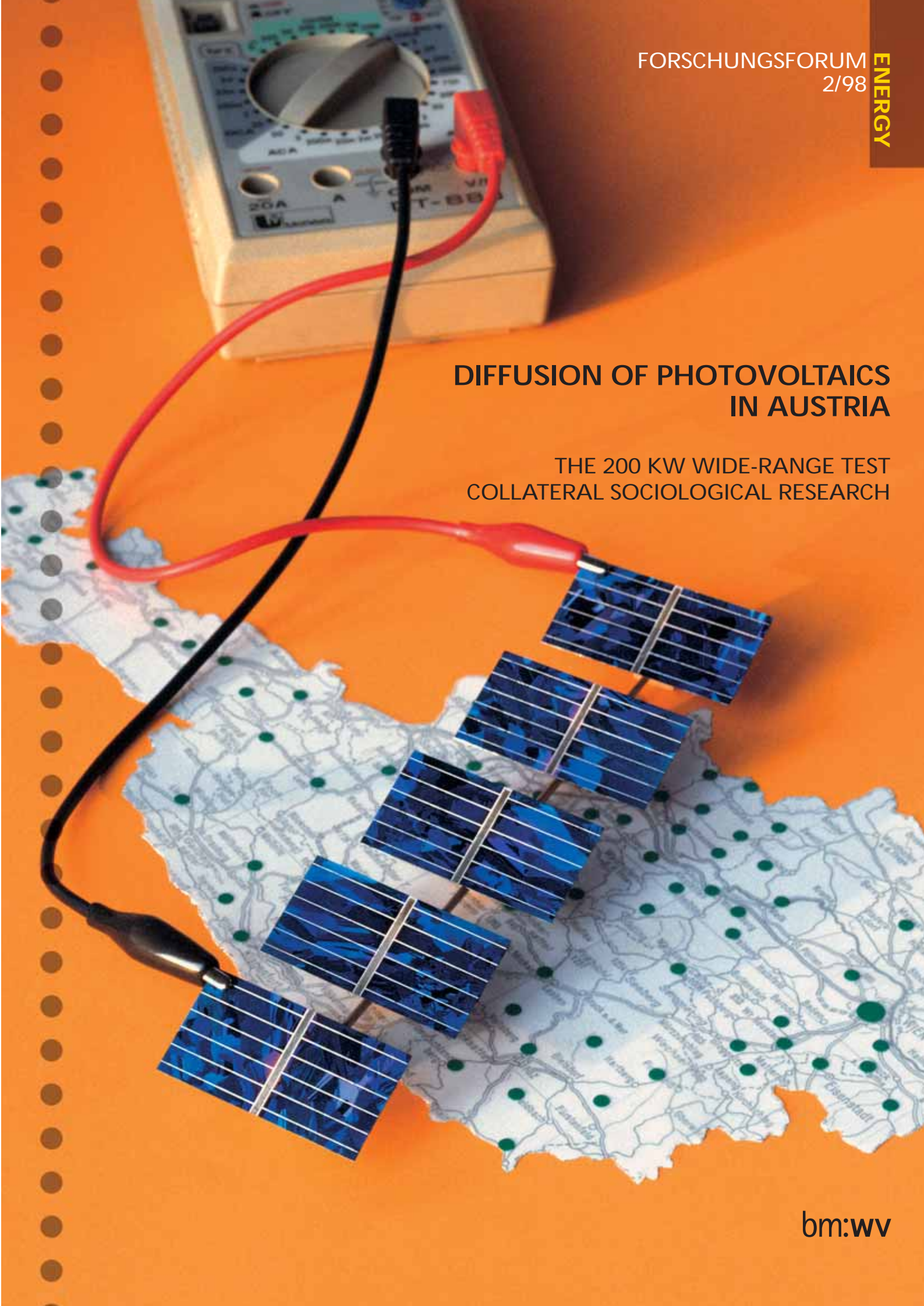


## DIFFUSION OF PHOTOVOLTAICS IN AUSTRIA

THE 200 KW WIDE-RANGE TEST  
COLLATERAL SOCIOLOGICAL RESEARCH



## RESEARCH ACTIVITIES IN THE FIELD OF PHOTOVOLTAICS

*Apart from wind and water power, photovoltaics is considered one of the environmentally most acceptable methods to generate electricity.*

■ Solar irradiation to the earth is the basis for all renewable forms of energy. Photovoltaics, i.e. the direct conversion of radiation energy to electricity constitutes a method of energy production which becomes more and more important from an economic and ecological point of view. Decentralized use of solar energy for electricity generation by means of photovoltaic systems today is considered a technology which helps to reduce environmental pollution caused by the generation and the use of electricity.

