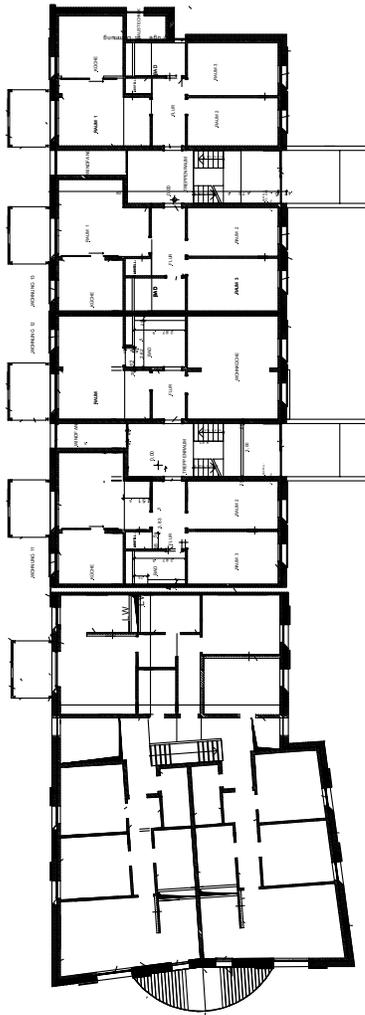


Kassel, Germany



south

north



Passive House standard

The conception of passive houses was developed in the late eighties. Meanwhile the super insulated houses with mechanical ventilation and heat recovery proved to provide high thermal comfort with extreme low specific energy consumption for space heating of about 15 kWh/(m²a).

The main intention of this project was to show, that the conception of passive houses works with low-income housing in an urban environment even under unfavorable orientation and shading conditions, and can be realized at moderate costs.

The project

The apartment houses were built by the GWG, a local housing company for low-income people. The intention was to provide space for young families. The dwellings are rented to the inhabitants.

The two apartment buildings with 40 dwellings in total are situated in the redeveloped urban area of Marbachshöhe in Kassel. Up to the late nineties military barracks have been located there. In this brochure one of the two buildings (realized by HHS¹⁾ and ASP²⁾) with 23 dwelling units is described thoroughly. This apartment house has three main storeys with 7 dwelling units each. Two units are located towards south one floor higher. All 23 dwelling units have three rooms, bath and kitchen on an average area of 72 m². To save costs, no basement is available but each dwelling has its storage room in the stair case.

As the development plan prescribed the main orientation of the buildings to be east / west, only two dwellings per storey are south oriented. So the living-rooms with balcony face towards west. To avoid overheating of the rooms in summertime temporary shading by shutters is provided. Low total solar gains during winter are compensated by the low A/V ratio and the high thermal insulation standard.

Construction

The construction of the exterior walls is massive by sand-lime bricks (thickness of 17.5 cm) with a thermal insulation layer made of expanded polystyrene (EPS, $\lambda = 0,040$ W/(mK)), thickness of 30 cm. The flat roof is made of concrete with a 35 cm thick EPS-layer on top. Above this a green flat 'flying roof' and some roof terraces are located. The lowest floor has a 33,5 cm EPS layer on top of the concrete plate. The outside walls of the ground floor have a thermal separating layer of tight PU-recycling-foam material ($\lambda = 0,075$ W/(mK)) to prevent from thermal-bridge effects.

Mechanical ventilation with heat recovery

The passive house conception includes controlled air supply and exhaust extraction with heat recovery. In this building a 'semi-central' ventilation system was realized: The heat recovery units (air-to-air heat exchanger) are located centrally on the flat roof. Inside the dwellings only few components of the ventilation system are located above the suspended ceiling and in the shaft. These are the silencers, the supplementary water-to-air heater, and the fans. So each inhabitant has the authority over the temperature and air exchange rate. The heat recovery is centralized to increase efficiency and to save costs. Every six to eight dwelling units are connected to one of the central heat recovery units.

