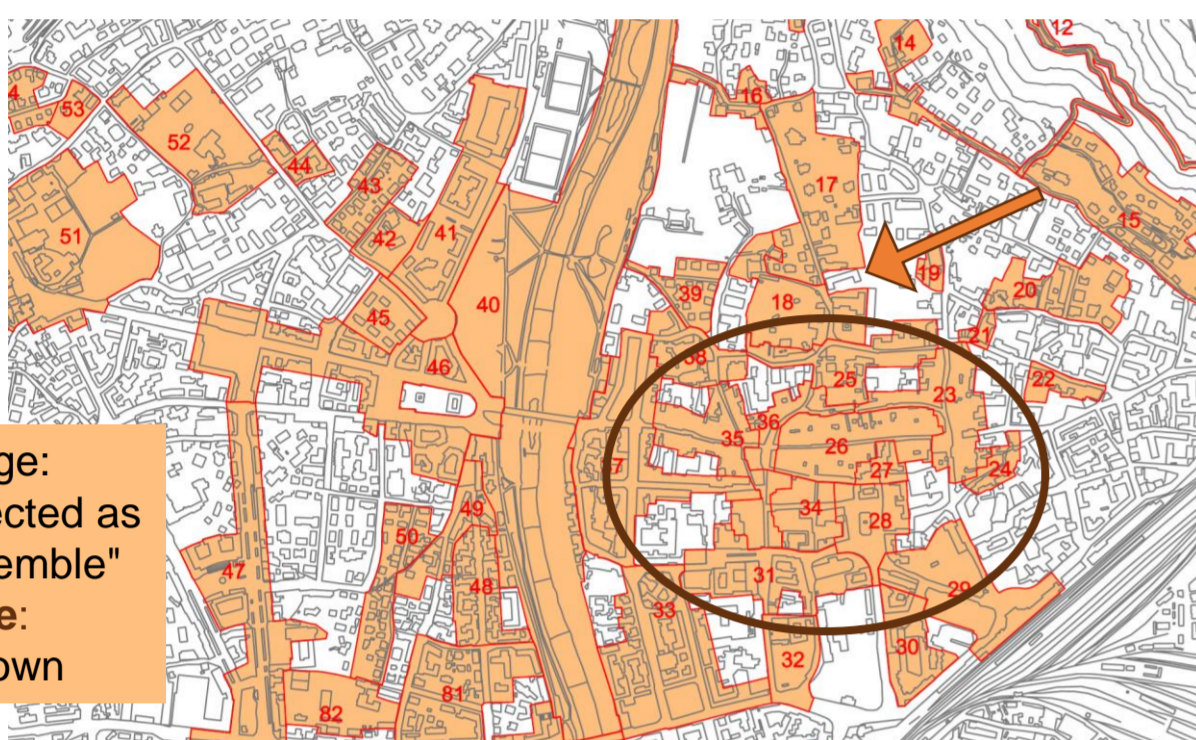


# Stepwise refurbishment towards nZEB of a rented out flat in a historic building in Bozen/Italy



orange: protected as "ensemble" circle: old town

## The building, its history and use

Located in the old town of Bozen, the building was constructed in the 1920ies by the Italian railway company for their workers. It is not formally listed, but shows characteristics worthy to be preserved. Until 2005 the flat had barely been changed, only in 2010 gas heating has been added.

### 1st step: window retrofit in 2017

As a first step the box-type windows with "Wolfsrachen" were improved to reach an overall  $U_w$  of 1.05 W/m<sup>2</sup>K by repairing the distorted original wooden frame and exchanging the inner single with double glazing (reaming the original frame and adding a wooden batten, calculations following EN 10077-1 and -2 ). A Blower Door test resulted with 3,5 m<sup>3</sup>/(h m<sup>2</sup>) @100 Pa in class 3 according EN 12207..

