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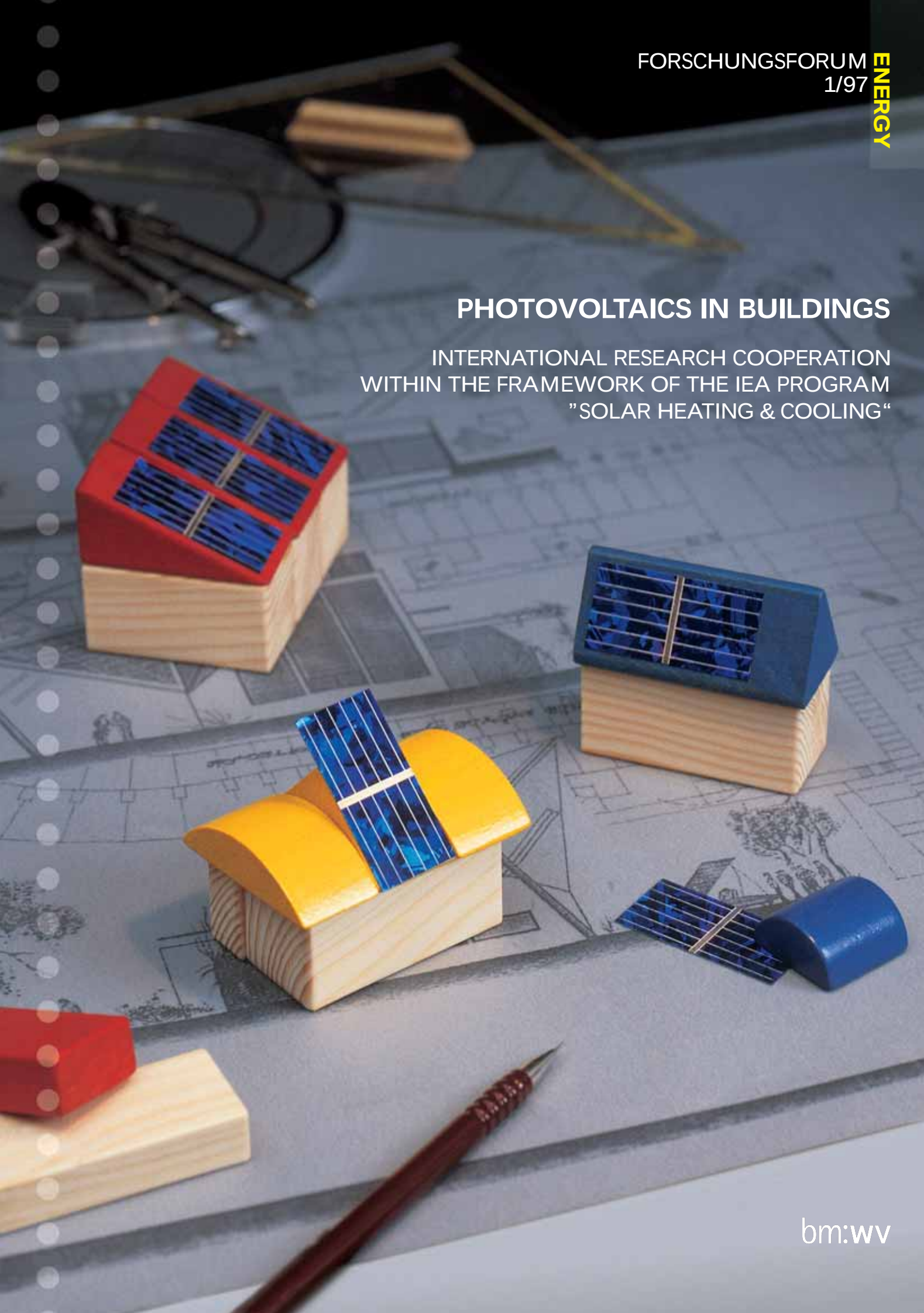

PHOTOVOLTAICS IN BUILDINGS

INTERNATIONAL RESEARCH COOPERATION WITHIN THE FRAMEWORK OF THE IEA PROGRAM "SOLAR HEATING & COOLING"

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T O P I C

THE RESEARCH PROGRAM "PHOTOVOLTAICS IN BUILDINGS"

International Research and Development in the Field of "Renewable Sources of Energy"

The tapping of environment-friendly sources of energy, along with the endeavor for a more efficient use of energy, is important for coming to terms with the ever growing global environmental problems. Environmentally benign sources of energy must be renewable and socially compatible, and their production should require but a minimum amount of energy. It must also be asked whether and how they may be able to influence consumer behavior.

