

**USER BEHAVIOR AND EVALUATION  
OF SUSTAINABLE CONCEPTS OF  
RESIDENTIAL BUILDINGS**

A FOCUS WITHIN THE  
"HAUS DER ZUKUNFT" SUBPROGRAM



■ Strategies of sustainability such as using renewable sources of energy, and raw materials as well as improving resource efficiency and user and service-orientation constitute crucial future-oriented fields of research and development.

From the viewpoint of a demand-oriented research and technology policy

## "HAUS DER ZUKUNFT": A SUBPROGRAM WITHIN THE SCOPE OF THE "SUSTAINABLE ECONOMY" STIMULATION PROGRAM

*the fields of building construction and dwelling are highly important. In developing sustainable forms of building construction future needs should be taken into account as much as possible and health aspects and the quality of life for users should be central points of all considerations. Energy efficiency, the intelligent use of ecological (renewable) materials and the use of renewable forms of energy constitute some of the requirements for a "Building of Tomorrow".*

*In order to put the vision of a "Building of Tomorrow" into practice and to*

*promote developments in this field, the Austrian Ministry of Transport, Innovation, and Technology (BMVIT) has initiated a special subprogram "Haus der Zukunft" (HdZ) within the scope of the "Sustainable Economy" stimulation program. The objective of this five-year subprogram is to find sustainable solutions for building parts and components and types of construction in the fields of residential, office and commercial buildings. The program aims at supporting RD&D projects and at demonstrating their feasibility by means of concrete projects.*

## USER BEHAVIOR AND EVALUATION OF SUSTAINABLE RESIDENTIAL BUILDINGS

■ The subprogram "Haus der Zukunft" networked three projects in the field of fundamental research and organized them in the form of a joint project. This joint project dealing with "User behavior and evaluation of sustainable residential buildings" has been realized in a close cooperation between Dr. Karin Stieldorf, TU Vienna, Dr. Alexander Keul, Angewandte Psychologie, Salzburg, and Dr. Michael Ornetzeder, Zentrum für soziale Innovation, Vienna.

The results of these studies are important contributions by social science to the development of sustainable buildings construction and support planning and implementation of innovative building concepts within the "Haus der Zukunft" subprogram.

The social factor plays an important role in energy efficient residential buildings. Considering the needs, motives, and experience of users of innovative residential buildings and taking into account these issues in future planning constitutes a crucial point in the diffusion process of innovative concepts and sustainable technologies. The social acceptance of technical and organiza-

tional solutions on a broad basis is an indispensable prerequisite for the implementation of savings potentials on a long term basis and for opening up new opportunities on the market.

The following studies form part of this focus:

- 1 **Subjektiver Wohnwert als soziales Akzeptanzkriterium von Nachhaltigkeit: NutzerInnen-Evaluation nach Bezug von sieben Energiesparprojekten und konventionellen Wohnbauten in der Stadt Salzburg**  
Angewandte Psychologie,  
Dr. Alexander Keul
- 2 **Analyse des NutzerInnenverhaltens und der Erfahrungen der BewohnerInnen bestehender Wohn- und Bürobauteile mit Pilot- und Demonstrationscharakter**  
Institut für Hochbau und Entwerfen für Architekten, TU Wien,  
Dr. Karin Stieldorf
- 3 **Erfahrungen und Einstellungen von NutzerInnen als Basis für die Entwicklung nachhaltiger Wohnkonzepte mit hoher sozialer Akzeptanz**  
Zentrum für soziale Innovation,  
Dr. Michael Ornetzeder



The three projects presented here investigated and analyzed different aspects in the field of user behavior. Cooperation between the three fundamental studies focused predominantly on literature research and the development of questionnaires.

Evaluation of the occupants survey and of user behavior yielded important data that should be considered in future planning processes. Concrete experience of users may serve as a basis for the further development of sustainable concepts for residential buildings. In addition, the results gained from the three studies yielded a number of suggestions for improvement in the field of dissemination of information and for strategic measures in the field of energy policy.

# SUBJECTIVE EVALUATION OF RESIDENTIAL BUILDINGS AS CRITERION FOR THE SOCIAL ACCEPTANCE OF SUSTAINABILITY



*What subjective and objective criteria do users apply to evaluate the standard of their homes in low energy and conventional buildings, respectively? Can energy saving measures, in addition to contributing to sustainability and environmental protection, also improve the well-being of users or do they rather impair the positive feeling and thus reduce the acceptance of sustainable building concepts?*

■ These questions constituted the focus of a study conducted by Dr. Alexander Keul, Angewandte Psychologie. The study explored the subjective assessment by tenants living in multi-story residential buildings and compared low energy housings with conventional developments.