### 2nd step: ventilation system and envelope insulation in 2023

6 years later, with a change in tenants changed, the 60 cm thick full brick walls were insulated internally with 16 cm of wood fibre insulation, resulting in a U-value of 0.2 W/m<sup>2</sup>K and the ceiling towards the attic was insulated with 20 cm, with a U-value of 0.16 W/m<sup>2</sup>K. The selection of insulation material and thickness was guided by hygrothermal simulation and the decision for wood fibre was finally also due to its carbon sink/storage capacity. Detailed thermal bridge calculations verified hygenic robustness

Additionally, the flat was equipped with a ventilation system and heat recovery, further reducing the potentially remaining risk of moisture damage due to interior insulation. The expected heating demand results in 2'469 kWh/a and respectively 29 kWh/m<sup>2</sup>a corresponding to a KlimaHaus A level. The calculation with PHPP results in 32 kWh/m<sup>2</sup>a and a one week test heating confirmed the calculated value.

### Next step: PV planned for 2024

A PV plant is in planned to be installed in 2024. Since the part of the roof envisaged for the installation is in rather prominent, visible position, both geometric and colour integration are decision criteria for the modules to be chosen. 3.5 kWp will produce 4'300 kWh<sub>el</sub>/a. Considering the self-consumption of 784 kWh for lighting and auxiliary energy the KlimaHaus value for the carbon emissions decreases to 1'065 kg CO<sub>2eq</sub>/a corresponding to 12 kg CO<sub>2eq</sub>/m<sup>2</sup>a and with this KlimaHaus class Gold.

On a yearly balance and considering grid feed-in, net zero emissions will nearly be reached: even if 1'200 kWh<sub>el</sub> might be needed by other appliances, the fed in 2'315 kWh<sub>el</sub>/a would result in 1'065 kg CO<sub>2eq</sub>/a saved (with the conversion factor of 0,46 kg CO<sub>2eq</sub>/kWh<sub>el</sub>).