The decentralized use of solar energy in photovoltaic systems may play a major role under these circumstances. It is in particular the attempt to use solar energy for the generation of electricity by means of systems integrated in buildings which constitutes an interesting new development.

By the end of the 1980s, pilot projects for such systems were already in existence in some countries (e.g. Austria, Baumgartalm 1985), but were lacking the necessary know-how and information for architects and electrical fitters. It was at that time that the decentralized use of solar energy by means of photovoltaic systems also attracted the interest of the ***International Energy Agency (IEA)***.

In 1991, the IEA's working group "Renewable Energy" developed the research program "Solar Heating & Cooling" which comprises 20 IEA member countries engaging in the research, development and marketing of solar heating, cooling and lighting systems and their integration in buildings and energy systems. Within this "Implementing Agreement", an international research project entitled "Task XVI" dealing with photovoltaics in buildings was adopted. From 1991 to 1996, 12 countries were cooperating in that program; from the onset, Austria had an important share in the program with a research project sponsored by the Federal Ministry for Science and Transport and supported by the Upper Austrian Power Company (OKA). In March 1996, the international research program was concluded with the "1st Solar Electric Building Conference" in Boston, Massachusetts, while the final results were presented to the public at the SOLAR '96 exhibition in Gleisdorf, Styria, by international and domestic experts.

The main focus of the research program was on the integration of photovoltaic systems in the shell of the building, e.g. in the form of roof or facade integration or also the use of photovoltaics as shading system etc. It was planned for demonstration buildings to be erected in all participating countries, with the results of these projects being documented and made available to the professional organizations concerned.

One important question to be raised is in regard to the benefits and societal relevance of photovoltaics. Inspite of their currently relatively high costs, the positive aspects of these decentralized photovoltaic systems make it appear sensible from a societal point of view to support and improve this technology by means of research and funding programs.

- In their operation, photovoltaic systems do not depend on the consumption of fossil fuels and are free from emissions.
- Their decentralized use may have an energy-saving effect; the proximity to the site of electricity production influences the consumer's behavior pattern.
- As there is no lower limit of performance for photovoltaic systems, they may also be used in low-power areas and are tailor-made to fit the customer's needs.
- Photovoltaic systems being integrated in the building, there is no additional consumption of landscape resources.

The International Energy Agency (IEA)
is an independent institution of the OECD (Organization for Economic Cooperation and Development) established in the wake of the oil crisis of 1974 with a view to coordinating the energy policies of 23 of the 25 OECD countries. In recent years, environmental aspects of global dimensions have increasingly gained in importance. In 1975, a program promoting international cooperation in the field of energy technologies was launched. The program is coordinated by the Committee on Energy Research and Technology (CERT). Multinational cooperation among as many IEA member countries as possible is to help develop and market new and better energy technologies in four areas: "fossil fuels", "fusion", "renewable forms of energy" and "net energy technologies", i.e. more efficient uses of energy. Working groups are established within the framework of Implementing Agreements whose function is to develop and carry out multinational projects and tasks.

