2 *The low-energy house – a new standard for architecture and architects*

Low-energy houses have existed for about 25 years. The idea of using heat loss reduction as the basic principle for construction initially evolved in the United States and was later taken up in the Scandinavian countries. In Sweden, a building standard that provided the basis for energy-saving construction, broadly corresponding to the German Thermal Insulation Regulation of 1995, came into force as early as 1975.

The term "low-energy house" describes a building standard, i.e. not a special method of construction or design. The key feature of a low-energy house is the greatly reduced heating requirement compared to the norm. Experts agree that the annual heating energy requirement of low-energy houses should be approximately 50 kWh per m^2 of living area per year. This means an annual heating energy requirement of 500 m^3 of natural gas or 500 liters of fuel oil for a living area of 100 m^2. By comparison, the average annual heating requirement per unit area of all the existing buildings in Germany in 1990 was approximately 160 kWh per m^2 of living area per year, and thus met the requirements of the 1977 Thermal Insulation Regulation. For houses built before 1977, this value is generally much higher (on average, 250 kWh per m^2 of living area per year).

2.1 *The technical challenge*

The low-energy house certainly does not demand a special construction or special building materials. On the contrary, low-energy houses can be constructed as detached, semi-detached or terraced houses and as apartment blocks, using conventional materials, in numerous designs and diverse forms of construction.

With these different designs, only the principle of energy efficiency is paramount – balancing the gains and losses. Low-energy houses are no longer experimental, but represent the latest state of the art. This is the main reason why the low-energy house standard has now been "officially" introduced by way of the Energy Saving Regulation.

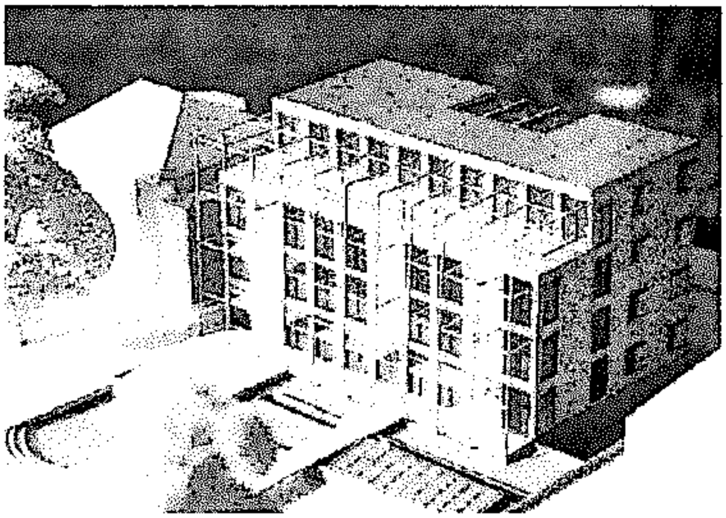

Fig. 8: SOLAR-LOFT, Braunschweig 2000
Multifunctional timber-frame building; based on a standardized grid of 2.50 m in the east-west direction and 5.00 m in the north-south direction; cubic structure, surface area to volume ratio = 0.47 m^{-1}; the south façade has 3.00 m high picture windows, while the east and west façades are more closed.

The low-energy house standard is met by respecting some components or constructional features that have a certain synergy and together have a major influence on the energy balance of a building. These technical components relate to the construction on the one hand and to the heating system on the other:

- compact design
- energy-efficient construction
- excellent thermal insulation in the external components
- wind-tight and air-tight building shell
- mechanical ventilation (heat recovery in some cases)
- rapidly controllable heat distribution.

Constructional demands on the low-energy house

Compact design

Heat loss through the building shell (transmission heat loss) has a critical effect on the energy balance of buildings. Complicated designs, projections, floor cavities and intricate shapes have an unfavorable effect on the energy balance. The smaller the surface area of the building through which heat exchange can take place, the less heat required per unit volume. The surface-area-to-volume ratio is therefore an important factor in low-energy houses.

Energy-efficient construction

This involves minimizing the U-values for particular components such as the external walls, roof, windows, floor and basement ceiling. Minimizing losses also involves the avoidance of thermal bridges in which heat transfer is increased because of structural factors. Just as components have typical cross-sections with an optimum U-value, the effect of thermal bridges has also been investigated. Adherence to these construction standards makes it possible to reduce losses.

Outstanding thermal insulation in the external components

The heat losses of external components due to transmission are reduced primarily by using insulating materials. If greater thermal insulation is to be achieved, polyurethane rigid foam with its high insulating efficiency per unit area has special advantages. Polyurethane rigid foam is available in the thermal conductivity groups (WLG) 025 and 030. With other insulating materials of WLG 40 and greater, the insulation must be thicker to achieve the same insulating efficiency. Polyurethane rigid foam offers the planning engineer the twin advantages of increased space and greater opportunities for styling.

Wind-tight and air-tight building shell

The better the insulation in low-energy houses, the more important it is for the building to be air-tight and wind-tight. Uncontrolled drafts lead to considerable heat loss. When the heating is on, cold external air enters the building through connecting joints, and sometimes through small gaps. On the other hand, warm internal air also escapes through the same openings. This uncontrolled ventilation must be eliminated by a wind-tight and air-tight design.

System demands on the low-energy house

Mechanical ventilation

In well-sealed, highly insulated low-energy houses, ventilation of the building is required to limit the relative air humidity. Ventilation through the windows that has been normal up until now is not always sufficient to provide the exchange of air required for good health. Controlled ventilation allows the constant removal of used air from the room and a constant supply of fresh air, irrespective of the wind or the occupants' behavior.