The project aimed at assessing the subjective quality of the housings and used a mix of methods (qualitative interview, semantic differential, inspection of the development) combining and analyzing qualitative and quantitative statements by users. A total of 114 tenants of four low energy (LE) and four conventional (C) new developments in the City of Salzburg participated in comprehensive field interviews. This mix of methods yielded a comprehensive strong points/weak points profile for the various buildings from the viewpoint of the occupants. This provides decision makers and advisors with a subtly differentiated feedback. The findings gained from the project may serve as a basis for the development of innovative building concepts in the future.

### ■ Quality of the Housing

The principal quality criterion for all interviewees consisted in the arrangement and the number of rooms. Other important characteristics for a positive evaluation included a good and quiet location of the apartment. Heating and energy issues were not considered relevant factors in the evaluation of the quality of the housing. 60 to 70% of occupants did not participate in the planning of their apartment, however, 30 to 40% would have liked to be integrated in the planning process. Concerning the issue of "healthy building" most users addressed the question of materials used in the buildings as well as light conditions and sun. In this con-

text, too, the topic "heating and energy" was not considered an essential factor by the users interviewed. 20% of occupants in conventional developments reported problems concerning the health aspect (predominantly moisture and mold), while in low energy developments there were no such shortcomings.

### ■ Heating, Energy; Energy Saving

While 60 to 70% of tenants considered their knowledge of heating and energy to be sufficient and 80% judged that dealing with these issues was "simple", the interviews showed considerable information deficits and insecurity in this field. Only 20 to 25% of the interviewees knew that space heating and hot water supply account for more than 50% of overall energy costs. Many did not know if they had a hot water meter. Only a minority of the tenants were able to provide accurate information about their operating costs and the respective proportion of energy costs. In one of the conventional deve-

lopments the space heating costs per square meter for the year 1999 differed by as much as 700%.

For the households surveyed, **protection of the environment** meant above all waste separation and saving on electricity. Living in a low energy apartment did not cause more than 80% of tenants to become environmentally more conscious.

The temperature range considered comfortable was identical for both types of developments (medium temperature 21°C in the living area, 17 – 18°C in the bedroom). However, a re-check showed differences in occupants' behavior: More than a third of tenants in LE developments controlled the temperature by means of a thermostat and a thermometer, while the percentage in C developments was only 13%.

Most occupants gathered information concerning heating and energy on their own initiative or from the media. There was no information from developers, authorities or advice centers. Here, the authors of the study saw a great need for improvement. Customer-friendly and transparent information on operating costs and energy are considered an important measure towards low energy buildings of the future.

### Importance of Environmental Protection for Surveyed Households

Are you environmentally aware?	Low energy apartment	Conventional apartment
Rather yes	56.8%	58.8%
Rather no	2.3%	8.6%
What do you do for the environment?	(Multiple answers admitted, 40.9% of LE occupants and 32.9% of C occupants gave three or more activities):	
	Number of Households	
Waste separation	40	58
Saving electricity	13	15
Waste prevention	11	11
Bicycle/Public transportation	3	21
Saving water	7	16
Bio products	9	4
Composting	4	4
Protection of animals	3	0
Supporter of ecology group	1	2

## EXPERIENCE OF OCCUPANTS OF PILOT AND DEMONSTRATION RESIDENTIAL AND OFFICE BUILDINGS

■ The study conducted by the Vienna University of Technology calculated the theoretical heating demand for 12 low energy buildings and passive houses, respectively, and also ascertained the actual energy consumption for space heating. Discrepancies between these values were to be expected and analyzed with a view to user behavior. Comprehensive interviews with users and modeling of energy consumption based on varying utilization modules in a simulation program are to explain differences between theoretical demand and actual consumption.

