Project report: Renovating and adding a Passive House annex to an apartment building in Kollwitzstrasse 1 – 17, Nuremberg

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1 Design aspects: urban planning and the buildings

Figure 1: View of building after renovation.

The Kollwitzstrasse apartment complex, which urgently needed renovation, is well located at the edge of the St. Leonhard-Schweinau urban renewal area about two kilometers southwest of Nuremberg's city center. The building owner, wbg Nürnberg, viewed renovation as key to improving the neighborhood's structural quality in terms of social and urban development aspects. Since 2008, a subway station has allowed residents to get to the city in seven minutes. The complex consists of three buildings with gabled roofs and minimal depth; the buildings each have three entrances and three stories for a total of 54 apartments before renovation. The small, uniform three-bedroom apartments with 58.5 m² of living area each gave way to six two-bedroom (57 m² of living area), three-bedroom (72 m²), and four-bedroom (87 m²) apartments in each building. Most of the ground-floor apartments are handicapped-accessible. In the attic, 18 Passive House apartments were added with prefabricated wood pitched roof structures and areas of 56 to 79 m². Instead of the original 3,160 m², the renovated floors now provide 3,895 m² of living area, with an additional 1,229 m² in the attic. The renovation and addition work was completed in 2009.

2 Energy concept and efficiency components

For the three original foundation floors, the energy concept included a complete renovation using the following Passive House components: exterior wall insulation with an exterior insulation and finishing system – 20 to 24 cm with λ = 0.035 W/(mK) and a U-value of 0.12 to 0.16 W/(m²K). Because of the basement's low height, its ceiling could only be partially insulated with 10 to 12 cm below the ceiling and 3 to 4 cm above the ceiling below the screed, with resulting U-values of 0.20 to 0.22 W/(m²K). Some areas allowed for more insulation with a U-value of 0.14 W/(m²K). Windows with highly insulating plastic frames (U_f = 0.85 W/(m²K)) in combination with insulating triple-glazing (U_g = 0.6 W/(m²K), Ψedge of glass = 0.035 W/(mK), and g-value = 53 %) achieved a U_w-value of 0.84 W/(m²K). Installed thermal bridges came to an average of $\Psi_{installed}$ = 0.025 W/(mK), while heating demand for the renovated apartment amounts to 26 kWh/(m²a).

The attic addition, a prefabricated timber panel structure, has a U-value of 0.12 W/(m²K). Cladding consists of a curtain façade made of corrugated sheet aluminum. The old roof structure was removed and replaced with a pitched roof with beams of glued laminated timber. The roof is insulated with 40 cm of mineral wool with thermal conductivity λ = 0.035 W/(mK) and a U-value of 0.11 W/(m²K). Certified Passive House plastic windows were installed in the attic. The frames have a U_f-value of 0.71 W/(m²K); the glass, a U_g-value of 0.6 W/(m²K), Ψglass edge = 0.035 W/(mK), and a g-value of 53 %. The resulting U_w-value is 0.78 W/(m²K). The wood window frames have five cm of insulation at the detail connection to the attic walls to minimize thermal bridges. Installed thermal bridges came to an average of $\Psi_{installed}$ = 0.015 W/(mK), while heating demand for the renovated apartments is at the Passive House level of 15 kWh/(m²a).

Calculation in accordance with EnEV (reference area A_N)					
Annual heating demand before renovation	152.6	kWh/(m²a)	Annual final energy demand before renovation	263.9	kWh/(m²a)
after renovation	26.3	kWh/(m²a)	after renovation	31.5	kWh/(m²a)
H_T' before renovation	1.37	W/m²K	Q_P before renovation	298.3	kWh/(m²a)
H_T' $_{allowed}$ in accordance with EnEV*	0.70	W/m²K	$Q_{Pallowed}$ in accordance with EnEV	80.7	kWh/(m²a)
H_T' after renovation*	0.31	W/m²K	Q_P after renovation	11.2	kWh/(m²a)
Percent below EnEV	56	%	Percent below EnEV	86	%
Calculation in accordance with PHPP (reference area A_{EB}/living area)					
Original building, ground floor to second floor (3,895 m²)			New Passive House area, 6 apartments, attic (1,229 m²)		
Heating demand before renovation	198	kWh/(m²a)			
Heating demand after renovation	26	kWh/(m²a)	Heating demand	15	kWh/(m²a)