At present, various, different PV systems, which directly transform solar energy into electrical energy are being used in many fields of application.

### **PV Pilot Projects**

*The development of photovoltaics in Austria began with the installation of solar modules supplying electrical energy for special facilities such as measuring and radio stations or cottages and recreational facilities in alpine regions that cannot be supplied by the public grid. As early as 1985, a 2,000 Watt installation at the "Hochleckenhaus" provided first important experiences. Finally, grid-coupled PV installations, too, were erected in Austria. The first solar energy system to be connected to the grid in Austria may be considered a precursor of the wide-range test installations and was erected by the OKA (Upper Austrian Power Company) on its industrial site at Gmunden. Additional pilot and demonstration facilities have been installed by public utility companies.*

**30 kW station Loser, Altaussee, in operation since January 3, 1989. Project partners: OKA and Association of Austrian Power Companies.**

During the last few years, intensive research and the development of new technologies brought about a simplification of the utilization of solar energy so that photovoltaic systems may be used for an increasing number of applications. The main objective of research and development in this field consists predominantly in innovations improving the quality of the several parts of the system and the efficiency of the system as a whole (generator, inverter, storage, etc.) thus reducing the specific costs of the plant.

Individual **PV Pilot Projects** and the 200 kW wide-range test launched in Austria in 1992 are to contribute to the further development and to the practical implementation of this environmentally sound form of energy production.

The wide-range 200 kW photovoltaics study was initiated in order to test the practical functionability of small, decentralized, grid-coupled PV systems. The "Energieforschungsgemeinschaft" (EFG) organized in the Association of Austrian Utility Companies, the Austrian Ministry of Economic Affairs, and local utility companies initiated the test and subsidized the installation of the facilities.



The Federal Ministry of Science and Transport commissioned a collateral scientific research program, which is being implemented by KWI company (Kapusta und Wildburger Ingenieurleistungen) in cooperation with the Österreichische Forschungs- und Prüfzentrum Arsenal, Elektrotechnisches Institut (Austrian Research and Testing Center Arsenal, Vienna). The results of the wide-range test will be evaluated, documented, and commented within the framework of this collateral study. The project will be continued until 1999/2000.

In addition to this study the Federal Ministry of Science and Transport also commissioned a collateral sociological research program, which was implemented by GrAT (Gruppe für Angepaßte Technologie/TU Wien) in cooperation with the "Institut für Energiewirtschaft" at the Vienna University of Technology and which concentrated on two main objectives:

- an evaluation of the 200 kW wide-range test
- an assessment of the chances for the future diffusion of decentralized, grid-coupled PV installations in Austria.

Various positive aspects of photovoltaics were confirmed by these studies. In contradistinction to other technologies for electricity generation, photovoltaics is also suitable for low capacity applications and thus optimized for load-dependent operation. The decentralized use of photovoltaics does not require any additional infrastructure. In addition to a reduction of environmental pollution the use of photovoltaics as an alternative to fossil energy sources also has been shown - especially in households with a high electricity consumption - to have an electricity saving effect on account of changed consumer behavior patterns.

