RETROFIT BUILDINGS CLOSE TO PASSIVE HOUSE STANDARD

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Summary

Old buildings comprise by far the greatest proportion of overall building volume in Switzerland. If energy consumption is to be reduced, renovations therefore play a decisive role. Three examples demonstrate that it is possible to come very close to the passive house standard even when dealing with 100-year-old urban properties and, in some cases, with the constraints imposed by preservation orders – and that it is possible to do this without incurring excessive costs, reducing the comfort level or impacting the architectural quality.

Keywords: Old buildings, architectural quality, reduction energy consumption factor 10, passive house standard, retrofit building, renovation

1 Introduction

In Switzerland, the annual rate of new constructions is about one per cent; 70 per cent of the total building volume was constructed before 1980. As a rule, the energy consumption in these old buildings is disproportionately high: houses that are more than 25 years old account for 95 % of the heating energy consumption for buildings. This means that, today, a hefty 40 per cent of the total energy consumed in Switzerland is used for heating.

In neighbouring European countries, the situation is very similar. Whereas the SIA-Norm 380 for new constructions stipulates a maximum consumption of 6 to 8 l of heating oil per square metre per year, and the corresponding limit set by the Swiss Minergie standard for renovations of old buildings lies at about 9 l, the average heating oil consumption in Switzerland amounts to about 20 l per square metre per year. These figures show that it is impossible to achieve a substantial reduction in energy consumption and CO_2 emissions simply through the construction of economical new buildings. Renovations, on the other hand, which have to be carried out periodically on older buildings anyway, offer a far greater potential in this respect.

However, up to now, technologies designed to reduce energy requirements have primarily been developed on and for new buildings. This may be partly due to the visionary nature of such experiments, but it is also due to the fact that any reconstruction work on old buildings is aggravated by additional, often unfamiliar, constraints that vary from case to case. Furthermore, there may well be specific requirements, resulting, for example, from the limitations imposed in the case of a listed building. Nevertheless, there appears to be a gradual awakening of interest in energetically optimal renovations. Three reconstruction projects realized over the last few years by Zurich architects Viridén+Partner demonstrate the possibility of at least coming close to the passive house standard – which stipulates a maximum consumption of only about 1.5 l of heating oil per square metre per year - with such renovations.

2 Magnusstrasse 23, 2001

The renovation of this multiple dwelling, constructed in 1893, was the first of its kind in Switzerland. In spite of the preservation order requirement to maintain the existing street façade and the constraints imposed by the regulation governing proximity to neighbouring buildings, which severely restricted the possibilities regarding heat insulation on the courtyard façade, the aim was to reach the Minergie P standard (or passive house standard). After this pilot and demonstration project was completed, measurements were taken over a two-year period, commissioned by the Federal Office of Energy. The subsequent study shows that the building only just fails to reach the Minergie P standard.

The weak points proved to be the air tightness (absolute air tightness is almost impossible to achieve in old buildings) and the heat insulation properties of the building envelope. As expected, the heating energy consumption is slightly too high: this is because, under the terms of the preservation order, only minimal visible changes could be made to the street façade, and therefore the outer and inner heat insulation on this façade is only 3 centimetres thick. In addition, the passive solar recovery is lower than expected because the occupants of the building frequently lower the blinds. However, in spite of this, the primary energy consumption for heating, hot water, ventilation and electricity was reduced nine-fold, which is four times lower than the Minergie standard for reconstructions. The financial investment is about 15% higher than for a conventional conversion – according to Karl Viridén, it was possible to reduce this percentage in subsequent projects. However, thanks to the unusually low additional costs, the rents remain competitive.

The renovation concept is pragmatic and adapted to the specific situation. Wherever possible, the building envelope insulation was improved: on the courtyard façade and side firewall, the heat insulation is between 16 and 40 centimetres thick, which corresponds to an average U-value of 0.15 W/m^{2}K, while the new windows have a U-value of 0.7 W/m^{2}K. The orientation of the building made it possible to integrate solar collectors with a total area of 15 square meters in the roofage; since the collectors are similar in colour to the dark metal finish on the dormer windows, there is an overall effect of uniformity. The energy for heating and hot water is supplied by these solar collectors, an air-water heat pump (9 KW) and a storage tank (2600 litres) with an integrated boiler. The rooms are heated via the ventilation system; when necessary, i.e. when the outside air temperature drops below -2 °C, additional heating can be provided by wood-burning storage heaters. Each flat has its own ventilation system, which can be adjusted to suit individual needs. As before, when the rooms were heated by individual oil and electric heaters, there is no conventional heating system, but the living comfort easily reaches the standard expected today.

The character and charm of the building have been largely maintained despite the comprehensive modernization. Even the new balconies fit in naturally with the structure of the façade. With the exception of the attic floor, which was in such poor condition that it had to be replaced with a prefabricated modular wood element, as much as possible of the original building was preserved; the ground plan in the flats is the same as before the reconstruction; even the old doors, door frames and wood panelling were successfully renovated.