RESULTS AND AUSTRIAN CONTRIBUTIONS

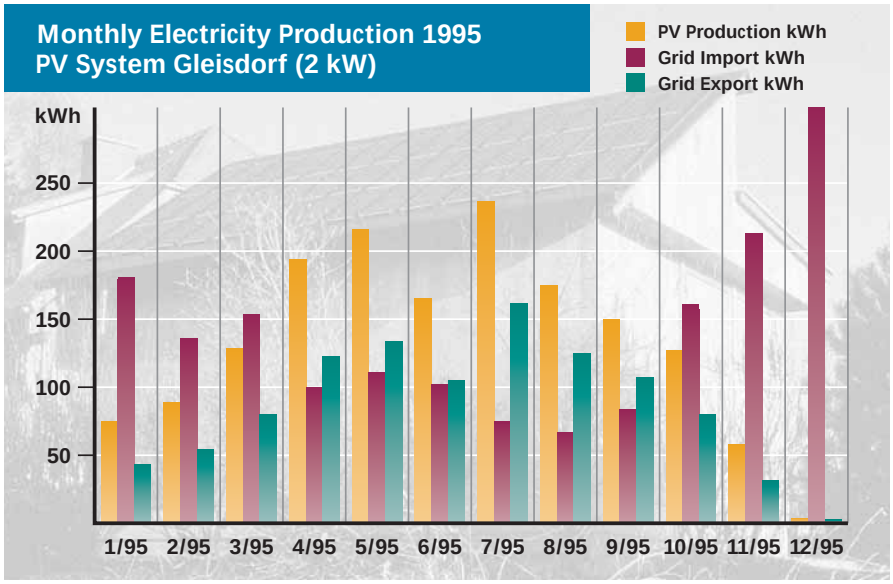
DEMONSTRATION BUILDINGS WITH INTEGRATED PHOTOVOLTAIC SYSTEMS

The central aim of this international research project was the realization of specific houses with integrated photovoltaic systems. The designs of these buildings were subject to the prior approval of all Task XVI experts which was obtained in the course of a design review procedure. The selected demo buildings were equipped with testing systems and measured for a period of at least one year. The results of these test series were then published. Owing to an intensive research cooperation and the active support of the Vienna Utility Company WIENSTROM and the Society for Renewable Energy (ARGE Erneuerbare Energie), Austria has been able to build three such demo buildings. This is the largest number of such projects in any single country and was only achieved by Austria and Switzerland. Overall, 17 demo houses were approved in 11 of the 12 participating countries. Only Japan was unable to contribute a project. All IEA demo buildings were documented and described in detail in a separate brochure; final events in which the results of the project are presented to the public are taking place in all participating countries.

WEISS FAMILY HOME GLEISDORF/STYRIA

The first demo building to be accepted in 1992 was a single-family home owned by the Weiß family in Gleisdorf. The project consisted in a 2 kW system integrated into the roof of an adjacent building using an assembly method that had proven successful in the integration of solar systems. The project was realized within the framework of the Austrian "200 kW Photovoltaic Rooftop Program".

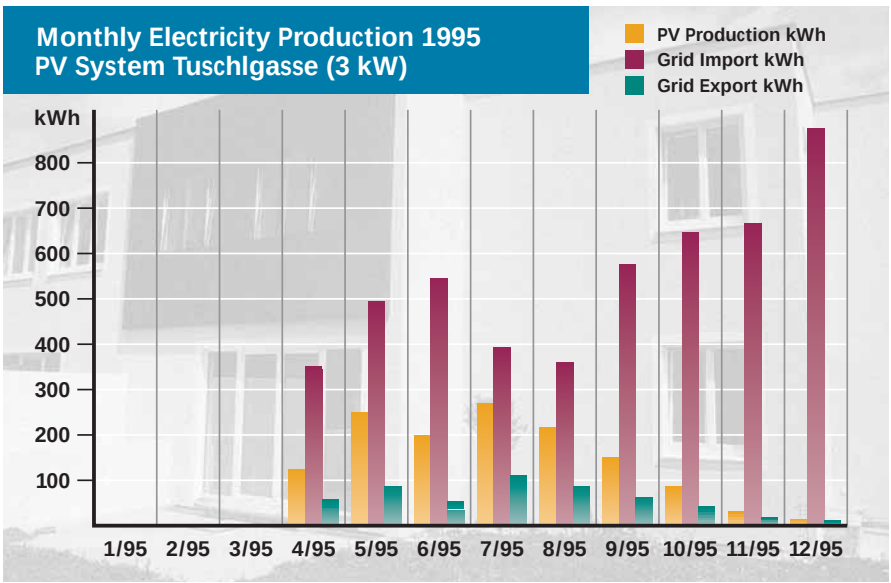
Contact: Werner Weiß, Gleisdorf (ARGE Erneuerbare Energie/ Society for Renewable Energy)



ROW HOUSE AT TUSCHLGASSE/VIENNA

The only row house recognized within the framework of Task XVI was a building subsidized by WIENSTROM in 1993. The building had a 1.4 kW PVA integrated into the facade and a 1.6 kW system mounted on a flat roof. The way in which solar energy is used for thermal purposes is via a vacuum collector system.

