Town hall renovation with passive house standard towards zero: economically sustainable undertaking?

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1 Introduction

Is it a luxury to bring an administrative building from the 60s/70s up to passive house new-build standard - or below - or is it a sustainable undertaking? Is such a renovation economically justifiable, sensible or even optimal?

These questions are discussed using the example of Löhne town hall - a T-shaped, four- to eight-storey administrative complex with 4830 m^2 EBZ, 5720 m^2 NGF and 7000 m^2 BGF. The main wing A was built in 1968, the side wing B/C in 1977. Since 2007, the building had been in a state of disrepair: panels were coming loose from the curtain wall, parts of the roof were damp, windows were dilapidated. High heating costs and overheating in summer marked energy deficiencies. Inside the building, fire protection demanded safety measures, while high electricity consumption revealed a need for action in the equipment and lighting areas. Radiators and heat distribution were at the end of their life cycle and needed to be replaced. In view of empty coffers, the city council discussed the question of what was a "luxury" and what was indispensable. At the end of 2008, the mayor called in the author's office to develop a concept, the implementation of which is the subject of this paper.

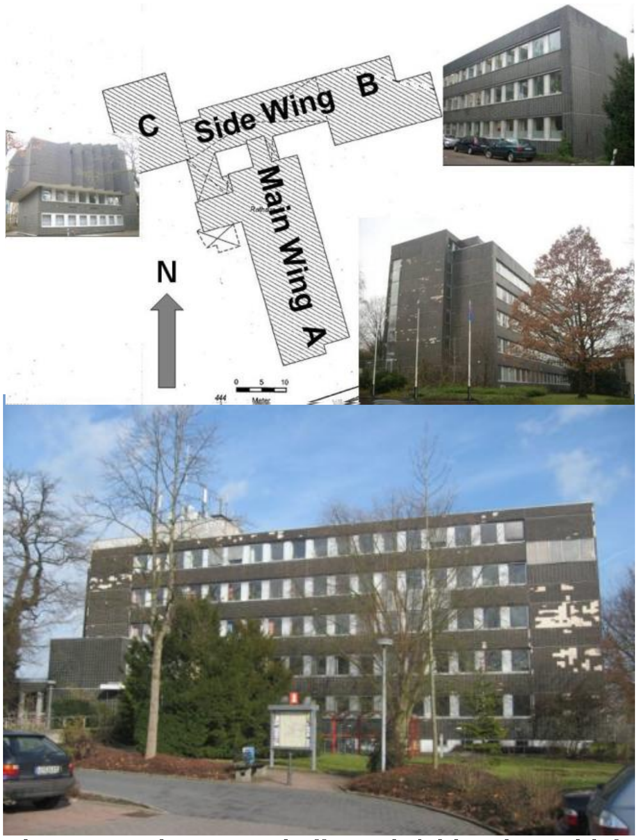
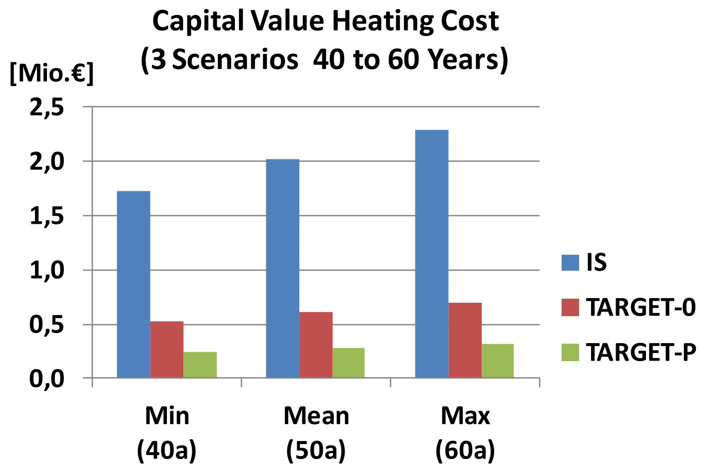


Figure 1: Löhne town hall - main/side wing Initial situation

2 Basic concept - NPV comparison

The present value of future heating costs in the ACTUAL case reached the order of magnitude of the refurbishment costs at approx. 2 million euros and signalled considerable energy-economic savings potential. Based on the ACTUAL and a low-energy TARGET-0 variant (approx. EnEV 2007), a more advanced TARGET-P variant was therefore analysed in the basic concept which

Passive House techniques and more than halves the heating costs of SET-0 (see Fig. 2 above). In some cases, the heating demand drops significantly below 15 $^{kWh/m2a}$, so that the heating system can be minimised and the costs for a Passive House ventilation system largely compensated (see Fig. 2 below). The remaining additional investment of around 200,000€ pays back twice through the heating cost savings. Furthermore, air quality and indoor climate improve, so that pursuing TARGET-P is not only beneficial for economic reasons, but overall.



