Karlsruhe high-rise residential complex

EnSan

In the 1950s and 1960s, tightly-packed residential settlements, and in some cases completely new quarters, were developed in cities' outskirts. In the meantime, a fundamental refurbishment of these high-rise residential buildings is necessary, in order to reduce energy consumption, and to improve the quality of living. In a high-rise complex from this era in Karlsruhe (Germany), three blocks, comprising 375 flats, were refurbished. The thermal insulation and the new windows now comply with the low-energy house standard. Control systems for heating and ventilation constitute a focal area of the research project. In 76 of the 375 flats, systems from two different manufacturers were installed. The refurbishment work began in autumn 2000, and lasted to the end of 2001. The subsequent measurement programme was completed in spring 2004.

After refurbishment, the high-rise residential complex is barely recognisable. Alongside the energy-related advantages, a considerable aesthetic improvement was achieved.
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Building summary

Project status	Optimized
Location	Goerdelerstraße 12, 76189 Karlsruhe, Baden-Württemberg
Year of construction	1969/71
Refurbished	2001
Building owner	Volkswohnung GmbH (+Betreiber)
Gross floor area	12,612 m^2
Gross volume	34,146 m^3
Heated living area	9,560 m^2
Usable floor area (according to EnEV)	10,927 m^2
A/V ratio before refurbishment	0.29 m^2/m^3
A/V ratio after refurbishment	0.29 m^2/m^3
Key aspects	Ventilation + heat recovery, Combined heat and power generation, combined heating and cooling, Control technology, operational management, building automation

Project description

The property at Goerdelerstrasse 12-18, with 147 flats, belongs to a residential complex which comprises three similar buildings in the southwest of Karlsruhe. The complex is part of a residential settlement comprising large blocks of flats. Mainly older tenants reside in the low-cost flats, which belong to Volkswohnung GmbH, and some have been there for more than 15 years. The proportion of infants is just 6%. The high-rise residential buildings exhibited substantial shortcomings before the refurbishment. The building envelope was insufficiently insulated, while windows and the entrance doors to the flats were not air-tight. The mechanical ventilation in bathrooms, lavatories and kitchens occurred by means of time-controlled roof fans, and could not be influenced by the tenants.

Refurbishment concept

The intention was to reduce the heating requirement of the entire residential complex from 120 to 56 kWh/m^2 p.a. by refurbishing the building envelope and the heating and ventilation systems. Heat generation occurs in the heating centre, with an NT natural gas boiler and two CHP modules for the base load. Here, CHP covers 80% of the total heating requirement. Within the framework of the overall concept, the influence of occupancy behaviour and of two different systems for individual room control were examined.

Energy concept

The existing ventilation was refurbished in order to realise the required level of air renewal in an energy-efficient manner. The timeworn roof fans were exchanged for permanently operated devices with constant pressure control and sound-absorbing bases. The flats were fitted with air outlets with adjustable air volumes (basic ventilation and demand-oriented ventilation) in kitchen, bathroom, and lavatory. Fresh air flows into the rooms

through controllable outdoor air apertures with storm protection in the windows. Thermostat valves were installed throughout the entire building complex. Two different systems for individual room control were installed in the flats at Goerdelerstrasse 14-16. A wall-mounted central device, with which all other components communicate, is situated in the corridor. Here, the occupant can program target temperatures for every room, and for any timeframe.

Performance

The thermal insulation and modernisation of the technical ventilation equipment and of the heating centre, as well as the use of a combined heat and power (CHP) plant, enabled reduction of the primary energy requirement by about three quarters. The achieved heating consumption results matched the expectations and model calculations. The combination of thermal insulation and controlled ventilation also proved a technical success. With the framework conditions as they are today, the implementation of a CHP plant is economically feasible for large residential complexes. However, with today's energy prices, the overall costs of this refurbishment can only be partially compensated for by energy consumption savings. Thus, the measures must be considered primarily in terms of added value and improved quality of living. Modern systems for individual room control can further reduce the heating consumption, yet their potential has not been fully tapped by the occupants. Technically, however, these systems have proven themselves. The results of measurements and socio-scientific investigation show that occupant behaviour has indeed improved to a certain extent, due to the information provided. However, there are considerable deviations between the occupants' self-assessment and the actual behaviour. This is because the functionality of the new ventilation is often misunderstood, and because the possibilities of individual room control are not being used optimally.

Optimisation measures and possibilities

It is apparent, that alongside better communication with the occupants, a significant improvement of the devices' user interface is required. In addition, prompt invoicing for heating costs, and individual invoicing for domestic hot water are absolutely necessary, so that the tenants experience a direct relationship between consumption and costs.

Construction costs and profitability

The costs for the individual room control systems, depending on the flat, amounted to €1280,- or €2350,- per flat, respectively. For the other costs, please refer to the table below.

Key energy data

Energy indices according to German regulation EnEV (in kWh/m²a)	before refurbishment	after refurbishment
Heating energy demand	100.50	40.20
Source energy for heating and domestic hot water (dhw)	161.00	61.03
Measured energy consumption data (in kWh/m²a)	before refurbishment	after refurbishment
Site energy for heating and domestic hot water (dhw)	114.87	57.72
Source energy for heating and domestic hot water (dhw)		38.98

Data from 072003 to 06.2004.

Implementation costs

Implementation costs in €/m²	
Construction (KG 300)	157
Technical system (KG 400)	46

These figures represent established costs

Net construction costs (according to German DIN 276) relating to gross floor area (BGF, according to German DIN 277)

Operating costs

Operating costs in €/m²a	before refurbishment	after refurbishment
Heating	5.37	4.10

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