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Marketable Advanced Low-Energy Buildings in Germany

An Appealing and Challenging Task for Architects and Civil Engineers

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As the energy consumption for heating purposes in the Fed. Rep. of Germany takes the order of the most important energy potential (as was stated in the final report submitted by the Enquête Commission on "The protection of the earth atmosphere"), political and economic decision making parties have placed their hopes in the building and construction sector. Reaching the ambitious goals set by the federal government by the year 2000 will take a highly efficient combined effort on all levels of the building sector. With buildings ranging among the most durable economic goods to be produced in Germany, the more important it is to effect graphic improvements in the buildings so as not to produce just tomorrow's stock of old buildings. Due to the long serviceability and the high guarantees given for building materials, the standards that are demanded for the long-time durability of the relevant parameters are particularly high. Given these requirements and boundary conditions, several considerable developing activities have been started in the sector of structural energy conservation, some of which are to be highlighted in the following.

By further reducing a building's heating energy demand beyond the current standards stipulated for new constructions the thermal quality of buildings will be considerably improved. Such buildings which are characterized by a heating energy consumption significantly lower than that of conventional buildings are referred to as 'low-energy buildings'.

With exception of buildings included in funded demonstration projects, low-energy buildings have up to now been built only sporadically, mainly on private initiative. From 1984 through 1988 the Fraunhofer Institute of Building Physics (IBP) was monitoring solar and low-energy buildings "of the first generation" within the framework of the "Landstuhl" demonstration project which was supported by the Federal Ministry for Research and Technology. Within this research project, 25 build-

ings at 14 different locations all over West Germany were investigated. These buildings were detached homes designed to consume less heating energy than comparable conventional buildings. The aim of this pilot project was to investigate the serviceability, efficiency and cost-effectiveness of novel technologies and building concepts and to trace and eliminate any technical problems still existing with various systems. For each building, all numerical and metrological investigations were documented and compiled. The final analysis of the data of all buildings comprised in this project provides a basis for a future concept of low-energy buildings. Some of the buildings under test performed as low-energy buildings.

For the demonstration project "Low-energy buildings Heidenheim" low-energy buildings demanding only a fraction of the heating energy consumed by a conventional building were designed and constructed using current know-how and marketable building and engineering technologies. The target value for a building's heating energy demand was set below 80 kWh/m²a, based on average use and Heidenheim climate conditions (low mountain range climate, G_t = 4,200 Kd). It was intended to demonstrate to what extent currently available building constructions and services engineering techniques may contribute to cut the rates of heating energy consumption down to the target limit. For each semi-detached house within the project several industrial manufacturers joined to have their products tested in practical applications. Quite deliberately, architectural aspects of design were not given priority in this project as here the main emphasis was attributed to demonstrating how low rates of heating energy consumption can be achieved by applying standard products to conventional buildings.

Taking as an example the multi-family building Lützowstrasse (Berlin) it may be illustrated that by making passive and hybrid use of solar energy some considerable reduction in the heating energy consumption can be achieved in a multi-family residential building, too. This building was planned by the Berlin Institute for Building, Environmental and Solar Research (IBUS) and completed in 1988. The Fraunhofer Institute of Building Physics performed an energetic optimization for this object and a two-year monitoring program. Within the framework of a research project of the International Energy Agency (IEA) this building presents the German contribution.

On a large scale, this new concept could eventually be implemented in a joint venture which was supported by building practitioners, researchers and politicians. Schopfheim, a municipality located in Southern Germany in the so-called "three-country region" close to the French and Swiss border, proved with the assistance

and scientific consultation of the Fraunhofer Institute of Building Physics that a significant reduction of energy losses does not automatically mean a dramatic increase in costs. The magic word is "low-energy buildings". This initiative was taken by Mr. Klaus Fleck, the mayor of Schopfheim. Although current know-how allows a building's energy losses to be significantly diminished, there is no legal hold on making builders act environmentally consciously. Mr. Fleck who can rely on an expert's technical experience gained in his term at Karlsruhe introduced his community board to the idea of taking action themselves, as the municipality is entitled to lay down private law obligations in the title deed if the town is the proprietor of the building ground to be purchased.