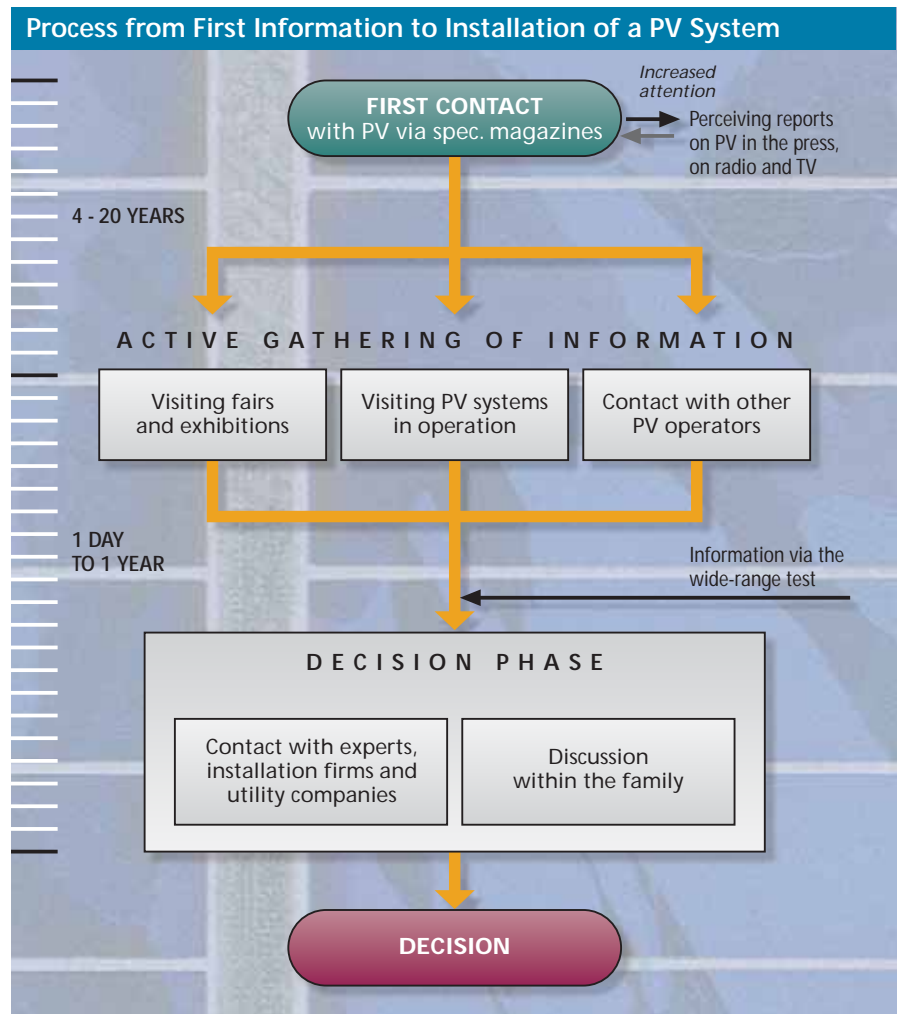
# MOTIVES AND BARRIERS IN THE DIFFUSION OF PHOTOVOLTAICS

The underlying idea for the concept of small, grid-coupled PV installations on the rooftops of private houses aims at generating part of the electricity needed in the household on one's own roof. Installations of this type use the public utility grid as storage facility. If the production of solar electricity exceeds demand the surplus is supplied to the local grid. On the other hand, if weather conditions are bad or at night, electricity from the grid is used to supply the household. The annual demand of a household is approximately 2,000 to 4,000 kWh. A 1 kW photovoltaic system in Austria supplies about 850 kWh per year and needs an area of approximately 10 m<sup>2</sup> for installation.

The collateral sociological research program accompanying the 200 kW PV wide-range study analyzed three groups involved in the test by means of questionnaires.

## ■ THE PARTICIPANTS IN THE WIDE-RANGE TESTS

Typically, the participants are "innovators", people interested in technology and prepared to take risks and who had long before gathered information on photovoltaics; their decision to purchase such a system was the result of detailed consideration. They usually are people with a high level of education and thus higher income, they live with their families in a rural area. The motives for the purchase of a PV system lie in an environment-oriented attitude, in an effort to support alternatives to nuclear power, and in a pronounced interest in the new technology. About 30% of the participants would have installed the system even if it had not been subsidized, for all other participants, the opportunity of public sponsoring contributed positively to their decision.



The typical participant had already exhausted other, - more cost-effective - energy saving methods (thermal insulation, wood chip heating, or thermal solar systems). The PV system is one of the last items in a series of environmentally relevant methods or investments of the household. Therefore, photovoltaics does not compete with other renewable sources of energy but rather has a complementary function.

Operators' satisfaction with their systems is rather high; almost all of the operators would install such a system again if similar conditions prevailed. Electricity saving-effects were pronouncedly higher in households with above-average initial consumption. Photovoltaics proved to be an adequate instrument to motivate well-to-do households with a high consumption to save on energy.