Instruction for inhabitants

All inhabitants were instructed in the use of the controlled ventilation system. The inhabitants MAY open windows, but they DO NOT NEED to accomplish ventilation through windows any longer. Only air filters must be changed regularly by the inhabitants.

Controlled air supply requires air tightness

Controlled air supply and exhaust extraction with heat recovery requires good airtightness of the total envelope as an essential precondition to the passive house standard. The airtightness of the building envelope was checked by means of a "blower door test", and reached a residual air change rate at 50 Pa of $n_{50} = 0.35$ ac/h. This is not a misprint: the houses are intentionally extraordinary airtight.

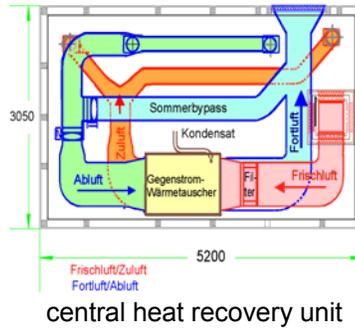
The supplementary room heating during the main winter (November to March) is performed by supplementary water-to-air heater of the supply air after the heat recovery which is connected directly to the heat supply line in the house. Artificial humidification of air is not necessary.

Energy performance

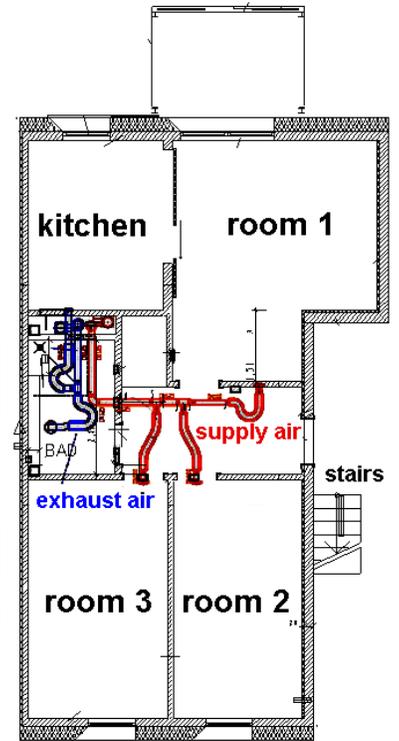
The house is connected to the grid of the local district heat supply. The connection (heat exchanger) to the grid has an additional heat storage tank (800 liters of hot water) to manage peak loads of hot water supply. The hot water installation is equipped with a circulation line.

All dwellings have the possibility to connect the dishwasher and the washing machine with the domestic hot water (DHW) supply to save electricity as much as possible. Special water cocks were installed to achieve reduction of hot water consumption.

The common corridors are completely equipped with energy efficient lighting. All other appliances are in the ownership of the inhabitants. They were advised how to reduce the energy consumption of their household appliances.



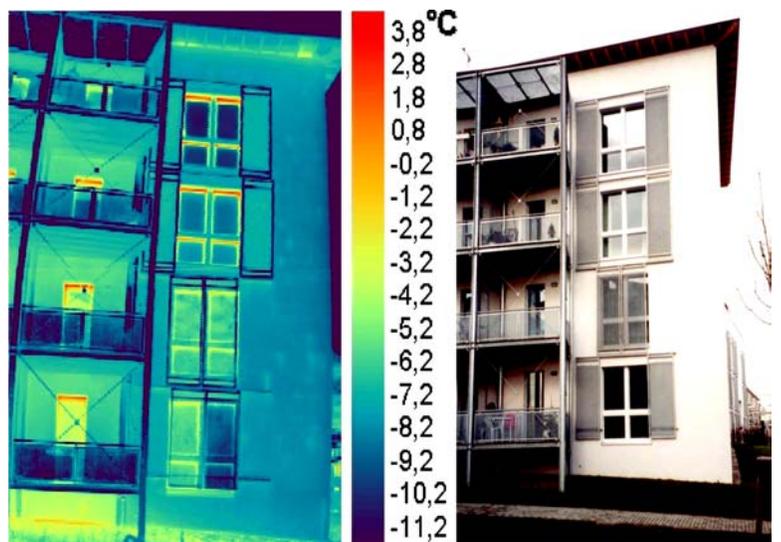
decentral installation in each dwelling



Costs

The building costs amount to about 90 000,- EURO per dwelling unit (72 m²). The extra costs to reach passive-house standard were about 8 000,- EURO per unit.