Table 1: Data from energy calculations for EnEV and PHPP

3 Quality assurance – thermal bridges and air-tightness

Detailed thermal bridge tests showed a ΔUWB of 0.026 W/(m²K) for the original part of the building and a slightly negative ΔUWB of -0.008 W/(m²K) for the Passive House attic addition. Once the building was completed, it underwent thermography for quality assurance and as a basis for fine-tuning individual problematic areas. The process demonstrated that the building's thermal envelope is of very high quality in terms of thermal bridges. For air-tightness, connections were planned to be as simple as possible and straightforward for the construction workers to implement in the real world. An important task for construction supervision (led by Hautmann & Wimmer Architects) was to ensure that these standards were adhered to. For quality assurance, blower-door tests were conducted at a time near the end of construction when the air-tight layers could still be reached in case any improvements had to be made during the measurement process. Measurements were also taken at each entrance. All buildings demonstrated n_{50}-values below 0.6 h^{-1}.

4 Building services – ventilation

In the Kollwitzstrasse buildings, a central fresh-air and extract-air system with heat recovery was installed in each building with central ventilation systems for each stairwell in the buildings' basements. Each Aerex ventilation unit is designed for an air volume of 500 to 800 m^3 per hour for eight apartments. The units' heat recovery systems provide an annual supply rate of over 85 %, reducing heat losses in the ventilation to about five kWh/(m²a). A preheating register installed in the outdoor-air line before the ventilation unit provides frost protection for the heat exchanger. Each building is heated via a central heating system, with a small heat exchanger providing glycol-filled secondary circulation. Average consumption was 2.3 kWh/(m²a) in the first heating period and 2.6 kWh/(m²a) in the second and is included in the consumption figures in Section 7. The ventilation system was designed for nominal ventilation in accordance with DIN 1946-6. When necessary, an electrically controlled disk valve can increase the amount of extract air in the bathroom. To prevent rooms from drying out too much in the winter, air volume is centrally dropped to the “reduced air volume” in accordance with DIN 1946-6 when outdoor temperatures are below about zero degrees Celsius. The ventilation system’s distribution lines run vertically through the bathrooms as ascending pipes and are in the L-90 fire protection category. One fresh-air and one extract-air line is selected per apartment for the required fire dampers in the central ventilation unit to allow for central maintenance without needing to enter the apartments. The horizontal distribution system in each apartment consists of a distribution box for fresh and extract air and plastic pipes about 90 mm in diameter. The distribution systems also function as soundproofing. The fresh-air elements are jet nozzles.

5 Building services – heating and hot water

The buildings are supplied with heat and hot water via a connection to Nuremberg's district heat network that has an extraordinary estimated primary energy value of 0.0 (calculations: 0.1). The excellent connection value is the result of a central transfer station combined with a hot-water storage charging system. The system was designed for the output needed for hot water in the summer. Required heat output is much lower. Distribution lines for heating and for hot water run below the basement ceiling on the southern side. In the last meter of each basement, the height can be reduced a bit more without significantly reducing usefulness. The distribution lines are installed in the insulation below the basement ceiling and are covered with a total of about 10 to 12 cm of insulation below the lines, so they can run within the thermal envelope and line losses can be kept to a minimum in this area. A distribution unit was installed in each apartment's hallway. In an affordable process, the lines were placed under the screed; the radiators with electronic heating cost meters were installed below the windows without taking up extra space.

6 Construction costs and funding

With a total living area of 3,895 m² in the original building and 1,229 m² of additional living area in the attics of the three buildings, gross construction costs for cost group 300 in accordance with DIN 276 were calculated to be 4,683,750 €. That figure comes out to 914 € per square meter of living area. This somewhat high number is the result of the comprehensive changes, including changing floor plans, adding living area, and thoroughly renovating the original building with a focus on noise protection, fire protection, and energy. For cost group 400, gross costs for ventilation were calculated at 348,152.80 €, or 68 € per square meter of living area. Bathroom facilities came to 461,139.51 € (90 €/m²); heating, 263,217.62 € (51.40 €/m²); and electrical work, 348,400 € – a total of 1,420,885 € (277 €/m²) including VAT. The grand total for cost croups 300 and 400 is 6,104,630 € gross, or 1,191 € per square meter of living area. Additional investments required to achieve the KfW 50 energy standard instead of KfW 100 in the original part of the building amounted to 108 €/m² of living area. Additional costs to build the attic to the Passive House Standard instead of the EnEV standard were 97 €/m² of living area.

Financial support came both from the Free State of Bavaria's Bureau of Residential and Urban Development in Nuremberg as income-dependent funding and from the KfW Group as dena KfW 50 model funding with reference to the 2007 EnEV guidelines for new construction.