Fig. 1 Magnusstrasse 23, view from the street after renovation

Fig. 2 Nietengasse 20, view from the street

3 Nietengasse 20, 2003

Unlike the ‘soft’ renovation described above, the reconstruction of this four-storey residential building, which dates back to 1907, involved major changes to the internal ground plan. Except for the central stairwell, all the internal walls on each floor were removed to make room for the generous spaces and open-plan kitchens of the new owner-occupied flats; the quality of the interior conversion is correspondingly high. The attic floor was demolished and replaced by a prefabricated wood element.

This building also comes very close to the Minergie P standard, despite the fact that, under the constraints of the preservation order, it was not possible to insulate the street façade of exposed masonry and brickwork externally at all. The only option was to install eight-centimetre cork insulation on the inside, which resulted in a U-value of 0.83. On the other hand, 28-centimetre external insulation was installed on the courtyard façade, which was also fitted with large windows and balconies and given a roughcast finish in a slightly glaring light-blue. When the outside air temperature remains above -6 °C, the flats can be heated simply by means of the controlled ventilation system; this can be adjusted decentrally to suit individual requirements. Should additional heating be required, each flat is equipped with a wood-burning storage heater. Due to the orientation of the building, it was not possible to make use of solar collectors, and in Kreis 4, the borough of Zurich where the building stands, borehole ducts are not permitted because of the high ground-water level. The energy for heating and hot water is therefore produced by a 10kW gas-driven mini block heating and generating plant, which is installed in the cellar. A gas-burning engine drives a generator, which produces electricity for the use of the occupants. The excess electricity is fed into the public supply system. The heat generated by the combustion is processed by a heat exchanger and used for heating and hot water, instead of being lost, as occurs with car engines.

Like the reconstruction on Magnusstrasse, this is a pilot and demonstration project, supported by SwissEnergy and accompanied by a measurement programme commissioned by the Federal Office of Energy. The first evaluations of the results should be available in autumn this year. The primary innovation here is the use of vacuum insulation panels (VIPs) as internal insulation. VIPs consist of a micro-porous core material – usually silica – which is heat-sealed in a gas-impermeable multilayered membrane film. Since VIPs provide five to six times better insulation than standard insulation materials, the required thickness of the insulation layer is correspondingly reduced. The disadvantage of this elegant technology is its vulnerability. If the membrane film is damaged and the vacuum broken, the sealed gas leaks out and the insulation effect is reduced. This means that the panels must not come into contact with any sharp or pointed objects on the building site, or, of course, be cut to size, and that they must be installed in such a way that they cannot suffer any damage subsequently, for example by someone hammering a nail into the wall. For this reason, up to now, vacuum insulation has primarily been used with prefabricated components such as shutter casements or boilers, and not as internal wall insulation. Extensive planning and safety measures were required for the ground floor at Nietengasse to be fitted with VIPs. Gypsum plasterwork creates a smooth surface on the old masonry, and a special adhesive is used to fix the VIPs in position. The joints between the panels were covered with aluminium adhesive tape. The ideal solution – two staggered layers – was out of the question because of the cost involved. A six-centimeter thick gypsum plaster wall protects the insulation.

4 Zwinglistrasse 9 and 15, 2003

Constructed in 1881, these two buildings in Zwinglistrasse are among the oldest in the borough. Between them, there was a gap of about 4 meters. The architects closed this gap by creating a structure which joins the two buildings at the level of the upper storeys and leaves open the access route to the courtyard behind the buildings. In doing this, they respected the constraints of the preservation order, under which the character of the street was to be maintained, and aligned the façade of the new structure with that of the neighboring buildings. On the courtyard side, however, the new structure projects and acts as the connecting element between the two buildings. Although it fits into the courtyard harmoniously, this new structure is clearly recognizable as a modern element. It allowed the architects to add a loggia or extend the living area of the flats on the upper floors.

Fig. 3 Zwinglistrasse 9 and 15

The pragmatic but, at the same time, experimental approach that characterized the first two projects can also be detected here. The insulation layers are thick: in the old buildings, 16 centimeters on the street façade and 20 centimeters on the courtyard façade and on the side walls of the access area; in the new structure, 24 centimeters on the walls and 28 centimeters on the roof of the access area. At No.9, the attic floor was demolished and replaced with a prefabricated element; the insulation here is rock wool (36 centimeters), with VIPs in the dormer windows. Next door, at No.15, it was possible to keep the original roof, which was then renovated and fitted with 32-centimetre cellulose fiber insulation. Solar collectors measuring a total of 40 square meters and a gas boiler produce the electricity for the heating, which, here too, is distributed via a controlled ventilation system and supported by wood-burning storage heaters if required. Once again, the buildings only just fail to reach the desired Minergie P standard – but they offer a very respectable level of comfort. The interior fittings and design of the owner-occupied flats is of a high standard, the inside air temperature is good, and the air always remains fresh even when the windows are kept closed. The triple glazing has the added advantage of providing effective sound insulation.

References

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