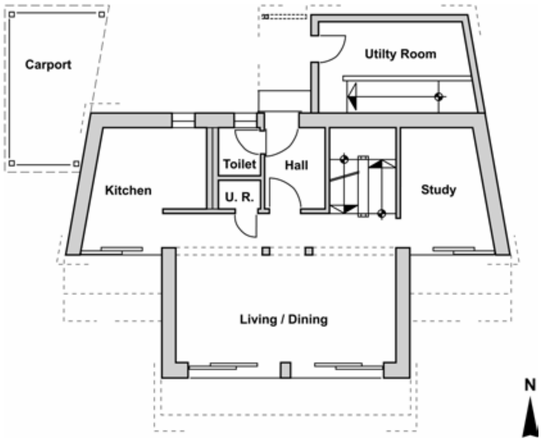
Ultra low Energy House
Durbach, Germany

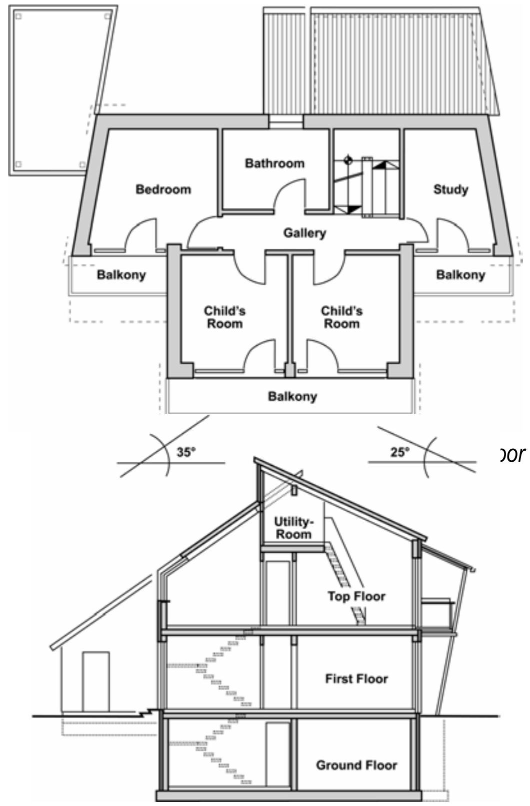
INTERNATIONAL ENERGY AGENCY

IEA-SHC Task 28 / ECBCS Annex 38:

Sustainable Solar Housing



Ground Floor



Building characteristics	
Building volume V_e	576 m³
A/V	0.67 m^{-1}
Useable floor area A_N	184 m²

Project

In 1996, a timber-construction double house was built in Durbach near Freiburg within the framework of the "Weber 2001" project. One half of this building was conceived as a low-energy building, the other one as an ultra-low-energy building. This paper presents the ultra-low-energy building, which is also offered by the manufacturer as a single-family house (see photo). The two-storied building has a usable floor area A_N of 184 m²; the building has an air leakage characteristic A/V of 0.67 m^{-1}. The living room, the kitchen, a workroom, a toilet and a storeroom are on the ground floor. The bathroom, another workspace and three bedrooms are on the upper floor. From one of these rooms, a stairway leads to a gallery that provides access to the mechanical service room, which is located in the attic. The mechanical service room hosts the entire building services installations.