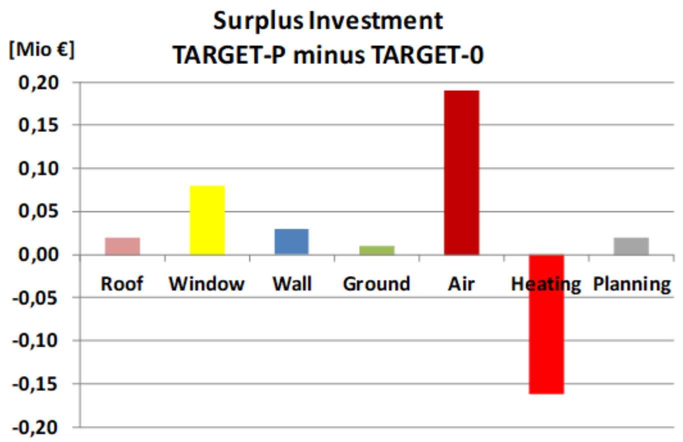


Figure 2: Present values of heat versus investment costs

The basic concept and the proposal for a renovation using passive house technology were therefore adopted by the city council on 24.6.2009. In the following step, the envelope and system concept were refined and funding was obtained from the state and federal governments. The refurbishment has been running since 2011 in parallel with the continued use of the building and is scheduled to be completed in autumn 2012.

3 Optimisation of the building envelope

The optimisation of the building envelope is the main focus, as it significantly determines the thermal and architectural properties of the building.

Roof and facade renovation

On the roofs, gravel and concrete slabs, mobile phone masts, damp areas of insulation and parapets with high thermal bridging potential were largely removed.

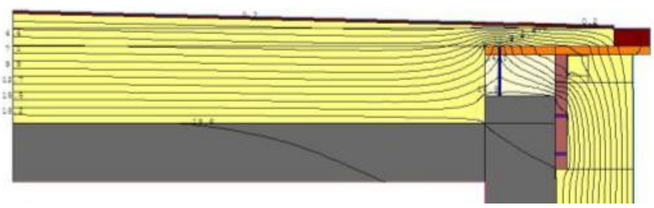


Figure 3: Roof/facade insulation

and 30 to 50cm of 2.5% slope insulation WLG 035 with a resulting average U-value $\leq$ 0.095 W/ m^{2}K was applied.

The main building gets a 26cm mineral wool insulated curtain wall, which is practically fixed without thermal bridges (see Fig. 4). The outbuilding will have a 26 cm thick ETICS (WLG035). In both cases, U $\leq$ 0.13 W/ m^{2}K applies. Exterior walls bordering on the ground are provided with 26cm WLG035 perimeter insulation up to a depth of approx. 1m. To reduce thermal bridges and heat loss, old light wells are "braced" in the upper area and filled with sand.

Figure 4: Anchor curtain wall

Figure 5:Office window of outbuilding

Windows & Doors

Unneeded windows and skylight domes were closed, over-insulated, and the remaining windows were replaced with triple-glazed elements ($U_g \leq$ 0.64 W/ m2K, g $\geq$ 0.61).

In order to further enhance the design of the window area and to bridge over separating pillars that are prone to thermal bridges, the single office windows were replaced by mullion-transom strips in a further development of the basic concept and the openability was ensured with small "floating windows", whose current design, however, raises the U-value of the passive house-certified mullion-transom construction from around 0.75 to 0.85 to 0.88 W/m2K. The mullion and transom concept was then transferred to the staircase and corridor areas, so that single windows are only used in special situations.

Transparent doors receive glazing suitable for passive houses (U-value $\leq$ 0.7). Opaque parts are brought to a U-value level $\leq$ 1 W/ m^{2}K. Due to the small surface area, however, they are of secondary importance from a thermal engineering point of view.

Figure 6: Window element

Cellar rooms and floor areas to the ground

Due to the size of the building, the ground in this and similar buildings has a strong loss-inhibiting effect (approx. 70 to 80%), so that the losses to the ground are already limited in the ACTUAL state. The application of very extensive insulation packages is therefore neither sensible nor effective in the case of parallel thermal bridges, and hardly possible in the case of floor slabs. Accordingly, the basement ceiling in the main building is insulated from below with "only" 10cm WLG035, the losses of the floor surfaces in contact with the ground in the outbuilding are limited by an approx. 1 m deep circumferential base edge insulation. Thermal decoupling of the basement reduces the calculated energy reference area to approx. 4300 $^{2.}$

Figure 7: Edge insulation

Floor areas that border on outside air (passage of outbuildings), on the other hand, are insulated like outside walls.

Thermal bridges and air tightness

The assessment, reduction and elimination of thermal bridges is of particular importance in renovation. In the case of the present renovation, all significant thermal bridges (approx. 100) were sighted, prioritised and iteratively subjected to a refined examination at an early stage. Care was taken to ensure that they were avoided a priori or eliminated by including them in the insulation.

