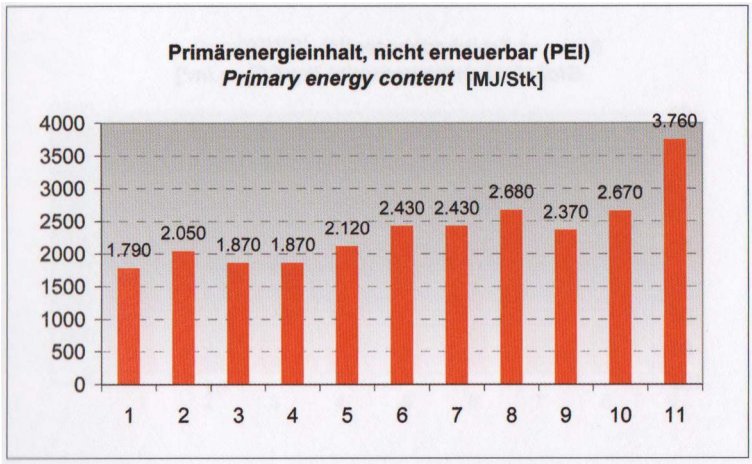
Window frames can be manufactured from different materials. Current most common options include PVC, timber and aluminium-clad timber frames. Austrian Institute for Healthy and Ecological Building (2009) rated windows looking at their primary energy content, global warming potential, disposal and utilization potential and maintenance evaluation.

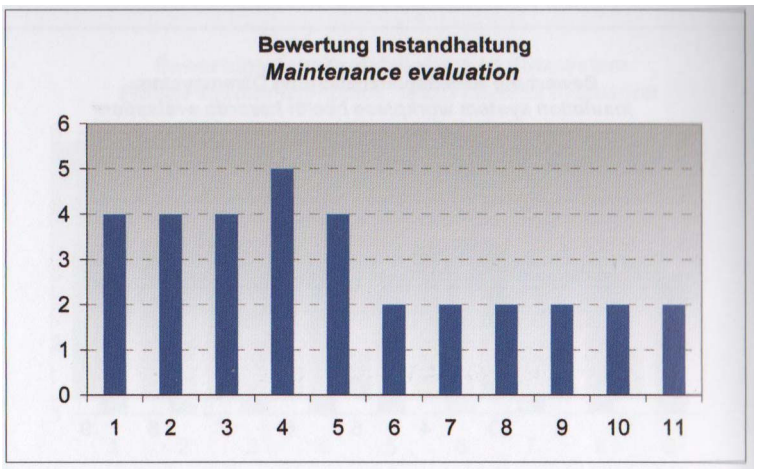
The following graphs present rating for global warming potential, primary energy content, maintenance and disposal potential for the chosen types of windows:

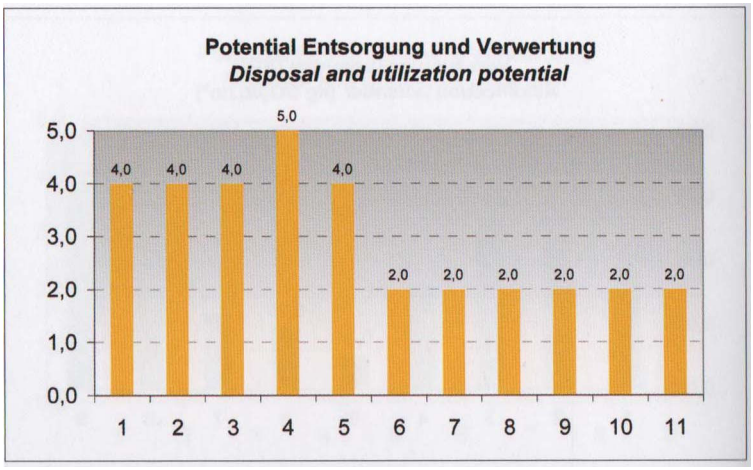
1. Solid wood with insulation

2. Solid wood with insulation, filled with Krypton
3. Wood/PUR/wood with insulation
4. Wood/PUR/wood without additional insulation
5. Wood/PUR/wood with insulation, filled with Krypton
6. Wood/XPS/aluminum with additional insulation
7. Wood/XPS/aluminum without additional insulation
8. Wood/XPS/aluminum with additional insulation, filled with Krypton
9. Wood/cork/aluminum with additional insulation
10. Wood/cellulose/aluminum with additional insulation
11. PVC with additional insulation