Thus the "Schopfheim model" came into being: In the deed of purchase, the buyer of the good value communal ground (2,700 DM per square meter floor space) is obliged to raise a low-energy building, i.e. the building's energy demand must not exceed a limiting value of 65 kilowatt hours per year and square meter. Proof of having met this requirement by way of adequate construction measures has to be furnished by some qualified authority. In case the agreed limiting values are exceeded, the builder will have to pay a one-off fine of DM 10 for every surplus kilowatt hour per year and square meter. This surcharge is paid into a fund the town is using for sponsoring low-energy retrofitting. Property speculation is clamped down on by means of another clause contained in the contract: Vendors selling floor space have to observe fixed price limits.

Mayor Fleck's plans are supported by the ministry of the interior of the federal state of Baden-Württemberg who commissioned the Fraunhofer Institute of Building Physics with the scientific consulting of planning, execution and test measurements. IBP researchers were particularly pleased with this task as they take the Schopfheim concept for an evidence that low-energy buildings are no longer entirely dependent on the initiative of researchers. Rather, this forward-looking construction method is losing its elitist appeal: Among building companies and manufacturers there is a positive response to the project. IBP's low-energy maxim is: we must reduce the heating energy demand - **how** we will do so depends on the particular building.

When selecting the different building materials and thermal insulants, particular questions concerning fixing and mounting methods were raised. In this context, special attention had to be paid to a common cause of faults: Due to improper connections of e.g. stairs, balconies or roofings, heat can be conducted out of the building - thermal bridges have been created. The art of constructing a low-energy

building is in the skilful execution of all the details: be it windows, shutters, the roof construction or the appropriate heating system - every item calls for an individual solution.

Consulting services and on-site monitoring complete the IBP researchers' considerations. By taking measurements prior to the building's interior furnishing and after occupation thermal bridges can be identified and eventually removed. In a workshop held in the fall of 1992 monitoring results were discussed with builders and architects prior to building the other types of terraced houses. Mayor K. Fleck hopes to convince also the sceptics with the "Schopfheim model": Low-energy buildings can do without eccentric expensive architecture while additional costs can be kept comparatively low. On the other hand, the heating energy consumption is reduced to half of the limit required in the latest regulations.

In the "Charlottenhöhe" development area at Rottweil the housing association Siedlungswerk Stuttgart is planning to construct an advanced low-energy building (the so-called 'ultra-house') and a low-energy building in a joint venture with the Fraunhofer Institute of Building Physics (IBP). While the east half of this building is conceived as a low-energy building the other half is to be executed as an advanced low-energy building.

This energy concept is intended to reduce the energy consumption by means of (1) the construction's concept and (2) the specific use of solar energy and heat recovery. The low-energy building's specific net heating energy demand per heated unit floor area is planned not to exceed approx. 50 kWh/m²a, while the limiting value for the ultra-house is set at 20 kWh/m²a. For both halves, the basic energy required for domestic hot water and heating purposes will be supplied by district heating.

The low-energy building is an energetically optimised design. Its external walls have a rather thick (above-average) thermal insulation (U_W = 0.2 W/m²K). Besides, low-e coated glazing (U_G = 1.0 W/m²K) was used. The building has a sunspace and will be equipped with a mechanical ventilation heat recovery system. Compared to the low-energy building, the advanced low-energy building will have been further optimized, with an even thicker layer of thermal insulants protecting its external walls (d > 200 mm), the attic and floors. Active solar collectors are used for domestic water heating, and there is high-performance "Superglazing" and frames (U_F = 0.5 ... 0.7 W/m²K). The ultra-house's energetic concept is rounded off by

draught air pre-heating through soil plus a ventilation heat recovery system, possibly in combination with a discharge air pump.

At present, the Berlin-based architectural team IBUS is planning in cooperation with the Fraunhofer Institute of Building Physics different types of zero-energy buildings which are to be constructed by the end of 1993. Consequently continuing to minimize a building's energy consumption finally results in technologically new approaches. The disciplines of structural and building services engineering are about to pave the way for a better environment in combining their efforts for innovation in the sector of energy-efficient buildings, thus conferring even more responsibility on future architects and civil engineers than on today's.