# PERFORMANCE MONITORING

During the planning and implementation phases, consultations took place between the architect, the client and specialists from the Passive House Institute concerning the building physics and energy efficiency of the building envelope. The energy-relevant optimisation of the building services was another focal point in these consultations.

BEFORE: 200 kWh/(m²a)
AFTER: 18 kWh/(m²a)
The heating demand was reduced by around 90%.

A detailed energy balance calculation of the buildings before and in particular after refurbishment was carried out using the Passive House Planning Package (PHPP). In this way, planning was optimised significantly with reference to energy-efficiency. This also ensured that both buildings functioned in accordance with the planning, meaning that pleasant indoor temperatures could be guaranteed year round.

The pressure test, which employs a Blower Door, checked for airtightness of the refurbished building envelope. The remaining leaks and problematic areas specific to old buildings were analysed in detail.

Results of the Blower Door test:
Before: $n_{50} = 4\ h^{-1}$ (not airtight)
After: $n_{50} = 0.5\ h^{-1}$ (good level of airtightness)

Checking of the volumetric flow balance of decentral ventilation units for apartments using the Flow Finder represents another essential quality assurance measure. Only carefully balanced ventilation units can function optimally with regard to heat recovery and electricity consumption.

The main focus of monitoring, the duration of which was two heating periods, was to verify building performance in terms of actual energy consumption and heating loads. In addition to other monitoring measures, the indoor temperatures, air humidity and consumption values for heating, hot water generation and electricity were measured in twenty apartments of one of the blocks.

The results of the analysis provided specific energy consumption, which could then be compared with the projected energy demand values of the energy balance calculation (PHPP). Optimisation potentials for further development of the technology could thus be derived.

Monitoring of both buildings after successful refurbishment was an integral part of this research project. In addition to the energy efficiency, proper functioning of the building envelope in relation to thermal comfort and indoor air quality was also tested. The results of the tests documented the effectiveness of the measures that were implemented.

Thermographic testing of interior and exterior surfaces was carried out before and after the refurbishment. Such evaluation provides quality assurance for demonstration projects as well as documentation of the concepts for future refurbishment measures.

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Passipedia

For further information, visit Passipedia, the Passive House resource, and see project ID number 1211 on the Passive House Database:
www.passipedia.org
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# REFURBISHMENT OF EXISTING BUILDINGS USING PASSIVE HOUSE COMPONENTS

# TEVESSTRASSE FRANKFURT/MAIN

EnerPHit
Certified Retrofit
Passive House Institute

## EnerPHit - certified retrofits with Passive House components

The use of Passive House components in refurbishments of existing buildings leads to extensive improvements in terms of thermal comfort, economic efficiency, absence of structural damage and climate protection. Reductions in heating demand of up to 90 % have been achieved in a large number of projects.

Achieving the Passive House Standard in refurbishments of existing buildings is not always a realistic goal, one of the reasons being that basement walls remain as barely avoidable thermal bridges even after refurbishment. For such buildings, the Passive House Institute has developed EnerPHit for certified energy retrofits with Passive House Components. This requires either a maximum heating demand of 25 kWh/(m²a) or alternatively the consistent use of Passive House components in accordance with the requirements for PHI certification of components. The heating demand calculated by the PHPP, and the quality of thermal protection of the individual components are indicated in the certificate.

The Tevesstrasse project presented in this paper is one of the first EnerPHit buildings certified.

## TWO EXISTING POST-WAR BUILDINGS: THE FRIEDRICH EBERT ESTATE, FRANKFURT/MAIN, GERMANY

Energy efficiency is a realisable goal in retrofits. For this complete refurbishment of 60 apartments belonging to the ABG-FH in Frankfurt, the architects (faktor 10, Darmstadt) consistently used products that had been developed for Passive House new builds. Energy-optimised retrofitting was thus possible, which led to significantly increased thermal comfort and improved living quality.

The thermographic image taken before refurbishment shows high heat losses due to inadequate building components.

## ANALYSIS OF EXISTING BUILDINGS

Both apartment blocks dating from the 1950s originally had a total of 60 accommodation units, each with a living area of 50 m². There were six apartments in sets of two over each entrance, accessible via staircases. In the course of refurbishment, some of the apartments were merged together (80 to 100 m²) in order to create apartments suitable for families. The buildings were in poor condition, a typical state for buildings of this period in Germany.