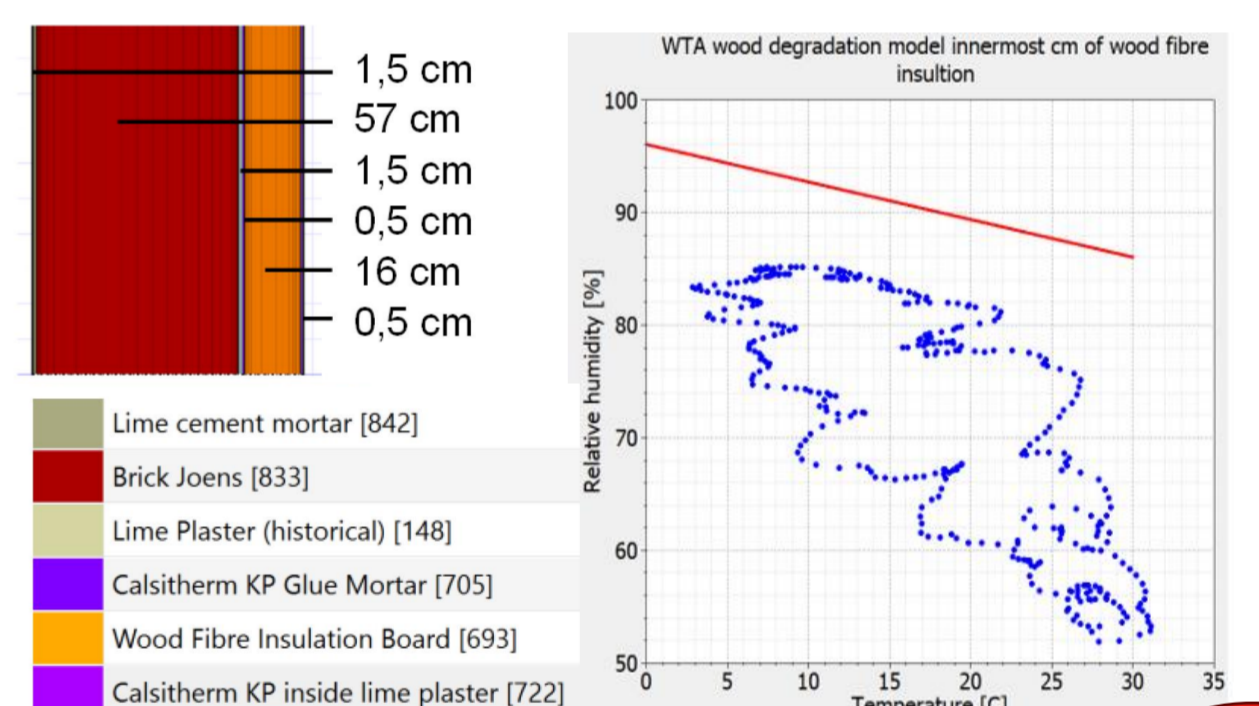
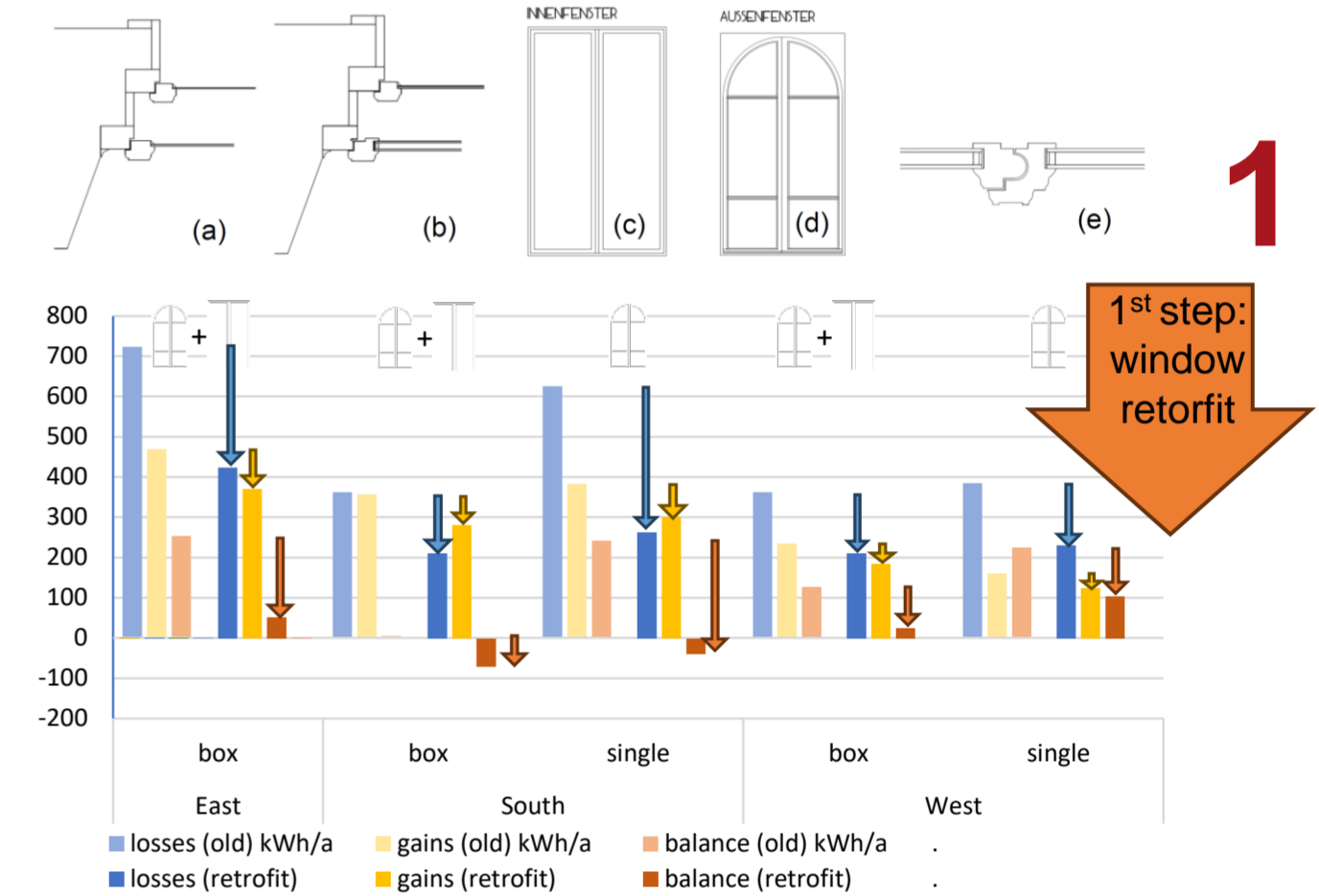
### Final step: heating system