7 Energy consumption

Heating demand (see Fig. 2) amounted to 26 kWh/(m²a) in the first year (May 2009 to April 2010) and 26.4 kWh/(m²a) in the following year and is therefore consistent with PHPP calculations. Consumption for hot water supply is relatively high at 24 to 28 kWh/(m²a) plus distribution and circulation losses in the district heating network of 17 to 18 percent. The figures for primary energy were excellent, since the primary energy factor was set at 0.1 for the calculation (according to N-ERGIE: 0.0; see Fig. 4).

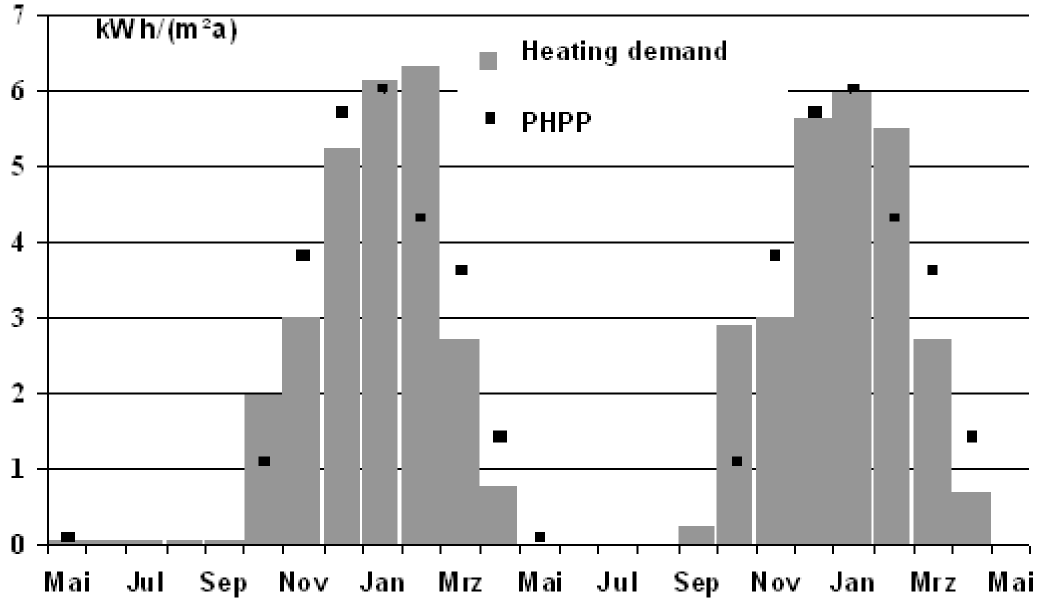

Figure 2: Heating demand for the renovated parts of the building, ground floor to second floor, for the first two time periods from May 2009 to April 2011; the 26 kWh/(m²a) calculated with PHPP was achieved despite two harsh winters.

Auxiliary power consumption for the ventilation system is about 3 kWh/(m²a) for the approximately 210 days of operation between winter and the transitional season. 2 kWh/(m²a) is used during the summer for comfort ventilation. Auxiliary power consumption for the heating system amounts to 0.6 kWh/(m²a).

