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Photovoltaic Programme Edition 2002

Summary Report, Project List, Annual Project Reports 2001 (Abstracts)

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Photovoltaic Programme Edition 2002

Summary Report, Project List, Annual Project Reports 2001 (Abstracts)

Contents

PHOTOVOLTAICS

Summary Report Edition 2002

Concerning programme 2001

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Mobicat

Sustainable mobility with the world's largest solar-powered passenger ship. This ship measuring 33m in length and 11m in width seats 150 passengers. The electrical energy is generated by a self-contained 20 kWp photovoltaics plant. With its very low electricity consumption, the ship glides through the water almost without a murmur.

(source: NET AG)

Contents Summary Report

1. Programme priorities and targets for 2001

In 2001, the photovoltaic (PV) programme was characterized by concentration on those national and international projects with an implementation bias and firmly oriented toward the market. The prevailing situation in national and international photovoltaic markets has led to the consolidation of certain activities. Thus while a number of long-term projects of a more exploratory nature were accorded lower priority, short-term projects with an implementation bias pressed ahead. Cooperation with private companies was further intensified. The good progress made in the implementation of thin film solar cells is also worthy of mention. In the period covered by this report, some 80 research, development and P+D projects were in progress. These figures include all projects enjoying public funding of which we are aware. The number of projects and the magnitude of funding were of the same order as last year.

The photovoltaic research programme 2000-2003 [85], which was approved by the Federal Energy Research Commission CORE, is divided into the following areas:

Solar cells for the future

Work on **thin film solar cells** continued during the report period, the emphasis being on **silicon** (amorphous, microcrystalline, low bandgap) cells based on **compound semiconductors** (CIGS, CdTe) and **dye cells.** Implementation efforts continued in all technologies, and several projects entered the active phase in collaboration with private companies.

Modules and building integration

In applications, the **integration of photovoltaics** in the built environment continued to be the main focus. For commercial solar modules with advanced mounting systems on flat roofs, gable roofs and facades, appealing aesthetics and lower costs were achieved. Efforts are also underway to obtain more complete integration of thin film solar cells into building components.

Electrical systems technology

Quality assurance of photovoltaic modules, inverters and entire systems, together with **long-period observations** of these components, are themes of high relevance to practical application. Long-period measurements are carried out both to obtain statistical information and to gain experience in the operation of different types of plant. Furthermore, in view of the increasing market penetration of photovoltaics, the **standardization** of products and systems, and the preparation of the relevant **standards** are a matter of high priority. This applies both to grid-coupled and island installations. For stand-alone installations, the question of reliable and durable storage systems is important.

Other projects and studies

This heading mainly covers projects to develop procedures for ensuring successful project implementation, and those projects providing modern planning and plant operation **tools**. These include new Internet technologies, computer models and graphics applications, and extend right through to satellite communication. At the other end of the scale are the non-technical aspects that play a central role in the developing countries.

International institutional cooperation

International cooperation forms the mainstay in all sectors. Remaining abreast of international developments and an intensified exchange of information within the **EU** and **IEA** programmes remained the central concern over the report period. Here too, activities are being consolidated, and market oriented strategies increasingly adopted. Where photovoltaic applications in the developing countries are concerned, efforts were undertaken to achieve more satisfactory involvement of these in international activities and networks.

2. Work completed and results achieved

CELL TECHNOLOGY

In the report period, the **broad spectrum of Swiss solar cell research** was pursued in cooperation with many different institutions. It is encouraging to note that the ETH Council's TOP NANO 21 programme is now increasingly undertaking fundamental work. Moreover, a rising number of industrial projects were supported by the KTI. Switzerland's intensive participation in EU projects serves to underline the international standing of her solar cell research programme.