Rapidly controllable heat distribution

In a low-energy house, which is built on the principle of minimizing heat losses, the heating energy requirement is accordingly reduced. At the same time there is free heating, from solar radiation and internal heat sources (such as people, lighting, appliances etc.) that can fluctuate greatly over a short period and can vary from room to room. The heating system therefore has to adapt to the fast-changing heat requirements so as to guarantee a comfortable temperature at all times. Rapidly controllable or fast-acting heating is necessary.

2.2 The architectural challenge

The technical requirements for constructing a building as a low-energy house should be seen, not as a completely new design parameter, but as an extension of the classic constraints [2].

Put simply, architecture can still be viewed as a three-way combination of form, function and technology. The functionalist approach to architecture has always been viewed as the synthesis of technically perfect construction, correct use of materials, sensible utilization and efficient production planning.

With this view of architecture, the requirements of the low-energy house standard give the design process a specific direction rather than being added as new design parameters. This direction is governed by factors external to architecture, such as conservation of resources, climate protection and energy efficiency.

As in the case of functionalism, the question of the architecture of a building also arises in relation to the low-energy house standard. Once again, the challenge is "to develop a new esthetic and create appropriate architectural designs from it". [3] Just as the formula "form follows function" is too simplistic for a good understanding of functionalism, the formula "form follows U-value" [2] is also an oversimplification. Building a low-energy house does not take anything away from architects' design language [4]. On the contrary, the challenge of the low-energy house standard is leading to new developments, for instance in the styling of the façades of large, complex buildings.

In the technical concept of the double façade, this component is no longer understood (or understood without question) to be merely a passive component in which the heat losses have to be minimized; it is also seen as an energy system, a "power station" that produces energy, to the point where it is considered as a "living system" that can respond to changes in the environment. Over the last generation, many high-rise buildings, which can broadly be considered as low-energy houses, have created an interesting, novel "façade landscape".

> <u>Matthias Sauerbruch, architect:</u>
>
> The challenge is to develop a new esthetic and create appropriate architectural designs from it. It's a bit like the nineteen-twenties, for example, when the new material of concrete led to novel esthetic solutions, or when machines have created a new esthetic as a general social phenomenon. ... It always depends on the context and the scale. Then, you just have to know what you're doing. [3]

Architects sometimes go as far as the Swiss architects, Herzog und De Meuron, for whom "the crudeness of the building shell, specifically the insulation, became the subject of esthetic reflection" [2]. This involves making the insulation visible behind a transparent pane of glass on the façade.

The architect's design process therefore involves optimizing diverse factors with the aim of maximizing energy efficiency.

2.3 Architects as stylists and engineers

Architects have to turn the technical requirement into a style challenge. Throughout the history of their profession, this is a task they have always set themselves.

"Anyone who objects to new requirements because they restrict freedom of design should bear in mind this extreme paradigm shift in the birth of classical modern architecture. In its historical development, architecture has always been closely linked to social requirements and social change." [2]

In principle, we might go back to the old view of the architect as a master builder and a generalist, who also works as a stylist and engineer or else seeks and implements new forms of cooperation with the engineer in the context of integrated design. For this reason, Thomas Herzog supports the view that, as an architect, you have to have an overview of the key dimensions that define a building if you want the building to harmonize as a whole. "This pertains to all of a master builder's work." [5]

<u>Architect Prof. Thomas Herzog:</u>

If you're trying to design buildings that have a better energy balance than was previously the norm, if you know that this energy balance depends to a great extent on the layout of the rooms and the design of the building construction, including the choice of materials, the individual colors and surfaces, on the position of the building, the organization of the floor plan, section and overall shape, and on the construction of the façades, and if you also know that there is a direct physical interplay between the building construction and the active energy that must be supplied for heating, cooling, lighting and ventilation, then it must be quite clear to you that you can't design something of this nature without having some idea of the individual dimensions and their relationships. [5]

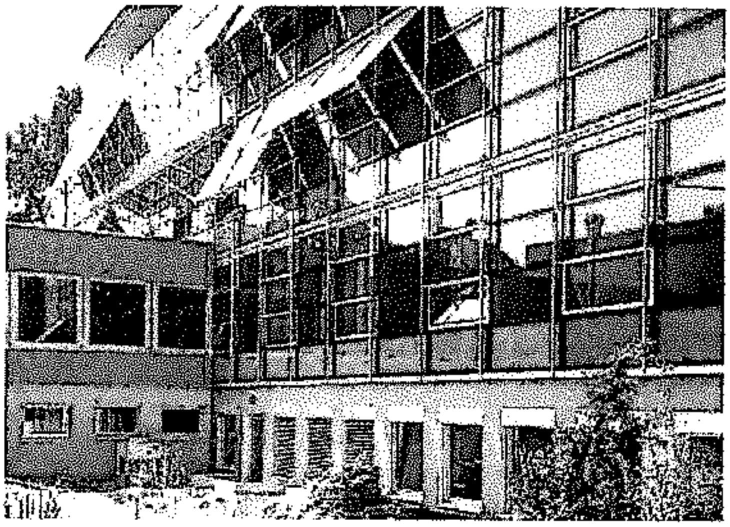

Fig. 9: Sport Toto, Basel

Proplaning Architekten und Generalplaner ETH SIA, Basel. Transparent thermal insulation with KAPILUX-H and OKATHERM 66/34.

Christian Ingenhoven, meanwhile, sees the architect's role increasingly as "that of a director who is by no means the authority on any given aspect of the planning or implementation of a project, but who instead has a comprehensive view of the project as a whole". [6]

Niklaus Kohler sums up the architect's new situation:

"Architects must demonstrate that they can build buildings that have low measured energy coefficients, are very comfortable, have controlled costs and are of a high architectural quality. Once this goal has been achieved and is included in the principles of architecture, there will no longer be any need for an Energy Saving Regulation. There would then be a new art of building and, who knows, perhaps a new architecture." [7]