# The impact of different design solutions on a pitched roof renovation

The pitched roof of a small detached house is to be renovated. The roof is already insulated with 8 cm of old stone wool between the rafters. The U-value of the existing roof (0.52 W/m$^2$·K) will be reduced to 0.16 W/m$^2$·K leading to a 14 % decrease in heating energy consumption. All other building elements and equipment remained unchanged.

The design solutions differ significantly according to the insulation material used:

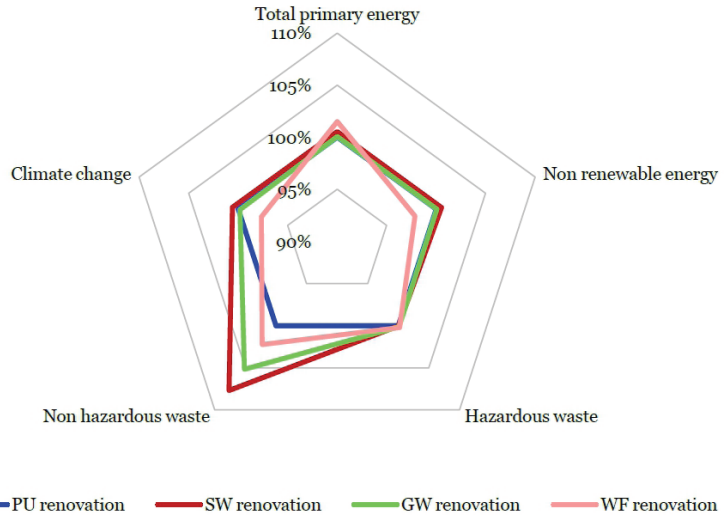
**Main results:**

- All insulation solutions show a very similar overall environmental performance over the component life cycle. Each insulation solution has different "strong" and "weak" impact categories. This emphasises the need to declare all indicators instead of merging them into one overall score or declaring only a few of them.

| | PU solution | WF Solution | SW Solution | GW Solution |
|---|---|---|---|---|
| Total thickness *mm* | 100 | 305 | 235 | 200 |
| Lambda *W/mK* | 0.023 | 0.038 between rafters<br>0.042 on rafters | 0.036 between rafters<br>0.040 on rafters | 0.036 |
| Installation | On rafters (existing insulation layer – 80 mm SW – between rafters can stay in place) | Between (125 mm) and on rafters (180 mm): existing insulation layer removed and fully filled with WF | On (135 mm) and between rafters (100 mm): existing insulation layer removed and fully filled with SW | Between (100 mm) and under rafters (100 mm): existing insulation layer removed and fully filled with GW and aluminium structure added perpendicular to rafters for additional GW layer |

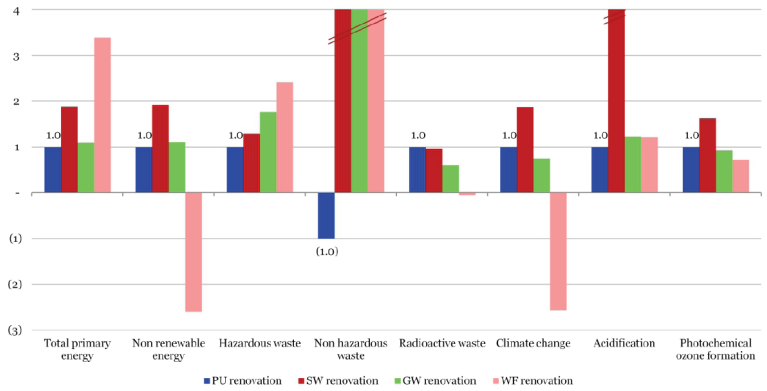
## Life Cycle Analysis

The environmental impacts of the different insulation solutions over the building component life cycle are relatively similar. The choice of the insulation material is therefore of secondary importance when assessing the environmental performance of this pitched roof.