Thus, in the roof area, chimney shafts are closed and the heads of the lift shafts are included in the thermal insulation, wall surfaces are insulated without gaps and thermal bridges, light shafts and the canopy of the main entrance are separated and the supporting pillars of the concrete skeleton construction are placed behind the window bands in the interior of the room. Component connections between roof/wall, wall/window are thermally optimised and the remaining relatively limited residual thermal bridges are taken into account mathematically.

Larger thermal bridges - including those caused by stairwells and lift shafts - remain only in the basement/floor area, but their effect is limited there - as explained above - so that they do not call the overall concept into question.

According to the Passive House Standard, an n50 value of 0.6 h-1 must be achieved for air-tightness, which in the present case is to be significantly undercut (target < 0.3 h-1). A consistently planned airtight level and special measures at neuralgic points (windows, lift access and ventilation) are prerequisites for this.

4 Building technology and operation

A central system with highly efficient heat recovery (80%) is used for ventilation, whereby the supply air can be cost-effectively distributed parallel to the main lift shaft and then in suspended corridor ceilings, while the exhaust air flows back freely via the corridors.

Figure 8: Highly efficient air, light and heat supply with mini-radiators above doors

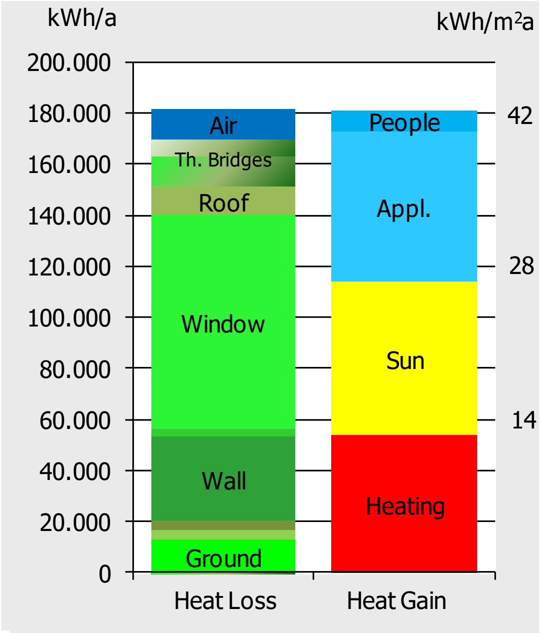


Figure 9:Annual heat balance

The efficiency measures reduce the heat losses to such an extent that around 2/3 of them can be covered passively by free heat and only 1/3 has to be actively supplied in heating energy. Highly efficient, dimmable lighting reduces internal loads.

Residual heat is supplied via district heating, with the cost-effective, minimised distribution system giving its heat to the rooms via micro radiators above the corridor doors. In addition, wind and thermal lift forces can be used for effective passive day and night ventilation/cooling during the transitional and summer periods via SHEV windows on the upper and lower corridor floors.

5 Towards zero with the passive house standard - economically and sustainably

As a result, the "passive measures" fall below the energy parameters of the new passive house standard, with the heating requirement falling by approx. 90% to below 15 $^{kWh/m2a}$ and the primary energy requirement falling by approx. 70% to around 80 $^{kWh/m2a}$. The corresponding primary energy demand for heating and lighting according to EnEV would even be 80% below the new EnEV standard.

If "active measures" are taken at this greatly reduced energy level, the primary energy demand can be reduced even further "towards zero" by further increasing the efficiency of the energy used or by using renewable energy sources locally. As is often the case in larger administrative buildings, sun-exposed roof surfaces are ideal for this purpose. These are already prepared for photovoltaics.

In this way, the requirements of energy efficiency and climate protection are taken into account in a special way, so that the project, as a climate protection model project of the federal government and the state, has a model and multiplier role. Despite the increase in window area and market-related cost increases, the total costs remain within the defined range and confirm the economic efficiency of the measures.

Convinced by the advantages, the city of Löhne has already successfully implemented the passive house standard in other upcoming projects and is promoting the further regional dissemination of this future-oriented construction and renovation method with the campaign "passiv bewegt" [Kreft 2011]. The renovation of municipal administration buildings to the passive house standard is therefore not a luxury, but a powerful signal that can effectively initiate the necessary sustainable reorientation in the municipality, region and environment, analogous to the toppling of a "domino chain". The project can be visited during the Passive House Conference 2012 (Tour 8). According to the current state of knowledge, it is the first to show the renovation of a town hall to passive new building standard.

Figure 10: Passive Pushes!

6 Acknowledgement

Special thanks to the city of Löhne as the client, the specialist planners involved, as well as the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the State of North Rhine-Westphalia, which have provided significant support for this project.

7 List of sources

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