In terms of living comfort and heating demand, the buildings fell far short of today's standards. The annual heating demand of the existing buildings was equal to approximately 20 litres of heating oil or 20 cubic metres of gas per square metre of living space annually.

The condition of these buildings was also unacceptable with regard to building physics: the building envelope was insufficiently airtight ($n_{50} = 4\ h^{-1}$), the exterior walls were not insulated and some of the windows still had single glazing. Due to this, the interior surfaces of the exterior walls were cold and despite the high heating costs, the indoor climate was not pleasant.

## REFURBISHMENT USING PASSIVE HOUSE COMPONENTS

The thermographic image taken after refurbishment shows that the well-insulated exterior walls, the new windows and thermal bridge free connection details have reduced heat losses significantly.

"A couple of years ago, I thought Passive House was just a niche product aimed at 'eco-freaks', but now I know that the future lies in this technology – with it energy and heating costs are almost of no consequence. The response from those living in these homes has been excellent".
Frank Junker, Director of ABG Frankfurt Holding

After the refurbishment was completed, both buildings almost achieved the Passive House Standard. Furthermore, they received refurbishment funding through the 'Low Energy Standard for Existing Buildings' programme, with monitoring by the Passive House Institute. Passive House suitable components for new builds were used for this refurbishment including high quality thermal protection measures for the building envelope and controlled ventilation. In the end, the annual heating demand was reduced to the equivalent of 2 litres of heating oil per square metre annually or 2 cubic metres of gas – a decrease by a factor of more than 10 as compared with the original state.

## LIVING AREA AFTER REFURBISHMENT

A new storey with additional apartments was created in place of the old pitched roof, and the newly installed windows provide more internal light for the entire building. All interior surfaces are now pleasantly warm. Heating takes place mainly via the warm supply air (supply air diffuser at the top of the picture). Every apartment has been fitted with a ventilation unit with heat recovery, positioned in the main bathroom. For added comfort, every bathroom has been also fitted with one radiator. In this way, the entire apartment is heated with a small heating coil positioned above the heat recovery device that warms the supply air.

## ENERGY-EFFICIENCY CONCEPT AND COMPONENTS FOR REFRUBISHMENT

Extensive minimisation of thermal bridges was a stated objective of the refurbishment measures. Different variants were studied in advance. Cost-effective solutions were worked out in cooperation with all those involved in the construction process. In order to optimise thermal bridges, two-dimensional heat flow calculations were carried out for all connection details.

## ENERGY-EFFICIENT REFURBISHMENT MEASURES:

- Thermal bridge free connection details
- Thermal insulation of the exterior walls with a 260 mm thick polystyrene compound insulation system.
- Insulation of the basement ceiling from below (80 mm) and above (40 mm) using polyurethane.
- Newly built top floor with a completely insulated, lightweight timber construction system.
- Reinforcement of the airtight layer at the floor slab on the ground floor, with interior plaster of the exterior walls and airtight window connections as well as an airtight connection of the new roof.
- Efficient reduction of the thermal bridge effects at all component connections.
- Excellent quality windows with insulated frames and low-e triple glazing
- Improvement of air quality and efficient reduction of the ventilation heat losses by means of controlled ventilation with heat recovery.

| Existing building parameters | |
|---|---|
| Exterior walls: | 1.3 W/(m²K) |
| Top floor ceiling: | 1.6 W/(m²K) |
| Basement ceiling: | 2.2 W/(m²K) |
| Windows: | 2.9 W/(m²K) |
| Thermal bridges: | $\Psi = 0.1$ W/(mK) |
| Window ventilation: | $n_v = 0.8\ h^{-1}$ |
| Airtightness of building envelope: | $4.0\ h^{-1}$ |
| Heat recovery: | – |

| Parameters after refurbishment | |
|---|---|
| Exterior walls: | 0.12 W/(m²K) |
| New top floor ceiling: | 0.12 W/(m²K) |
| Basement ceiling: | 0.18 W/(m²K) |
| Windows: | 0.85 W/(m²K) |
| Thermal bridges: | $\Psi = 0.02$ W/(mK) |
| Controlled ventilation with heat recovery: | $n_v = 0.1\ h^{-1}$ |
| Airtight of building envelope: | $0.5\ h^{-1}$ (average value) |
| Efficiency of the ventilation heat recovery: | more than 85%. |