Relative results on the whole study period (PU scenario being 100 %)

A look at the direct embodied impacts of the renovated roof shows the good performance of the PU solution in practically all impact categories. This is mainly due to the high thermal performance of PU, the reduced need for ancillary materials and the fact that the PU solution allows keeping the existing insulation layer in place.

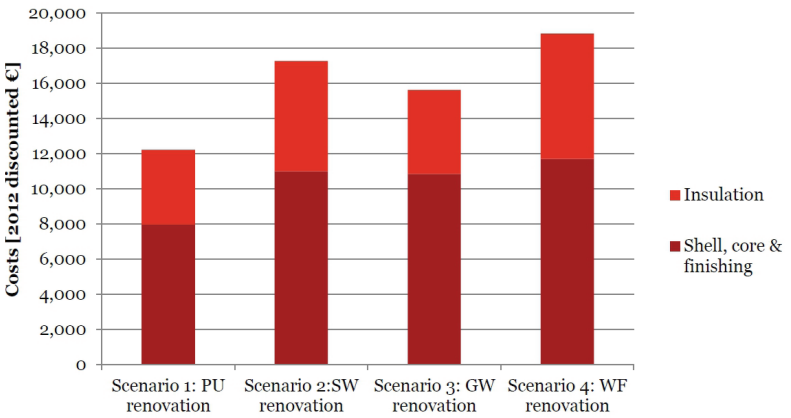



Relative results for roof renovation components (PU scenario being 100 %)

Disclaimer : The negative GWP of the wood fibre ("carbon sink") solution is common in Germany but contested by many scientists and practitioners. EN 16485 "Product category rules for wood and wood-based products for use in construction" specifies that biogenic $CO_2$ should be considered an intrinsic product property provided the wood harvesting process does not affect the forest carbon pool property (i.e. deforestation). Also, the standard reminds us that biogenic $CO_2$ is only temporarily "captured in wood" and will be released at end-of-life, with a net balance of biogenic $CO_2$ becoming ultimately neutral. When taking into account the carbon impact of all related forestry processes and wood treatment, the intrinsic GWP of wood should not show negative values.

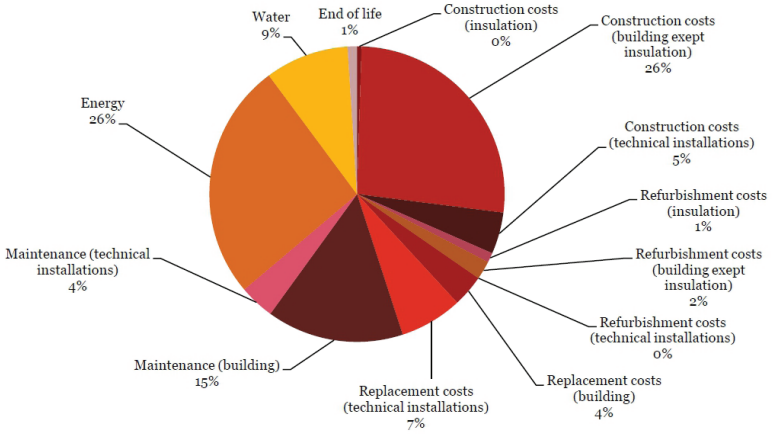
## Life Cycle Costs

The refurbishment costs are significantly lower when PU is used thanks to its high thermal performance, the reduced need for ancillary materials and the fact that the existing insulation layer can stay in place.




Refurbishment costs of the pitched roof – components

Taking a life cycle prospective, the additional cost for improving the roof insulation is very low (1 % of life cycle costs) whatever the insulant used, whereas savings are significant. The construction costs of the whole building (32 %) and the use phase energy costs (26 %) dominate overall costs.




*Life cycle cost breakdown for the residential building*

*Source: http://www.pu-europe.eu/fileadmin/documents/PU_Europe_files_2013/PU_13-136_PWC_for_PU_Europe_-_Environmental_and_economic_analysis_of_insulation_products_in_low_energy_buildings__May_2013_.pdf*