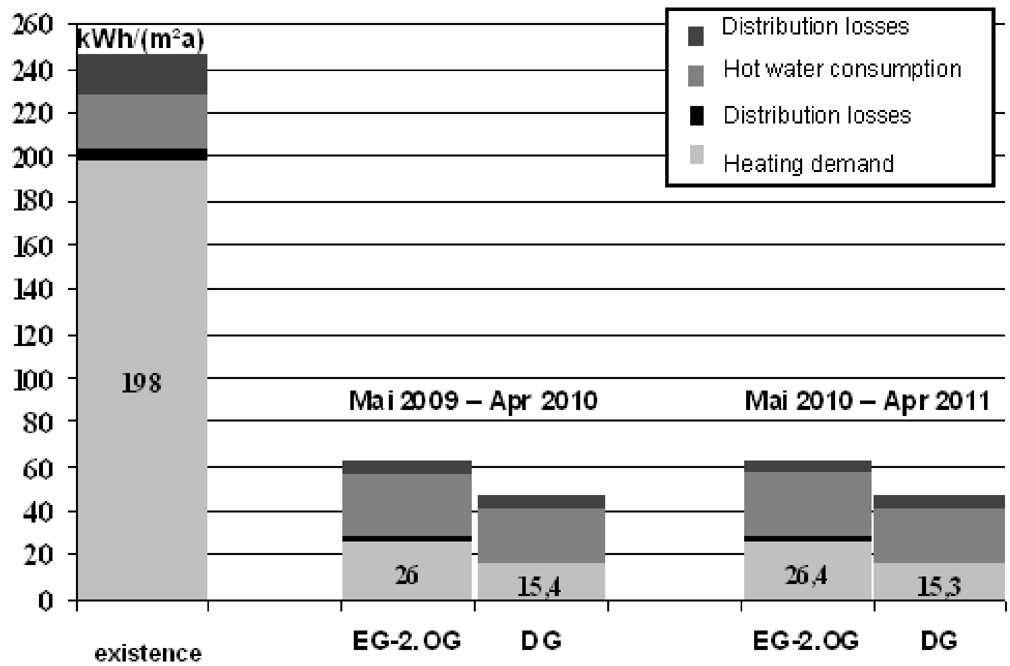

Figure 3: Final energy consumption (heating and hot water) for the renovated parts of the building (EG-2. OG) and the new Passive House attic apartments (DG).

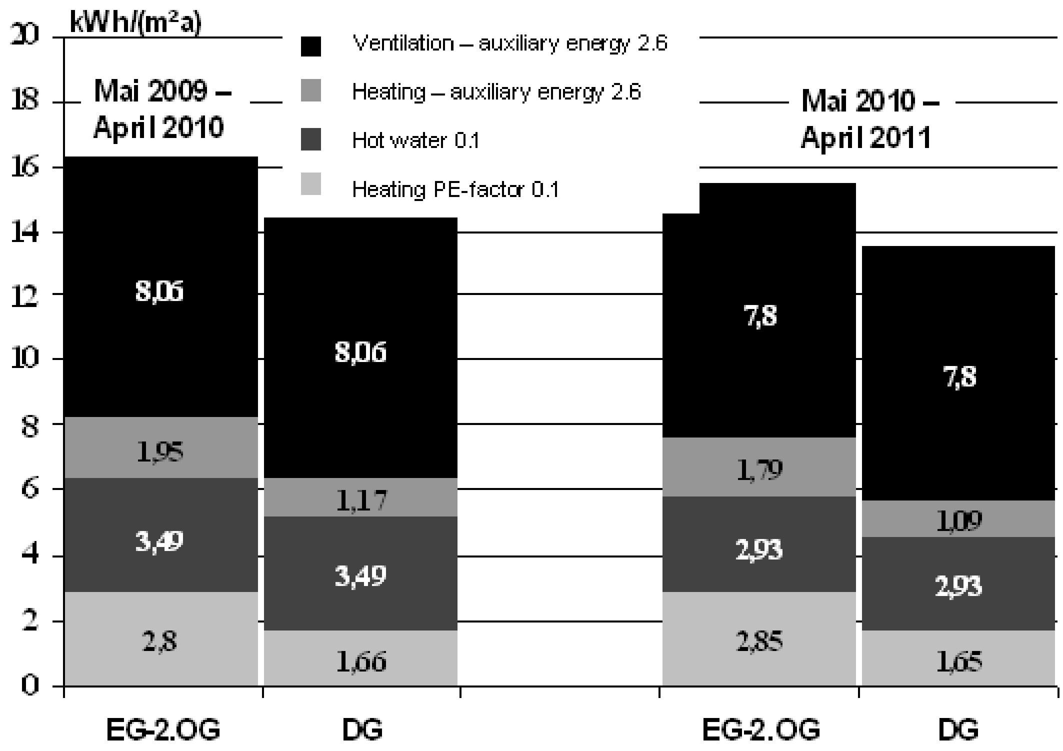

Figure 4: Primary energy consumption for renovated areas (EG-2.OG) and Passive House attic apartments (DG).

8 User survey and summary

After two years, some of the tenants were asked to fill out a survey on comfort and energy aspects. Of those surveyed, 79 percent gave an overall rating of "very good"; 21 percent selected "good," although two of those responses were not final, since they were waiting for some technical adjustments to be made, such as to the windows during the next heating period. There was some constructive criticism regarding ventilation controls, the placement of fresh-air elements, and improvements to the windows. Nevertheless, a number of tenants proclaimed that they were living in an apartment where they "feel comfortable in every way" for the first time or even that “it’s the best apartment I’ve ever had!”

This positive feedback justifies the extra expense and time for modernizing the three Kollwitzstrasse apartment buildings. High energy standards, ambitious architecture, and a perceptive design for the living environment combined for a project that adds a lot of value to a neighborhood that was seen as "problematic" just a few years ago.