The houses were funded in the framework of low-income housing programs as all council houses in Germany. For this reason the building cost were restricted to an upper limit. Nevertheless the passive house features could be realized within this restricted budget.



Infrared thermography test

Planning tools

The planning process of passive houses is assisted by the PHPP (passive-house-planning package). This is a spreadsheet calculation tool, which is based on the EN 832. Some calculations and assumptions such as air-tightness, heat-recovery, internal gains, solar gains and shading etc. are treated more sophisticatedly. The reason is, that some assumptions in national standards (e.g. DIN 4108) are not valid with respect to buildings with a very low energy consumption especially passive houses. It is essential in this case to calculate with higher accuracy to get reasonable results.

Scientific research studies:

Within the CEPHEUS project (Cost Efficient Passive Houses as European Standards) the temperatures and heat energy consumption was measured to show the reliability of the passive-house conception in the framework of low income housing, see the following publications:

Fingerling, K.-H., Feist, W., Otte, J., Pfluger, R. 'Konstruktionshandbuch für Passivhäuser', Teil 1 des Forschungsberichts zum Projekt: 'Das kostengünstige mehrgeschossige Passivhaus in verdichteter Bauweise' gefördert mit Mitteln des Bundesamtes für Bauwesen und Raumordnung, Passivhaus Institut, Darmstadt, 2000.

Pfluger, R., Feist, W., Kostengünstiger Passivhaus-Geschoßwohnungsbau in Kassel Marbachshöhe, Endbericht, CEPHEUS-Projektinformation Nr. 16, Passivhaus Institut, Darmstadt, 2001

Schnieders, J., CEPHEUS – Wissenschaftliche Begleitung und Auswertung, Endbericht, CEPHEUS Projektinformation Nr. 22, Passivhaus Institut, Darmstadt, 2001, see as well at www.cephesus.de

Pfluger, R., Feist, W., Sommerliches Innenklima im Passivhaus-Geschoßwohnungsbau, Meßtechnische Untersuchung und Auswertung des sommerlichen thermischen Verhaltens eines Passivhaus-Geschoßwohnungsbaus in Kassel-Marbachshöhe, CEPHEUS-Projektinformation Nr. 42, Passivhaus Institut, Darmstadt, October 2001.

Drawings on page 1 and 2 originate from the architects, HHS and ASP, see below.

Drawings on page 3 originate from innovatec. All photographs PHI.

Architects:

1) ASP, Planungs- und Bauleitungsgesellschaft mbH, Architektur und Stadtplanung, Emilienstraße 4, 34121 Kassel

2) Hegger, Hegger, Schleiff, HHS Planer + Architekten BDA, Habichtswalder Straße 19, 34119 Kassel

The energy and ventilation conception was developed by innovaTec Energiesystem GmbH, Im Graben 5, 34292 Ahnatal-Weimar, email: info@innovatec-web.de

Scientific accompanying work and consulting was done by Passivhaus Institut (PHI),

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Additional scientific research about the Marbachshöhe passive houses was done within the CEPHEUS project, which was funded by the European Commission, Directorate-General XVII, Energy, Thermie, Project Number BU / 0127 / 97 Duration from 1/1998 to 5/2001 and the 'Hessische Ministerium für Umwelt, Landwirtschaft und Forsten'. Funding within the framework of IEA Task 28 (documentation) came from the German Bundesministerium für Wirtschaft und Technologie (BMWi).