The last, still open step, will be to get rid of the gas boiler: Connecting the building to the district heating system will reduce CO<sub>2</sub> emissions from the 12 kg CO<sub>2eq</sub>/m<sup>2</sup>a to 1,5 kg CO<sub>2eq</sub>/m<sup>2</sup>a. If the connection to the district heating should not be possible before the end of life of the gas boiler, the installation of a heat pump will be the alternative.

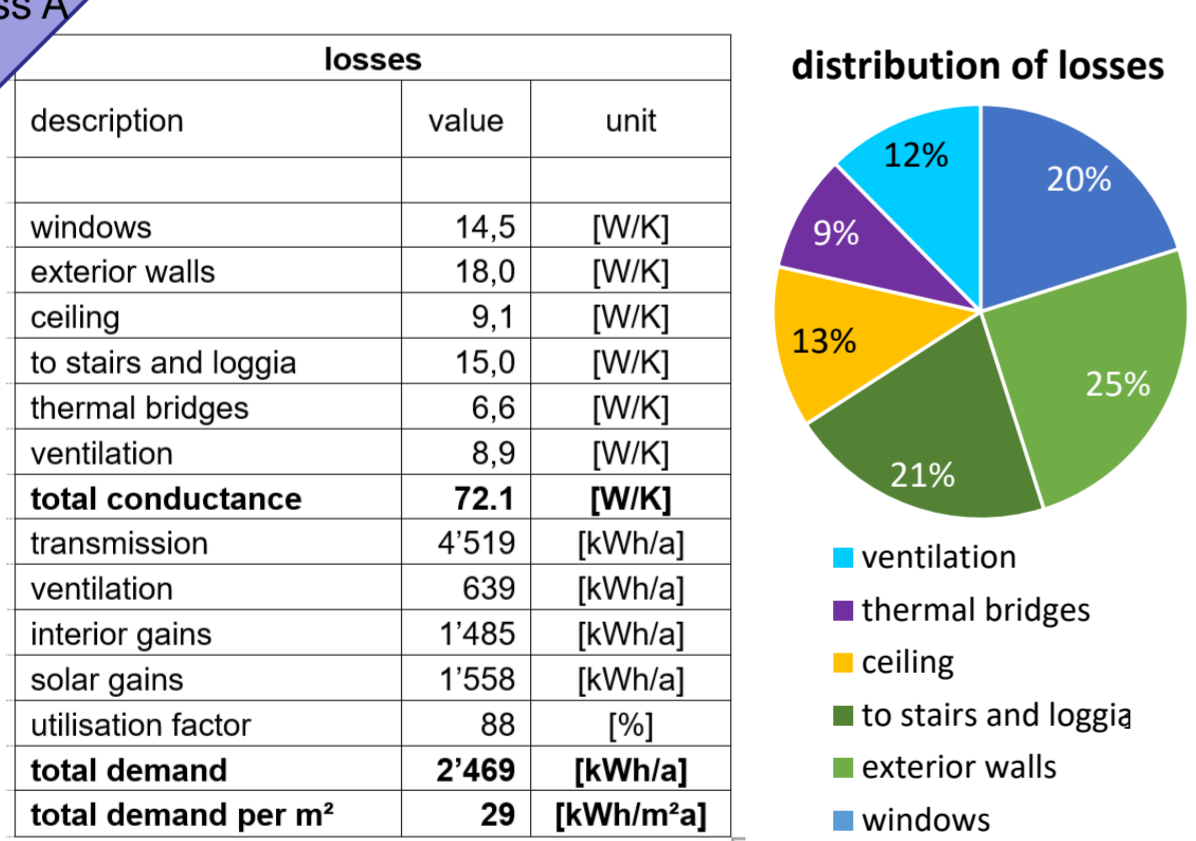
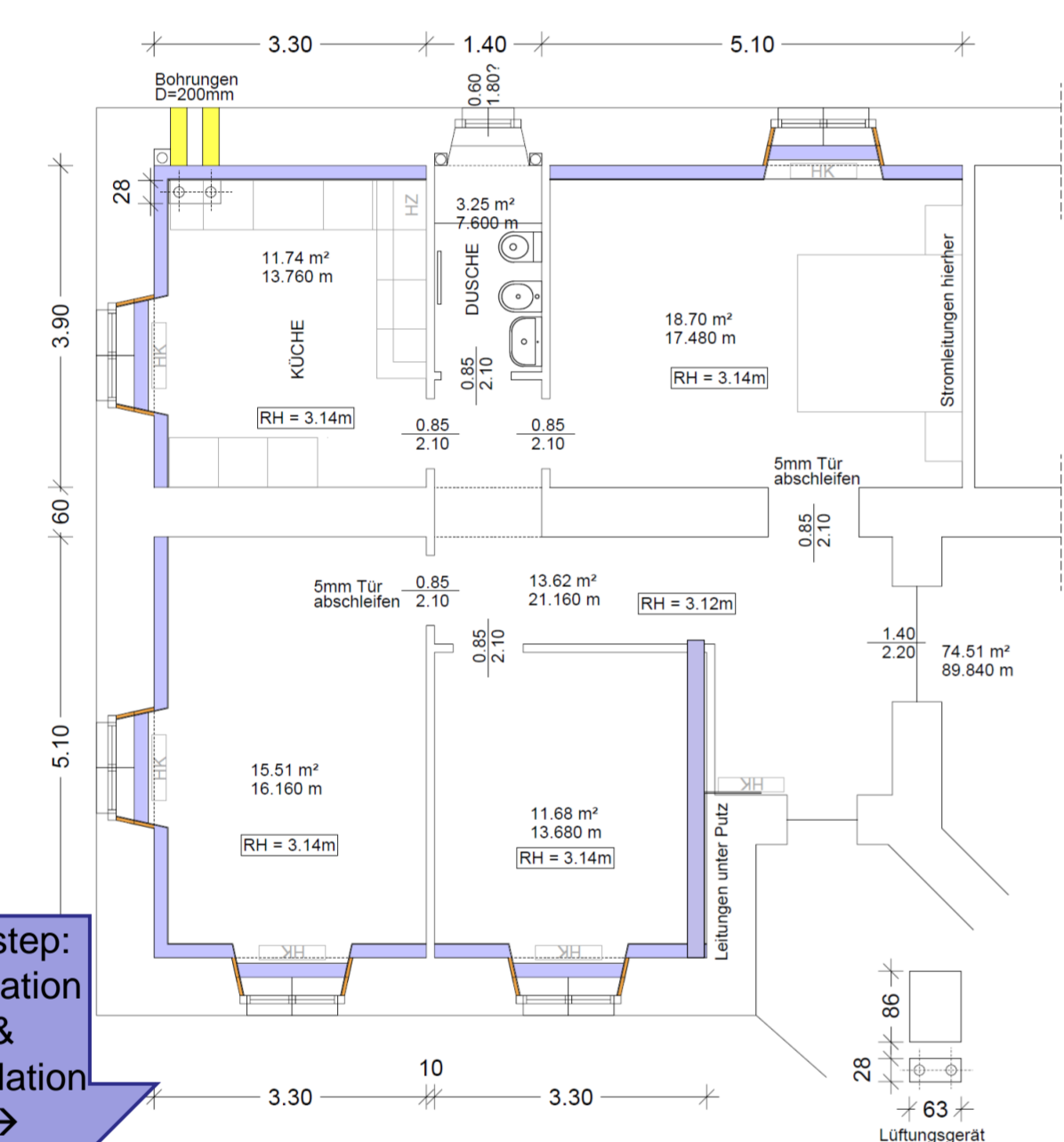
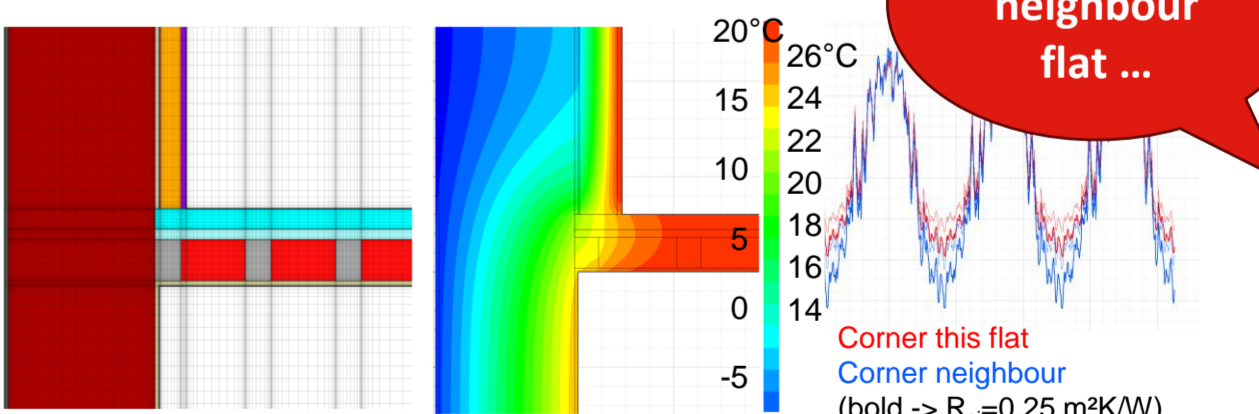
### Considerations of the owner