## ■ FIRMS SPECIALIZING IN PV-SYSTEMS

In Austria, there are only a few specialized companies with the necessary know how in the field of photovoltaics. In most cases, these are small companies with one or two employees trained in this technology. Two thirds of the specialized companies operate a PV system on their own premises and employees use PV systems privately to generate electricity. These companies consider the wide-range an important contribution to the diffusion of the technology, the majority, however, criticizes the 200 kW limit. One of the positive aspects from the viewpoint of the firms was that the initiative caused further technological development in their companies. More than half of the

companies reported an increased interest and a higher demand in the field of photovoltaics. However, the relevant companies, as well as the specialists involved in this field of activity underline the need for continuing efforts to disseminate comprehensive information.

### ■ SPECIALISTS INVOLVED IN THE FIELD

The group of specialists belonging to the "ARGE Erneuerbare Energie" (Working Group Renewable Energy) is very similar to the participants of the wide-range test as to their socio-demographic structure, as well as to their environmental awareness and environment-oriented behavior. The specialists were well informed about the new technology. Some of them are potential future operators. Necessary prerequisites for the purchase of a PV system - according to this group - would be a reduction of prices and sponsoring by the state, and the expectation of subsidies still would remain important even if investment costs were to decrease.

### ■ ECONOMIC VIABILITY AND SPONSORING

The costs of individual systems used in the wide-range test varied considerably. The most price worthy system cost approx. ATS 83,000 (per kW, incl. 20% VAT), the most expensive ATS 300,000 (per kW, incl. 20% VAT). Costs were considerably reduced in cases where operators had the opportunity to participate in the installation of the system, therefore, this aspect was an important factor in choosing a certain company.

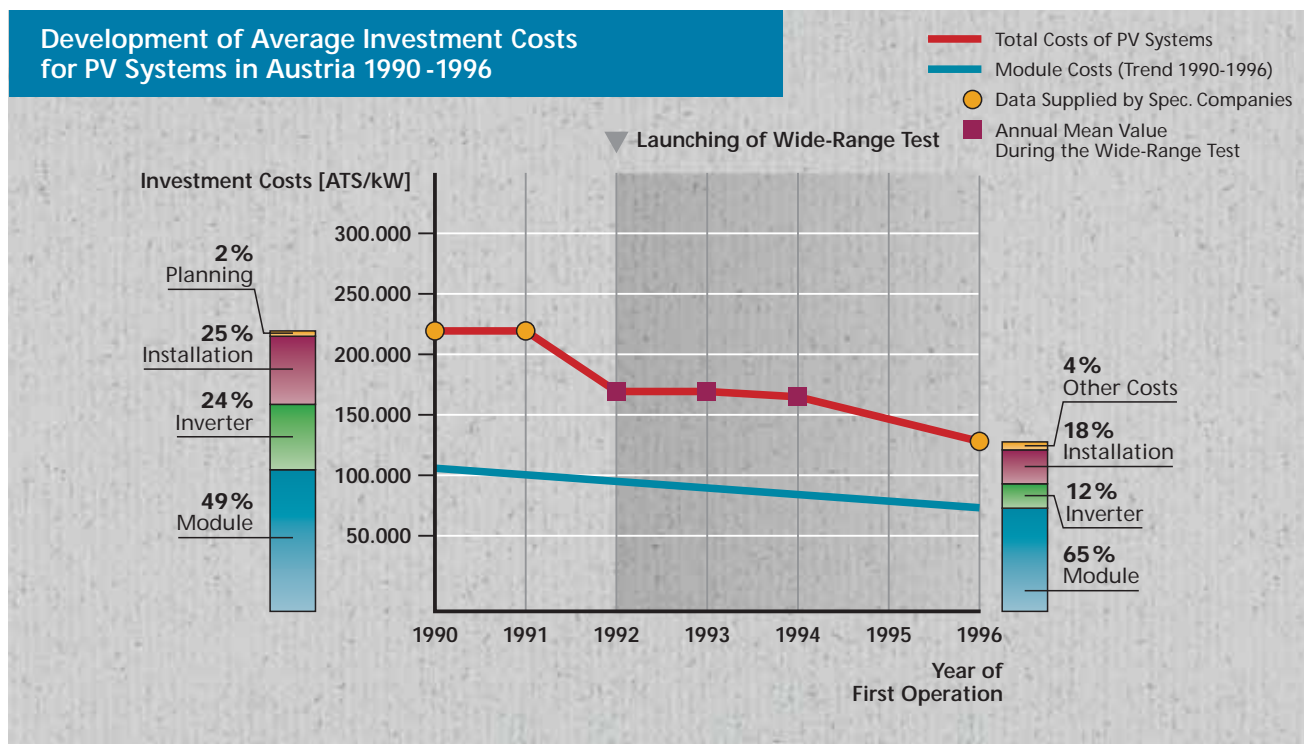
The figure below shows the development of the investment costs for PV systems in Austria between 1990 and 1996 and the impact of the wide-range test. The average investment costs decreased by more than 50% within this period; this fact suggests that the wide-range test had an important impact on the development of prices.

