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Refurbishment of a dwelling house, protected as local monument, regarding the “Sustainable house” concept

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Publised: CESB13 - Central Europe towards Sustainable Building 2013. Konferencia kiadványa pp. 115-118. (ISBN:978-80-247-5015-6)

Summary

In the paper the experiences of a refurbishments based on the “Sustainable house” concept are discussed.

Curiosity of the case study is that the front façade of the house is protected as local monument. Other difficulty to achieve the energetic aim is that the solar gains are very limited because of the layout of the building and the density of the settlement.

By the energetic aspects environmental, economical and social aspects of refurbishments are introduced.

Keywords: sustainability; refurbishment; local monument; zero-fossil energy consumption; cost-efficiency

1 Problem statement

It is well known that buildings consume about 40% of the total energy consumption in Europe. Besides the reduction of the energy consumption of new buildings, it is necessary to reduce the consumption of existing buildings. But it is difficult to achieve a high energy performance in existing building because of many reasons (bad orientation, low solar radiation in urban environment, building protection, etc.).

The paper tries to find the answer, whether it is possible to refurbish a protected building according to the “sustainable house” concept, taking into consideration the limit of local resources. [1]

2 State of the building before the refurbishment

The exact establishment date of the examined building is not known. The street was built at the end of the 18th century. Considering the materials of the walls (stone, adobe, brick) some part of the building was erected 150-200, some part about 100 years ago.

According to the local building code the front façade was protected. The house both from inside and outside was in very bad condition. (**Fig. 1**)

3 Applied architectural and technical solutions

The basic idea of the architectural concept was that with a U-shaped extension, the representative, street-facing rooms get a new function, as the residential functions are moved to the southern part and close to the garden. This plan allows to establish large windows facing south. This was a very important element as from the east the neighbouring house has a 9 m high solid fire-back, which reduces the solar radiation.

It was important to solve the waterproof problems of the building before the heat-insulation of the external constructions. Under the walls a synthetic resin was injected.

On the facades on average 18,8 cm rock wool insulation was installed. Because of the building regulation, on the front façade only 15 cm, and on the wall adjacent to the neighbour only 12 cm rock wool insulation was permitted. Otherwise 20 cm insulation was established. On the street façade to replace the original decorations individual prefabricated decorations made from polystyrol were installed. (**Fig.2**)

To reduce the heat losses through the floor construction, 20 cm XPS insulation was placed next to the foundation. This solution was applied both in the refurbished and the extension part of the house. In my PhD Thesis I demonstrated that this way the insulation is almost as effective as the horizontal insulation under the floor, but it reduces very effectively the number of unpleasant hours in summer time. [3]

Fig. 1 *Plaster decorations on the original facade*

Fig. 2 *New façade with the PS decorations*

On the roof to the loft 25 cm formaldehyde-free glass-wool, and in the attic-roof 25 cm cellulose insulation were installed.

The replacement of the old, poorly insulating windows was not permissible because of the street façade protection. The window-frames were kept on the original place and only the wings were changed in the original style. The double wings with 1+1 glass layers were replaced by double wings but with 2+2 layers of glass (3-9-3, and 3-9-4 LOW-E). This construction has a U-value of 0,85 with the original inner wood box-shutters.

The heating energy needs are covered by a 18 kW wood gas boiler combined with a 1000 l storage tank, as the DHW (domestic hot water) supported with 3 flat-plate solar collectors and 300 l storage tank.

With the above mentioned investments the original energy consumption was reduced radically:

- the primary energy demand of heating and DHW from 380 to 58 kWh/m^{2}a,
- the net heating energy demand from 218 to 47 kWh/m^{2}a,
- the net DHW non solar energy demand from 36 to 18 kWh/m^{2}a.

4 Financial analysis of refurbishment

To follow up the investment cost a very detailed database (more than 800 items) was built up. Two significant different building types were separated. The refurbishment of the old building costs were gross 540 EUR/m^2, and the extension costs gross 770 EUR/m^2. Both costs are less than the new house investment cost (1060 EUR/m^2) according to the cost estimation of the Hungarian Chamber of Engineers. [4]

The calculated annual operation cost of heating and DHW is 510 EUR, which is much lower than the consumption of a house with the same geometry and with the officially required building constructions and building systems (1920 EUR).

5 LCA assessment

The whole life cycle environmental effect of the refurbishment was analyzed by the own developed Belső Udvar E-P-LCC-LCA Excel chart. As environmental indicator values the ecoinvent v1.2 data adapted to the Hungarian circumstances were used. [5] Three environmental indicators were examined:

- Cumulative energy demand (GLO, fossil) [MJ],
- Global warming potential (GLO, CML2001, GWP100a) [kg $_{CO2\text{-}eq}$],
- Acidification potential (GLO, CML2001, acidification potential) [kg $_{SO2\text{-}eq}$].

Three variations of the building were analysed:

- existing building without any refurbishment,
- refurbishment as was described in Chapter 2.,
- new building with the same geometry as the reconstructed building with the officially required building constructions and building systems.

Because of the limit of the paper only the data of the cumulative energy demand are introduced. (**Tab. 1**) Only those measures are counted which have an effect on energy efficiency!

Tab. 1 *Annual fossil cumulative energy demand of different scenarios [MJ/a].*

	Without refurbishment	“Sustainable house” refurbishment	New house with the official requirements
Production and demolition	0,00	18 657,04	12 345,09
Operation	248 098,21	12 499,35	165 012,04
Total	248 098,21	31 156,39	177 357,13

6 Concept of social engagement

Already at the beginning of the design it was important for the owner to introduce the architectural and ecological values of the house to the public. As a new function for the street-facing imposing rooms, with some friends of the owner, the “Belső Udvar Studio” has been established. The rooms were furnished with multifunctional furniture, which allow to use the spaces as temporary architect office, school of drawing or school of photography.

The students and their parents by the direct education can learn about the architectural and ecological quality of the building, and the income from the studio helps the economical sustainability of the building.

7 Conclusion

Although the calculated energy consumption of the refurbishment is a little bit higher than the “sustainable house” requirements (net heating energy demand is 47 instead of 36 kWh/m^2a), with a heat recovery ventilation system the requirements can be achieved. A more important question is, if it’s worth making such a “deep” refurbishment in a protected building?

To my mind firstly a building protection assessment has to be performed. If the level of protection allows to apply building materials different from the original, the external insulation can be chosen and can be supported.

Secondly an environmental assessment has to be prepared. The partly introduced LCA study shows that the refurbishment reduces the fossil energy consumption to the eighth, the global warming potential to the 35% of the original value. Only the acidification potential increased because of the high effect of building material production. If the acidification potential of the building material production can reduce, from all examined environmental aspects the described investment is reasonable.

Thirdly the cost effectively of refurbishment has to be analysed. Counting with the method described in the 244/31/EU regulation the total life cycle cost per square meter of this kind “deep” refurbishment is 15% lower than the original version and 12% lower than a new “standard” house. Therefore the refurbishment based on the “sustainable house” concept is economically reasonable to the owner of the house.

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