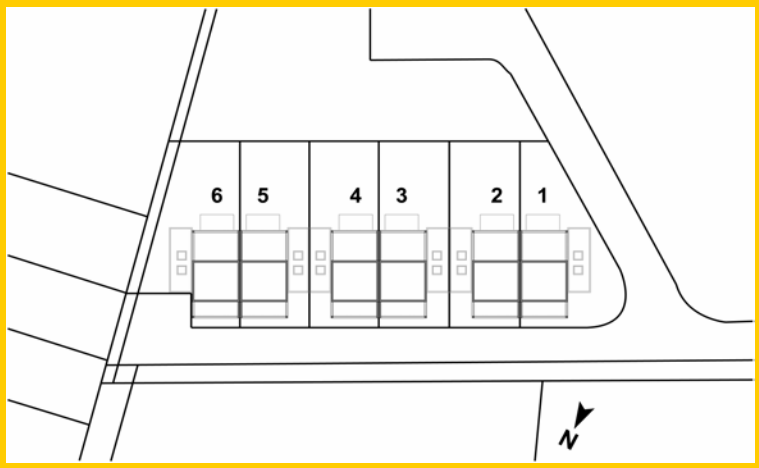
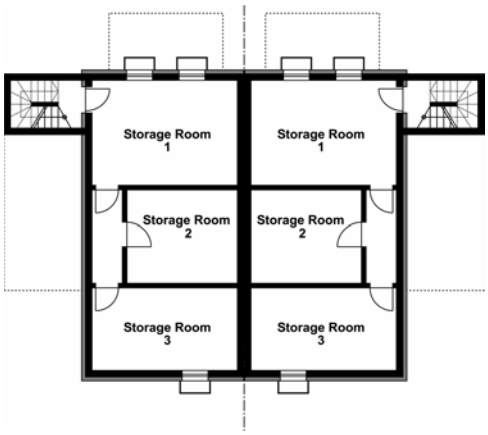
3-Litre Twin Houses
Ulm, Germany

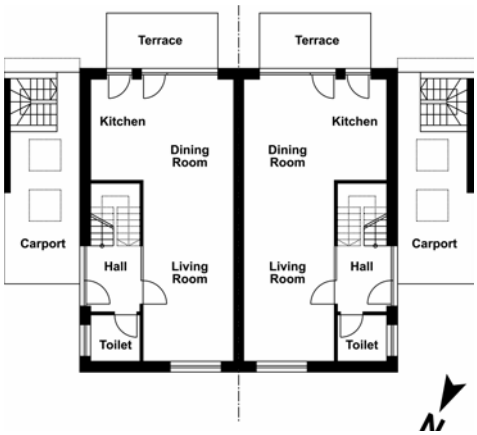


INTERNATIONAL ENERGY AGENCY

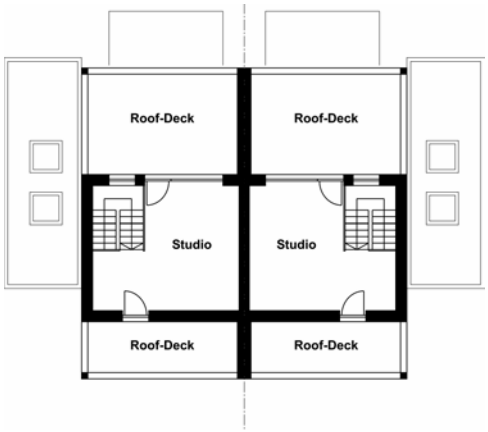
IEA-SCH Task 28 / ECBCS Annex 38:
Sustainable Solar Housing



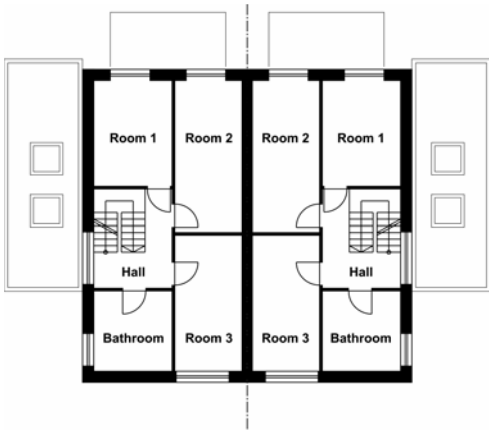
Basement



First floor



Top floor



Second floor

Building characteristics	
Building volume V_e	556 m³
A/V	0.62m^{-1}
Usable floor area A_N	178 m²

Cross section

The project

In collaboration with major manfacturers of building materials, the municipal housing society (NUWOG) of the city of Neu-Ulm, Germany, raised 3 semi-detached buildings that were designed as 3-litre houses within the framework of a model project located in Ulm. The term '3-litre house' applies to low-energy buildings, whose annual primary energy demand for heating figures below 34 kWh/m²a (including the auxiliary energy required for pumps and fans). This corresponds to a primary energy content of 3 litres of fuel oil. The buildings were optimized with regard to their energetic performance and to construction costs, offering maximum amenity in conjunction with a maximum of liberty regarding the floor plan and possible uses. On the first floor, there is a small draught-lobby, the stairway, the kitchen and a south-facing living room, a toilet with a shower and an additional room for uses as required. The bedrooms and a large bathroom are situated on the second floor. The top floor hosts a studio giving access to the south terrace and an exit to

the north terrace. In all the buildings there is a basement. Covered courtyards are located between the buildings. During two heating periods, the Fraunhofer Institute of Building Physics will validate the energy concept of these buildings that were completed and occupied at the end of 2003.