1° step: 17'000,-€ for 22'500 kWh<sub>saved</sub> in 30a → 0.76 €/kWh (better if also increased air-tightness considered)  
NPV with tax reduction of 65% and 5% interest rate → 8'500,-€  
2° step: 64'800,-€ for 429'000 kWh<sub>saved</sub> in 30a → 0.15 €/kWh  
NPV with tax reduction of 50% and 5% interest rate → 39'800,-€

To get this investment back over 20 resp. 30 years the rent has to be increased by 165,-€/month resp. 110,-€/month. As final remark: The loss of net living area due to interior insulation is 4,2 m<sup>2</sup> i.e. 5%. The rooms were big enough not to suffer – and the overall amount less than expected.



| thermal bridges                  |            |          |              |
|----------------------------------|------------|----------|--------------|
| description                      | Length [m] | ψ [W/mK] | losses [W/K] |
| windows                          | 33,1       | 0,077    | 2,5          |
| window (kitchen)                 | 4,0        | 0,18     | 0,7          |
| (thick) interior to outer wall   | 3,0        | 0,267    | 0,8          |
| (thin) interior to outer wall    | 15,0       | 0,094    | 1,4          |
| floor edge                       | 32,0       | 0,160    | 5,1          |
| (thick) interior to ceiling      | 10,0       | 0,180    | 3,6          |
| (thin) interior to ceiling       | 20,0       | 0,100    | 4,0          |
| corner                           | 10,5       | -0,270   | -2,8         |
| ceiling edge (outside)           | 26,1       | -0,230   | -6,0         |
| ceiling edge (neighbour)         | 3,9        | -0,010   | 0,4          |
| ceiling edge (stairs and loggia) | 8,0        | -0,235   | -1,9         |
| bridges to staircase and loggia  | 3,0        | 0,181    | 0,5          |
| bridge bathroom (window)         | 1,9        | 0,783    | 1,5          |
| bridge bathroom (reveal)         | 0,9        | 1,011    | 0,9          |
| <b>Total</b>                     |            |          | <b>6,6</b>   |



| KlimaHaus class | Efficiency envelope [kWh/m <sup>2</sup> a] | Overall efficiency [kg CO <sub>2</sub> /m <sup>2</sup> a] |
|-----------------|--|---|
| Gold            | 10   | 15  |
| A               | 30   | 17  |
| B               | 50   |   |
| C               | 70   |   |
| D               | 90   |   |
| E               | 120  |   |
| F               | 160  |   |
| G               | > 160                                      |   |

PHPP: 32 kWh/m<sup>2</sup>a verified with one-week test-heating