It turned out that economic viability was not the first priority for the operators of the systems. The group of participants and interviewed specialists were prepared to pay a higher price for photovoltaics - the usual analyses of economic efficiency notwithstanding.

The decision to purchase such a system was rather determined by the available income, aspects of environmental protection, and the readiness of the government to invest in this new technology.

Average subsidies for the PV systems of the sample accounted for 57% of the total costs, on an average. The participants of the wide-range test and the specialists would prefer subsidizing on the basis of a "cost-oriented supply compensation" instead of investment subsidies. This, however, is in contrast to the argument that locally produced electricity should be consumed at the site of production as far as possible.

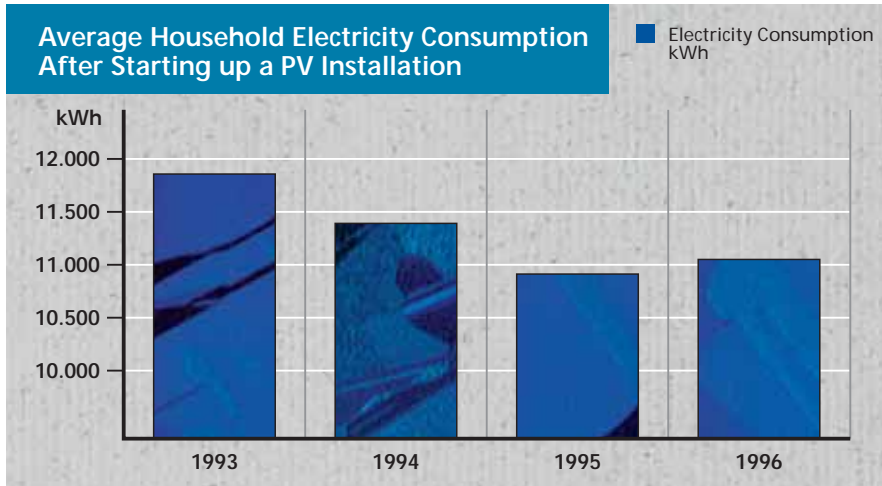
The wide-range test clearly shows that a great part of the population is prepared to invest in innovative, environmentally sound technologies. It has, however, also been shown that public support will remain important in order to promote the further diffusion of the new technology.



Source: Reinhard Haas

# THE 200 KW PHOTOVOLTAICS WIDE-RANGE TEST

*Gathering data concerning the operation of photovoltaic installations constitutes a decisive prerequisite for the further development of individual components of the installation and for the diffusion of this new technology.*



*Average electricity consumption per household decreased during the first years after the PV system was set up. The decrease of electricity consumption from the grid was also caused by changed consumer behavior patterns.* Source: KWI

■ The 200 kW PV wide-range test is to demonstrate the practical functionality and the yield of small, grid-coupled PV installations in Austria. In the collateral scientific research program operational data of several years will be gathered and interpreted, and the installation will be evaluated. This demonstration project will analyze a total of approximately 100 PV installations in Austria, the test comprises private solar installations with capacities ranging from 1 to 3.6 kW, the total capacity of the installations studied being 200 kW. The program was initiated in 1992, a jury of experts selected 96 installations from a great number of applicants. In 1993 already, the whole budget provided for the test was exhausted, and in 1994 almost all installations were in operation.

The objectives of the test were defined as follows:

- Comprehensive collection of operation data for the further development of components and systems
- Test and evaluation of long-term operation of installations
- Assessment of the repair and maintenance requirements of installations

- Optimization of the system technology of small, grid-coupled installations
- Increased efforts to commercialize the product
- Further development of this form of energy production

The wide-range test consists of three stages: Installation of the plants, interpretation of the technical characteristics, which will be sent to the relevant utility company once a month by the operators, as well as a more detailed analysis of some selected systems. Standard measurements currently made in 94 installations situated in nine different *Länder* are to analyze these PV systems. Measurements comprise electricity generation, grid import and export metering. Data will be collected, interpreted, checked for correctness, and, if possible, commented. Key characteristics describing operation and performance of the system will be calculated.