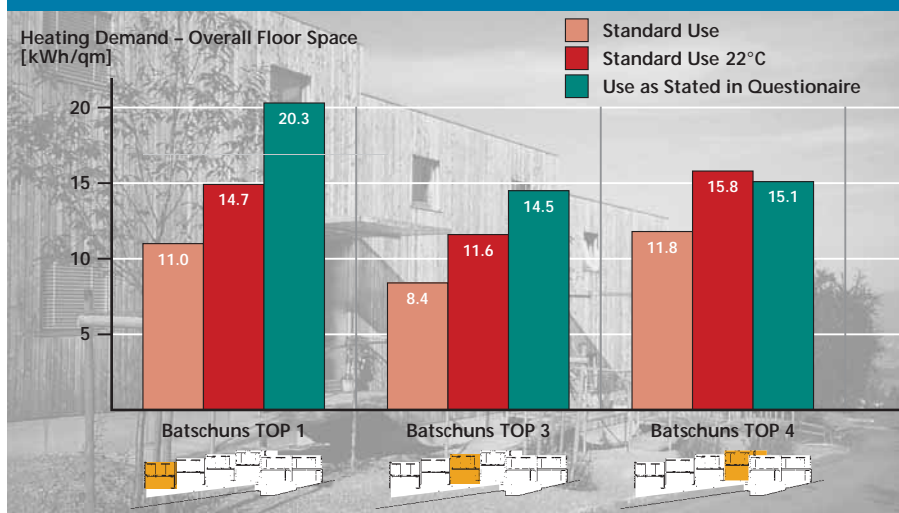
In selecting the twelve projects the authors aimed at realizing a high diversification with a view to regional distribution, technologies used, overall building concept, the types of building, and form of ownership. In addition to investigating the correlation between user behavior and heating demand, the study also explored the users' motives for selecting a particular apartment, their contentedness, acceptance of new technologies, and state of information. Another part of the project compared energy and ecology aspects of the pilot and demonstration projects.

### ■ *Impact of user behavior on heating demand*

In order to assess the impact of parameters that depend on the particular form of utilization of an apartment (or building) the authors first calculated the (theoretical) heating demand on the basis of standardized parameters of utilization. Subsequently, the calculation was repeated using parameters deduced from the user interviews. In this context, the number of occupants, medium stay in the apartment, and the prevailing interior temperatures during the heating period play an important role. As the interviews showed that an ambient temperature of 20°C is rather an exception during the heating period, a third step of the study calculated the impact of an elevated room temperature on the overall heating load.

### Row Houses Batschuns, Austria

#### Impact of Use-Specific Parameters on Heating Demand



The values for standard utilization have shown that the heating demand for the apartment in the middle (Top 3) is much lower than that for the two apartments situated at the outside. Raising the setpoint temperature to 22°C increases the heating demand by 25%. Calculations taking into account the user interviews have shown that the middle apartment (Top 3) almost reaches the values of the outside apartment Top 4.

The outside apartment (Top 1) has a considerably higher heating demand. This is due to the fact that this row house is occupied by only two persons who are out for work all day. Analysis has shown that the number of persons and their daily presence have a decisive influence on the energy demand for space heating. Given the standard requirement that minimum ventilation has to be granted even if the occupants are absent, the heat loss caused by ventilation is independent of the number of persons present in the building. Heat gain, however, decreases considerably in proportion to the number of persons staying in the apartment and the duration of their presence.

The "standard utilization" has been changed only in so far as the setpoint temperature was elevated to 22°C because the majority of interviewees desired this value for the living area.

The example of the passive row houses at Batschuns, Austria confirmed these values and their significance.

### ■ *User experience and information*

Concerning the selection of an apartment the present study has shown that above all the location, the floor plan and sufficient light are important aspects, while ecological factors come second. Contentedness was highest in one-family homes, critical aspects such as limited control of the room temperature, air quality, and noise were address-

ed predominantly by occupants of multi-family buildings.

It has been shown, again, that targeted information, such as feedback on energy consumption has a positive influence on user behavior.

## ECOLOGICAL BUILDINGS IN PRACTICE

*Experience and attitudes of users as basis for the development of sustainable concepts of building with a high degree of social acceptance*

■ The research project conducted by the "Center for Social Innovation" deals with the attitudes and the behavior of users of ecologically optimized residential buildings in Austria. The goal is to identify and analyze specific experience gained in the practical utilization of ecological buildings. In addition, the interaction between manufacturers (planners, developers, and subcontractors) and users constitutes a central element in the further development of adequate technologies.