For the construction of these 3 semi-detached houses, the municipal housing society was awarded the builders' prize 2004 for "High quality – Affordable costs"by the Association of German Architects.

Objectives

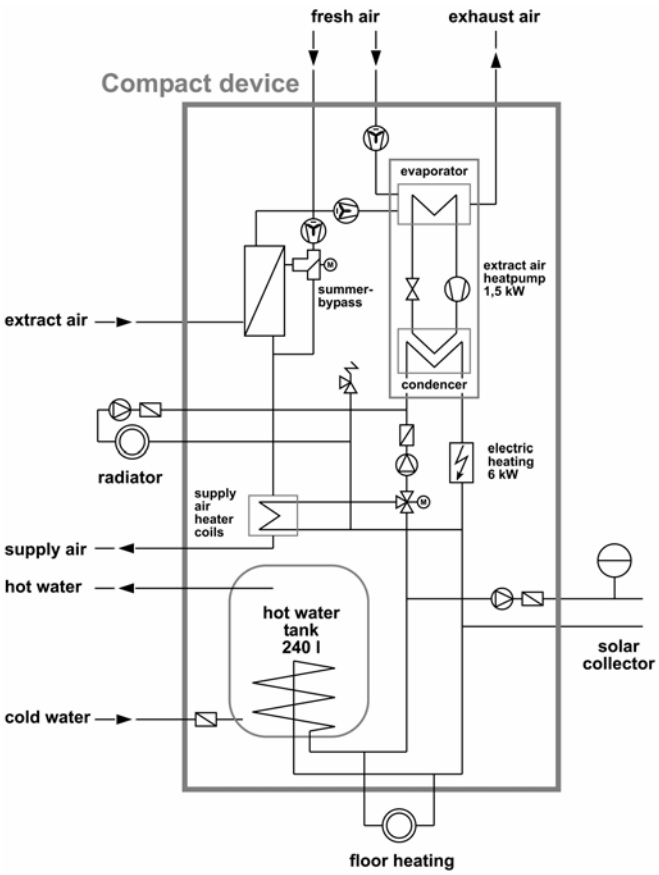
The model project was to demonstrate how innovative technologies and innovative external wall blocks, in conjunction with an optimally selected building orientation, make it possible to construct monolithic buildings that achieve the standard of a 3-litre house without any thermal insulation being applied to the external walls. The buildings are referred to as "Houses for all periods of life" because they can be adapted to meet the occupants' changing needs and wants concerning space and habitation during their different periods of life. Initially designed as a spacious, open home, the house can be broken up into zones as time goes by. It is possible to separate the first floor to obtain a supplementary, self-contained flat.

Building construction

The buildings have a south-east orientation of approximately 25°. The surface-to-volume ratio is 0.62 m^{-1}, with a gross volume of 556 m³. The building's usable floor area is 178 m², the floor space is 142 m². The external walls are monolithic, 42.5 cm brickwork constructions (U=0.20 W/m²K). The windows are made of triple glazing and wooden frames (U_w=0.80 W/m²K) with high-performance thermal insulation. The horizontal roof is a lightweight construction with high web girders between which a mineral wool insulation was inserted (U=0.08 W/m²K). A 20 cm layer of rigid foam insulation (U=0.11 W/m²K) was applied to the lower surface of the concrete basement ceiling. Special importance was placed upon the building's airtightness. Appropriate sealing strips were used to seal the connections between the window frame and the wall. The n_{50} – values that were measured in the blower-door test range below 0.6 h^{-1}.

Technical systems

The buildings are heated by means of a warm air heating system. The entire building services equipment comprising fans, filters, an extract-air heat pump, a cross-flow plate heat exchanger and a hot water tank with an electric heating rod, is integrated in one compact device which was installed in the bathroom. The outdoor air is drawn in from above the roof. While the air is passing into the habitable rooms, the cross-flow plate heat exchanger will transfer part of the heat contained in the extract air to the fresh air.



Scheme of installation

The air is further heated up by the heat pump. The exhaust air will be extracted from the wet rooms (kitchen, bathroom and toilet) to be then passed on through the cross-flow plate heat exchanger. This is where it cools down by transferring part of its heat to the supply air. The heat pump's evaporator unit will cool the air still further. The exhaust air will be discharged via the roof. In some residential units though, radiators that also receive energy from the compact device were installed in the bathroom. The heat pump also heats up the service water. In case of insufficient power output, the electric heating rod can be used for reheating the water. To support domestic water heating (and space heating, as well) a supplementary solar heating system with a collector area of 5 m² was installed.