Within the framework of a more comprehensive measurement program, six installations situated in different *Länder* will be analyzed in greater

detail each year. In addition to the standard measurements, the following data will be collected:

- Module temperature
- Air temperature
- Voltage and electrical current of the inverter
- Capacity of the solar generator
- Inverter output
- Horizontal irradiation and irradiation on a tilted area

These measurements will be taken every 15 minutes over a period of one year, checked for their plausibility, and collected. Subsequently, additional load curves and other characteristics of the PV system will be ascertained.

In general, the operation of the installations is trouble-free. Breakdowns were caused predominantly by problems involving the inverter as was shown at the very beginning of the wide-range tests. As a consequence of these experiences an initiative to install an Austrian test bench for inverters was launched. Commissioned by the Federal Ministry of Science and Transport and supported by the Austrian National Bank, a testing equipment was installed on the premises of the Austrian Research and Testing Center Arsenal in the years 1993 - 1994.

Today's PV systems still have to be considered pilot or demonstration installations. One of the objectives of the wide-range test is to test performance in practical operation and to collect as many data as possible on operation characteristics, efficiency, and reliability. Only a comprehensive interpretation of measurement results will provide a basis for the comparison of different types of systems.



Anlage: DI Bartl, Jenbach

■ A reduction of costs, the improvement of the technical reliability, an increase of the average yield, and growing standardization of small-scale systems were major milestones in photovoltaics research and development.

## FIGURES / DATA / FACTS

### PROJECT SPONSORS

Collateral research was commissioned by the Federal Ministry of Science and Transport and implemented by:

"KWI (Kapusta und Wildburger Ingenieurleistungen) and the Österreichische Forschungs- und Prüfzentrum Arsenal, Elektrotechnisches Institut.

**Project Director:** DI Kapusta, Ing. Scheuch

The collateral sociological research accompanying the 200 kW photovoltaics wide-range test entitled "*Motive und Hindernisse für die Verbreitung kleiner dezentraler Photovoltaikanlagen*" (Motives and Barriers in the Diffusion of Small Decentralized Photovoltaic Systems) was commissioned by the Federal Ministry of Science and Transport and implemented by GrAT in cooperation with the Institute of Energy Economics at the Vienna University of Technology.

**Project Directors:** Reinhard Haas, Michael Ornetzeder

The 200 kW PV wide-range test was sponsored by the Federal Ministry of

## PERSPECTIVES

### KEY FACTORS FOR THE FURTHER DIFFUSION OF PV SYSTEMS

In order to realize a broader diffusion of photovoltaics in private households certain prerequisites must be fulfilled:

■ Initial costs for PV systems should be further reduced.

■ The technical reliability of systems has to be continually improved.

■ The supply market should become larger and more transparent.

■ Positive experiences of people already operating such a system should be presented to a broader public in order to implement an effective dissemination of information.

This first phase of the test provides information especially on the functionality of the systems and presents important data and experiences. At the same time, diffusion of the new technology was relatively successful and it turned out that operators and people interested in the technology were prepared to invest in environmentally acceptable technologies.

Targeted information of certain groups of the population, such as the 70,000 households already equipped with a thermal solar installation, could considerably boost the further promotion of this technology.

Economic Affairs and by the Energy Research Group of the Utility Companies within the Association of Austrian Power Companies, as well as by local utility companies.

### PUBLICATIONS

*Motive und Hindernisse für die Verbreitung kleiner dezentraler Photovoltaikanlagen*

was published in the BMWV series 15/97 "*Berichte aus der Energie- und Umweltforschung*", available from: PROJEKTFABRIK, Nedergasse 23, A-1190 Vienna.

### INFORMATION

Forschungsforum 1/97 "Photovoltaik in Gebäuden" - International Research Cooperation within the IEA-Program "Solar Heating and Cooling", BMWV (Federal Ministry of Science and Transport)

Der Österreichische Photovoltaik-Breitentest, Wilk, Reichel, Pink, Schneeberger, Zach, ÖZE 1993, Heft 3

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