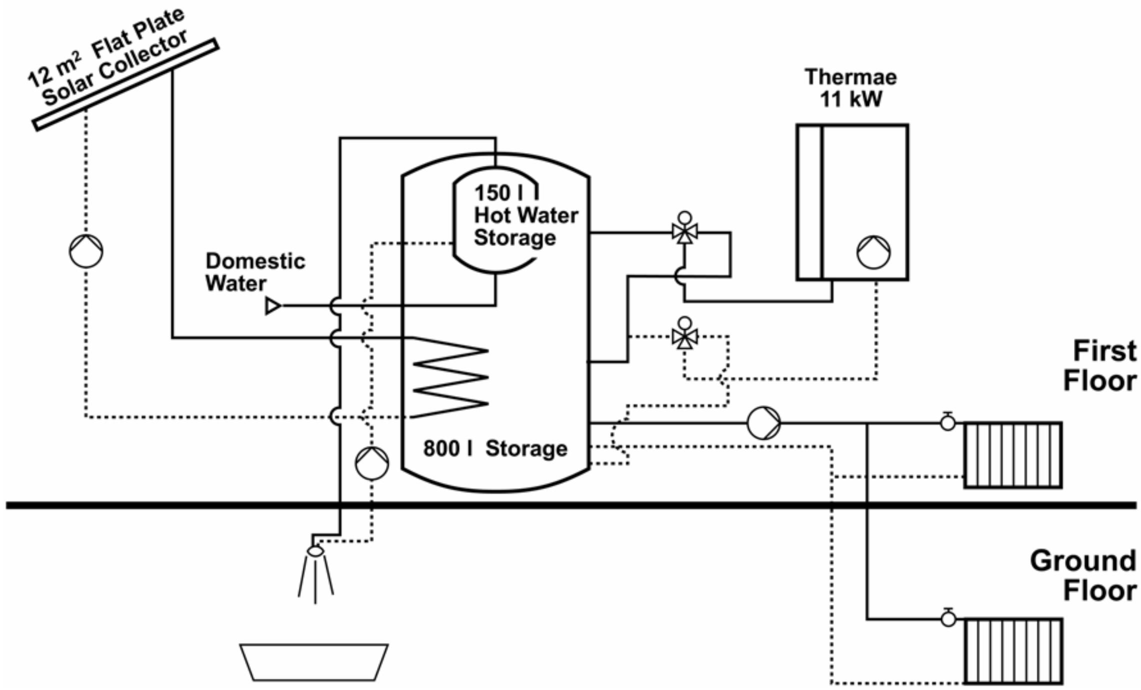
Objectives

With their project "Weber 2001", WeberHaus (a manufacturer of prefabricated buildings) followed the objective of developing building concepts with expected energy demands that were to remain clearly below the future requirements to a building's heating energy demand, and this even prior to the introduction of the EnEV regulations on energy conservation. Along with the WeberHaus Company, the project involved several enterprises specializing in services-engineering and construction-engineering. The ultra-low-energy building is an advanced type of the formerly produced low-energy building. In addition, this demonstration project was to prove that it is indeed possible to develop and build prefabricated dwelling houses, which combine very low heating-energy demands and a high level of amenity. As a high standard of thermal insulation and efficient building-services engineering are usually not that much appreciated (and paid for) by the purchaser, as are an exclusive architectural approach and extravagant interior furnishings, some cost-effective type of construction had to be favored. Besides, the objectives mentioned above, minimizing the primary energy input for production and construction was another focal point of this project.

Building construction

The building was raised as a prefabricated construction. The walls are insulated with a 160 mm layer of mineral wool between the wooden posts. At the outside of the wall, a 60 mm multilayer board was applied in order to avoid thermal bridging in the area of the timber posts, and to receive the exterior finish (U = 0.20 W/m²K). Parts of the external walls were not plastered, but sheathed with timber (U = 0.19 W/m²K). The mineral-fibre insulating board between the rafters is 200 mm thick. Below the rafters, there is another 40 mm insulation layer (U = 0.17 W/m²K). The basement ceiling is a wood construction. The insulating board between the timber beams is 200 mm thick. Above the timber beams, there is a particleboard with a 30 mm rigid foam board. The flooring was applied above a 60 mm screed layer (U = 0.14 W/m²K). Thermopane double-glazing was used for the windows (U = 1.4 W/m²K).

To ensure air tightness, the vapor barriers and the roofing membranes were continued across the respective prefabricated compounds and were fitted together on the construction site. The air tightness n_{50} was measured in a blower door test; the measured value amounts to 1.6 h^{-1}.



Technical systems

A gas condensing water heater with 11 kW power input, which can be reduced to 3.5 kW, runs the heating installation. The condensing boiler feeds an 800 liter combined storage, which contains a 150 l integrated service-water reservoir. As required by the situation, this storage can be loaded with energy at different levels. A 12 m² solar collector field on the 25° inclined southern roof supports heat supplies. The building is heated by means of tubular radiators. The system is controlled by way of central zone valves, allowing individual space heating control. The central zones valves are controlled via the internal building installation bus. They are protected against unintentional heating while windows are open (by means of window contacts). Besides, the building has PV modules with a total area of 8.7 m². The direct current thus produced is turned into alternating current; it is fed into the net of the local energy provider.
A mechanical ventilation system (including heat recovery) was installed in the ultra-low-energy building. The exhaust air that was extracted from bathroom, kitchen and WC transfers part of its energy (by means of a plate heat exchanger) to the intake air, which is then preheated to be supplied to the habited rooms. The system may be switched off by the users, and its capacity can be adjusted in three steps. If an occupant opens a window, the operation will be automatically interrupted.
The control functions (individual space heating control, locking the radiators and the ventilation system, controls of the lighting system including louvers and blinds) were implemented by means of a decentralised installation bus. To support the user, a central bus-operation and information tableau was installed.

Energy performance

Solar energy contributes to space heating and domestic hot water. In the 1998/99 heating period, the measured final energy consumption required for heating purposes was 70.6 kWh/m²a. This figure includes the power consumption of the heating circulation pump, namely 1.8 kWh/m²a. The balanced ventilation system required a power input of 0.7 kWh/m²a. In addition to the solar supports, heating of domestic hot water still required a final energy input of 10.4 kWh/m²a. If the final energy consumption rates are multiplied with the respective primary energy factors, a total primary energy supply of 84.1 kWh/m²a results.

Consumption	Final energy [kWh/m²a]	Primary energy [kWh/m²a]
Heating	61.2	18.3
Ventilation	0.7	2.1
Domestic hot water	10.4	11.4
Total	72.2	84.1

Planning tools

The building's annual heating energy demand was calculated on the basis of the calculation procedures prescribed in the 1995 regulations on thermal insulation standards (when the building was planned, the 1995 thermal insulation regulations were in force). Calculations of different variants were computed using the dynamic simulation programme Suncode.

Innovative products

Building: www.weberhaus.de
Building installation bus: www.siemens.de

Financing

The research project was funded by the Federal German Ministry for Economics and Technology (BMWi).

Project team

Manufacturer of the prefabricated building:
WeberHaus GmbH, Rheinau-Linx, Germany

Architect:
Architekturbuero Disch, Freiburg

Elaboration and evaluation of the energy concept and implementation of the monitoring programme: Fraunhofer Institute for Building Physics (IBP), Stuttgart.

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