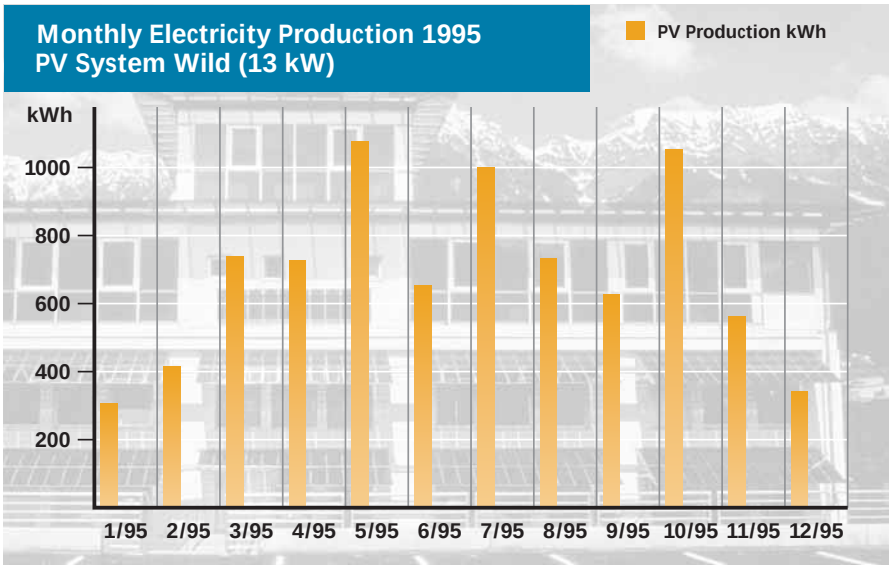
Contact:
Christian Peterka, WIENSTROM



HOUSE OF WILD TRADING COMPANY INNSBRUCK/TYROL

The largest photovoltaic system of any demonstration house in Austria is installed on the commercial building of the Innsbruck-based trading firm Wild. As part of the renovation of the office building, a 13 kW PV system, which is also used as a shade, was installed.

Contact: Heinrich Wilk,
OKA (Upper Austrian Power Company)



WORKING DOCUMENTS

Within the context of Task XVI, working documents and reports were compiled with regard to various priority issues, some of them with Austrian guidance or participation. The report "A survey on computer programs and simulation tools" provides a comprehensive documentation of international computer programs for the installation of PV systems. "Batteries and storage" gives an overview of the worldwide selection of batteries with a special focus on the storing of PV electricity. The report "Documentation of existing projects" (authored by Reinhard Haas, Austria) lists all PV systems installed worldwide. Another working document prepared by Austria is a report which analyzes the value of photovoltaic electricity (The value of PV electricity, by Reinhard Haas) from various aspects including private households, utilities and society at large. A central question is the degree of conformity between solar irradiation and the load profile of a power supplier and to what extent photovoltaic technology can help meet peak demand.

An architectural competition and a special workshop on "building integration of photovoltaics" (Boston 1994) were also conducted as part of these supplementary tasks. The main priorities of the workshop were component development, assembly techniques, integration methods and the analysis of empirical examples.

CONCLUSIONS

Over the past few years, there has been enormous progress in the development of PV modules integrated into existing buildings, from which two main areas of interest have emerged: roof-top integration in family homes and similar such buildings, and integration in the facades of commercially used buildings.

Although neither of the two approaches passes the test of economic viability, they have undergone a constant, albeit modest, diffusion process. On the cost side, there has been a steady decrease, e.g. in Austria where the cost of installation has gone down from ATS 200,000/kW in 1990 to ATS 110,000/kW in 1996. A major part of this cost cut has been due to the 200 kW wide-area test.

One of the findings of Task XVI was that, outside the USA, it has above all been some smaller European countries (like Austria, Switzerland and the Netherlands) that have become driving forces of this development.

Other research activities and programs for practical testing on the regional and communal levels, along with new forms of assistance, are some of the necessary measures to promote the promising development of decentralized systems and the implementation of these concepts. The IEA has already launched a new research program on "Photovoltaic Power Systems", again with Austrian scientific participation. The following aspects are in the center of these further research activities:

- The potential for standardization of both photovoltaic systems (e.g. by means of module-integrated inverters) and building integration.
- Simultaneously, a clear cut in costs should be aimed for. Especially those costs which are not related to the hardware component of the system, e.g. planning and assembly costs could be markedly reduced.
- Suitable diffusion strategies need to be developed.

T H E P R O J E C T

OBJECTIVES AND METHODS

"A close cooperation of international research activities and similar programs for practical implementation on the regional and local levels is an important step towards an environmentally benign future."