From: Austrian Institute for Healthy and Ecological Building (2009)

It is interesting to note that the solid timber and insulated timber windows have the smallest primary energy and global warming potential and are the easiest to dispose of, but their maintenance is the most demanding. In the middle of the scale are alu-clad timber windows, with middle values for energy use and difficult to dispose of, but easy to maintain. The PVC windows have the highest energy content and are difficult to dispose of, but do not require maintenance. From the environmental point of view PVC windows are the worst choice, but they are commonly the least expensive option.

b. Calculations

It is proposed to use timber and alu-clad timber windows to eliminate the worst performing environmentally PVC option. Each option's U and g-values are described in Table 1 in detail. The costs includes an installation with a minimal Ψ=0.009W/mK, according to Fig.1.. Column 7 presents the window's heat losses and column 8 shows how much energy is gained due to solar energy. The balance between losses and gains explain why the higher upgrade levels are beneficial. When it comes to the door replacement, the well insulated examples can currently achieve a U-value of 0.8W/m^{2}K, a significant improvement over solid timber doors with a U-value of about 3.0W/m^{2}K.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		U-value [W/ m^2/K]	Heating Energy [kWh/ m^2/y]	Saved energy [kWh/ m^2/y]	Capital Cost [€]	Cost/TFA [€/m^2]	Saved kWh/ m^2/y per 1€	Transmis-sion Losses [kWh/ m^2/y]	Solar Gains kWh/ m^2/y
	Base - metal, no thermal break, single glazing, g=0.87	5.50	394					67.9	17.3
A	timber, double glazing (Ug=1.1, Uf=1.0, g=0.64, Ψ_{spacer}=0.14); doors U=1.4	1.18	341	53	€6,837.00	€78.59	0.67	14.5	12.8
B	timber, triple glazing (Ug=0.6, Uf=1.0, g=0.54, Ψ_{spacer}=0.14); doors U=1.2	0.90	338	56	€7,525.00	€140.39	0.40	10.4	11.7
C	alu-clad, triple glazing (Ug=0.6, Uf=1.0, g=0.54, Ψ_{spacer}=0.14); doors U=1.2	0.90	338	56	€8,600.00	€160.45	0.35	10.4	11.7
D	alu-clad, triple glazing, Passivehaus certified (Ug=0.53, Uf=0.75, g=0.55, Ψ_{spacer}=0.027); doors U=0.8	0.66	333	61	€9,245.00	€172.48	0.35	8.2	13

Ug=U-value of glazing
Uf= U-value of frame
g= solar transmittance
Ψ_{spacer}=thermal bridge of the spacer

Table 1. Window replacement options

As can be seen in column 6 the biggest savings in kWh/m^2/y per each Euro invested is brought by the double glazing in Level A when looking at energy savings comparing to the original house performance. However, the net heat gains delivered by windows are only possible with triple glazing (options B to C), as shown in columns 7 and 8. The biggest net gain is achieved by the Passivhaus certified window (option D) and comparing to option C, its higher costs is recovered by bigger energy savings.

c. References

Austrian Institute for Healthy and Ecological Building (2009) *Details for Passive Houses. A catalogue of ecologically rated constructions*. 3rd ed., Austria: SpringerWienNewYork

EST (2011) *Sustainable refurbishment* [Online]
Available at: http://www.energysavingtrust.org.uk/Publications2/Housing-professionals/Refurbishment/ Sustainable-Refurbishment-2010-edition (Accessed: 8 May 2011)
EST - Energy Saving Trust

Feist, W. (no date) *Cost-Efficient Passive Houses in a Central European Climate*. [Online]
Available at: http://www.efcf.com/reports/E20.pdf (Accessed: 29 March 2012).