Energy performance

According to the EnEV (German regulations on energy conservation) method of computation, the application of

which is required by law, the calculated primary energy demand for heating and ventilating including the auxiliary energies amounts to 23 kWh/m²a. This figure implies solar supported heating, and the cross-flow plate heat exchanger is assumed to have a heat recovery rate of 80 %. Further, all thermal bridges were minimized in such a way that no allowances were required when calculating the transmission heat losses. The calculated value of 23 kWh/m²a corresponds to a heating oil equivalent of 2.1 litres of heating oil per square meter per year. Domestic water heating (DHW) requires a primary energy input of 16 kWh/m²a including the solar supports. Accordingly, a primary energy total of 39 kWh/m²a will cover heating, ventilating and domestic hot water including the required auxiliary energies.

Planning tools

During the planning stage, the different options for the building's optimization were evaluated by means of the monthly balance method laid down in the regulations on energy conservation (EnEV). The calculations required for minimizing heat losses due to thermal bridging were performed by means of TRISO, the three-dimensional thermal bridges programme developed at the Fraunhofer Institute of Building Physics (IBP).

Costs

The building's costs per unit floor area (without carport, floor coverings, interior painting work, costs for development and land) amount to 1050 €/m². This value corresponds to the cost limit for local authority housing in Bavaria.

Marketing strategy

The twin houses were built by the Neu-Ulm Wohnungsgesellschaft GmbH (NUWOG), a communal housing construction firm owned by the city of Neu-Ulm, possessing a stock of almost 2,500 flats (either owned or administrated). Sales strategies for the six halves of the three twin houses included both traditional methods (e.g. press advertisements, on-site inspections, sales literature etc.) and unconventional procedures, namely members of the "construction team“ who had accompanied the building project engaging in sales promotion activities. For instance, the building society Allianz-Dresdner Bauspar-AG introduced this project on a national scale to interested visitors from the trade on the occasion of the "Bad Vilbel Talks" staged by this company. Further, the manufacturer of building bricks Ziegelwerk Bellenberg has used several occasions during the building brick industry's trade conferences to draw the attention to the exceptional qualities of this pilot project. Last but not least, the City of Ulm (represented by the mayor in charge of urban construction projects) has not ceased to propagate the project as an excellent example of residential building in these times of severer requirements with regard to ecological concepts, being fully aware of hosting a very special residential building in its city limits.

Innovative products

Building envelope

Wall: Bricks (Planziegel SX plus): www.bellenberger.de
Window: Passive house windows: www.freisinger.at
Roof: Insulating rafters (PN-Daemmsparren): www.1a-kmh.de

Heating and ventilating

Space heating and heat recovery unit:
VITOTRES 343: www.viessmann.de

Financing

The validation measurements scheduled to be performed after the occupancy of the dwellings will be funded by the housing society of the city of Neu-Ulm (NUWOG), by the Supreme Building Authority in the Bavarian State Ministry of the Interior of the free state of Bavaria (Germany), and by the Ministry of the Environment and Transport of the federal state of Baden-Wuerttemberg, Germany.

Project team

Builder:
NUWOG Neu-Ulmer Wohnungsbaugesellschaft mbH,
Johannisstrasse 12, D-89231 Neu Ulm

Architect:
G.A.S.-Architektur und Stadtplanung
Sahner + Sahner, Ludwigsstrasse 57,
D-70176 Stuttgart

Construction supervision:
Planungsgruppe Sterr – Ludwig,
Arnegger Strasse 1, D-89134 Blaustein

Building services planning :
Planungsbuero Bohnacker,
St.-Antonius-Str. 2, D-88601 Schmiechen

Scientific monitoring of the execution of the works and performance of the validation measurements:

Fraunhofer-Institut fuer Bauphysik,
Nobelstrasse 12, D-70569 Stuttgart

Construction team:

- Allianz Dresdner Bauspar AG,
  Am Sonnenplatz 1, D-61116 Bad Vilbel;
  Dresdner Bank AG in Ulm.

- BAYOSAN Wachter GmbH & Co. KG,
  PO Box 1251, D-87539 Hindelang/ Allgaeu

- Freisinger Bau- & Moebeltischlerei GmbH & Co. KG, Wildbichlerstrasse 1, A-6341 Ebbs

- Viessmann Werke GmbH & Co.,
  D-35107 Allendorf/ Eder

- Ziegelwerk Bellenberg Wiest GmbH & Co. KG,
  Tiefenbacher Str. 1, D-89287 Bellenberg

The construction team cooperated from the very beginning, performed joined marketing measures and accompanied the building process by giving professional support.

Contact persons

Georg Sahner, architect
(gas.sahner@t-online.de)

Johann Reiss, Fraunhofer-Institut fuer Bauphysik
(Johann.reiss@ibp.fhg.de)

NUWOG Neu-Ulmer Wohnungsbaugesellschaft mbH
(info@nuwog.de)

Technical literature

Reiss, Johann; Erhorn, Hans: 3-Liter-Haus Modellprojekt OE.KOM.MOD in Ulm/ Soeflingen. Concept development and validation by measurements. IBP Report WB (to be published on completion of the validation measurements)