■ The main objectives of "Task XVI - Photovoltaics in buildings" were two-fold: The first aim was the erection of so-called IEA demo buildings with PV elements integrated in the hull of the building in all of the 12 member countries, while the second aim was the publication of an international ***Handbook for Architects and Electricians*** covering questions of layout, installation and design.

In addition to these central objectives, some practice-oriented results were also desired. A demo site for possible solutions of integrating PV elements into the building shell was established at the ETH Technical College at Lausanne (Switzerland) in 1992. In this international exhibition and testing center for photovoltaic construction elements, manufacturers from all participant countries are given the opportunity to display their novel products (already integrated in a roof-top or facade construction). At the initiative of the Netherlands, an international competition for architects with 99 participants from 15 countries was held in 1993. The central aspect of the competition was the integration of PV modules in building shells, and prizes for the winners were awarded at the international PV conference held in Amsterdam in 1994.

For Austria, a number of specific assignments resulted from Task XVI. The most important task was the creation of Austrian examples of building-integrated PV systems. Another requirement was to collaborate in the compilation of the Handbook and other materials known as Working Documents, and to conduct national information events. (Joint meeting of the Federal Ministry of Science, Transport and the Arts together with GrAT and WIENSTROM in 1993, SOLAR '96 in Gleisdorf, 8th University seminar for energy consultants, Klagenfurt 1996).

The project was chaired by Germany. With a view to coordinate the necessary tasks, the program was divided into four subtasks:

Subtask A:
System design and applications
The task assigned to this unit was to address questions relating to PV system technology and to write working papers documenting the state of the art in the field of PV systems and components.

Subtask B:
Building integration
This task unit was asked to examine various methods of integrating PV modules in buildings and to develop some new approaches.

Subtask C:
Demonstration buildings
On the basis of the results of A and B, demo houses were equipped with photovoltaic systems and tested in almost all participating countries. The draft proposals were examined and approved before commencement.

Subtask D:
Technology communication
The main result from this working group is the above-mentioned Photovoltaics Handbook.

House with autonomous energy system in Woubrugge, Netherlands

The handbook "Photovoltaics in Buildings" *is an internationally recognized design handbook on building-integrated PV systems compiled with the participation of numerous experts and published by James&James, London (UK). The book was edited by Thomas Erge and Friedrich Sick of the Fraunhofer Institute for Solar Energy Systems, Freiburg/Leipzig, Germany. A major contribution to the handbook comes from one of the Austrian delegates to this research program, Heinrich Wilk (OKA). The book is geared to a target audience of architects and electricians and its aim is to contribute to a better understanding and a more realistic assessment of the possible uses of photovoltaics. The book covers not only the basics of photovoltaic uses of solar energy but also architectural and electrotechnical details.*

ASSISTANCE STRATEGIES

University of Northumbria, Newcastle, England. PV integrated in rain protection casing

■ As regards the funding of decentralized photovoltaic systems, there are generally two different approaches. The method most widely used internationally is to promote PV electricity via subsidized supply prices. Another possibility to support PV energy is through investment subsidies. A common practice in the USA is net metering.

As it is desirable for electric energy produced by PV to be used locally at the site of production, the subsidization of supply prices as sole funding instrument cannot be functional in the long run. In order to effectively support this new technology, a variety of strategies will be necessary. First, a sensible scheme of investment support like the one presently in force in Upper Austria. The scheme provides for an investment aid of 1 Austrian schilling for the expected production of every kWh, which also supports the amount of locally used electricity. Second, reimbursement for actually supplied electricity should be much higher since an adequate supply price provides motivation to maximize the difference between production and private consumption and to minimize one's own demand. This is a strong energy saving incentive.

To what extent it will be possible to enhance the realization of this new technology in the future depends largely on the value that will be given to the decentralized use of photovoltaics in the context of energy policy considerations. Intensive cooperation of international research activities and appropriate programs for practical implementation on the regional and local levels will play an important role in this process.

PROJECT SPONSOR

The final report entitled *Results of Task XVI "PHOTOVOLTAICS IN BUILDINGS" within the framework of the IEA Research Program "Solar heating & Cooling"* was prepared on commission from the Austrian Federal Ministry of Science, Transport and the Arts.

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Handbook "PHOTOVOLTAICS IN BUILDINGS"
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