The users of ecological residential buildings typically are "classic innovators" with a high level of education and, therefore, a high income. The majority of persons interviewed worked in the fields of technology, education or social work. Interviews have been conducted, both with occupants of one-family homes as well as with users in group housing projects and large ecological multi-story buildings. The motives for selecting a certain apartment are rather traditional with all users. The decision



The topic has been approached from **three different perspectives:**

■ A nation-wide survey based on questionnaires analyzed the experience and attitudes of 350 users of ecologically optimized residential buildings ("Post Occupancy Evaluation")

■ Two innovative building concepts developed within the scope of the "Haus der Zukunft" program have been evaluated by experienced users in focus group discussions.

■ Based on these two approaches a participation model has been designed that demonstrates concrete possibilities as to how users can be integrated in the various phases of development, planning, and implementation of sustainable concepts of building construction.

for a house of one's own or a new apartment often is made because people need more living space on account of changed family structures. While home owners preoccupied with ecological issues take into account ecological motives in the decision process, tenants of rented apartments are less concerned with these questions.

There were considerable differences in the assessment of the overall living conditions. Occupants of multi-story buildings showed the lowest level of contentedness; technical problems, too, were most frequent in this category.

Planning of one-family homes and group housing projects often integrates future users in the process. Tenants of large multi-story buildings usually may not participate in the process. Targeted

information and integration in the planning process enables users to get acquainted with the innovative technology of the building. This provides for a considerably higher degree of acceptance and, consequently, to a better handling of the rather unfamiliar technology of the building.

The second part of the project simulated an exemplary user participation. Experienced users of ecological residential buildings discussed two different concepts realized within the scope of the subprogram "Haus der Zukunft". The two projects chosen for evaluation were: "HY3GEN – Ein nachwachsendes Haus (HY3GEN – a renewable building)" and "Implementation of passive house technology in state-subsidized residential buildings in Vienna". Two group discussions yielded concrete feedback for the projects and have shown that it is possible and useful to have innovative building concepts evaluated from the user perspective at an early stage of development.

Subsequently, a model for future strategies of participation has been developed. It comprises four phases: Research and development, planning, construction, and utilization of the buildings. For each of these phases the authors defined topics suitable for a participation of users, the methods to be applied, and what group of users should be integrated in the process.

Like the two other studies, the present study, too, has shown that the acceptance of technical solutions depends not only on their reliable operation but, above all, on the social organization of the users and their identification with the new technology.

## P E R S P E C T I V E S

# RESULTS AND FUTURE STRATEGIES

*"Users are content when they stand behind the objectives pursued by technical concepts, when they can individually control the technology, and when they have a feeling to be adequately informed and may obtain counseling if problems should arise."*

(Study by M. Ornetzeder)

■ All three studies of this focus emphasize the paramount importance of adequate diffusion of information to users and future occupants of innovative buildings. It has been shown that it is useful to integrate the experience made by users into the planning process. Models for participation should be developed that make possible to integrate the user perspective in all phases of planning and implementation.

Given a growing demand by customers for service quality in all areas it will be necessary to provide for a user-friendly visualization of heating, energy, and operating costs. Graphic comparison with the costs of previous years or with the costs of other occupants will provide transparent information and thus form the basis for a modern energy awareness.

This kind of measures will support the identification of occupants with the environment they live in and improve the acceptance of new technologies. In

parallel to the further technical development of future building concepts, learning processes should be initiated that may be used by all actors involved. The objective of such "fields of experiment and learning" (study by M. Ornetzeder) consists in a sustainable change of user behavior and in the social integration of new technologies as well as an improvement of these technologies.

Energy policy strategies and networking of research will have to be used in order to further promote sustainable concepts for residential building construction. Subsidy policy for innovative building projects should require an optimal design of the building envelope and a sustainable supply of remaining heating demand by means of renewable forms of energy and also prescribe adequate measures for the diffusion of information.



### FORSCHUNGSFORUM in the Internet:

<http://www.forschungsforum.at>

in German and English

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## PROJECT SPONSORS

The studies below have been conducted within the scope of the BMVIT subprogram "Haus der Zukunft":

### ■ Subjektiver Wohnwert als soziales Akzeptanzkriterium von Nachhaltigkeit

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### ■ Analyse des NutzerInnenverhaltens und der Erfahrungen der BewohnerInnen bestehender Wohn- und Bürobauten mit Pilot- und Demonstrationscharakter

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## INFORMATION PUBLICATIONS



Information and publications on the BMVIT subprogram "Haus der Zukunft" are available at [www.hausderzukunft.at](http://www.hausderzukunft.at)

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