Silicon

At the University of Neuchâtel, efforts continued at IMT during the report period on the priority theme of **micromorphous solar cells** [1], which emphasizes industrial production techniques and processes (Fig. 1). Work concentrated on improving the properties of transparent conductive oxide films (TCO), optimization of p-i-n and n-i-p films using amorphous silicon, and manufacture of micromorphous minimodules. The results of the various tasks can be summarized as follows: the deposition rate for microcrystalline silicon could be increased to 10Å/s. Further, the initial efficiency could be raised to 10.6% for amorphous cells with p-i-n film sequence. For micromorphous cells with p-i-n/p-i-n film sequence, an initial efficiency of 12.3% was obtained. The good quality of the TCO produced in the laboratory on the basis of ZnO was confirmed by spectral measurement. Two new films were developed for the back contact of n-i-p configurations, and their light diffusion characteristics measured. With micromorphous tandem cells in this configuration, an initial efficiency of 9.6% was achieved. Work on micromorphous solar cells was complemented during the report period by the new EU **DOIT** [2] project. The objective is to produce a small micromorphous module measuring 30 x 30 cm^2 and having a stable efficiency of 11%. IMT's final objective is to achieve large-area deposition by means of VHF. The associated reactor was built during the report period and films with a homogeneity of better than 10% deposited. In the **ASOLANT** [3] project, a full-scale prototype satellite antenna with integrated solar cells on plastics substrates was built with the support of ESA. Using a special design, module parameters meeting the specification were achieved (V_{oc}=6.36 V, I_{sc}=55.8 mA, FF=0.554). The project was completed during the report period and demonstrated the viability of thin film silicon cells for satellite antennae.

The joint project on the **rapid large area deposition facility** [4] for thin film silicon solar cells of the CRPP at EPFL, IMT and Unaxis, was continued during the report period. A similar plant to the existing Unaxis plasma deposition facility at CRPP was built at IMT. This will permit fundamental process mechanisms to be investigated at CRPP in parallel with work on solar cells at IMT. The main points requiring clarification are process contamination in a single chamber system, and reactor electrode configuration. An initial batch of solar cells was produced.

The KTI start-up project at Le Locle College of Technology in collaboration with VHF Technologies on the **continuous (roll-to-roll) fabrication process** [5] for amorphous solar cells on plastics substrates was completed during the report period. By in situ deposition of the required films on a 30 m long and 30 cm wide polyimide substrate, an efficiency of 3 - 4 % was achieved at a throughput of 2000 m^2/a (Fig. 2).

Over the report period, the development of **low bandgap cells** for thermo-photovoltaic applications [6] was further pursued at PSI. Work concentrated on the fundamental mechanisms of SiGe quantum well structures produced in a UHV-CVD reactor.

Fig. 1: *Plasma reactors at IMT (source: IMT)*

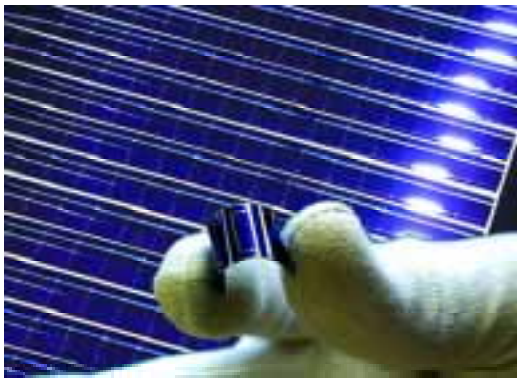

Fig. 2: *Flexible solar cells manufactured by VHF Technologies (source: VHF Technologies)*

II-VI composites (CIGS, CdTe)

Various EU projects on solar cells based on compound semiconductors were continued in the thin film physics group at ETHZ. The EU **CADBACK** [7] project further pursued the optimization of the rear contact. For CdTe cells with buffer films of Sb or Sb_2Te^3, and metallic Mo films for the rear contact, an efficiency of approximately 12% was achieved. Good stability was demonstrated in accelerated ageing tests. The project was completed at the end of 2001. The EU **FLEXIS** [8] project on the deposition of CIGS cells on flexible substrates (polyimide) was also completed during the report period. In addition to single-stage deposition based on the lift-off process, which had been used earlier in the project, a 3-stage process operating at a lower temperature of 450°C (initial deposition on glass) was developed. With this, an efficiency of 14% was achieved. In the new EU **PROCIS** [9] project, techniques for manufacturing larger-area CIGS cells were developed. These involved reduced deposition temperatures and buffer films (e.g. CdS, ZnS, ZnSe), which may also be produced with a vacuum process. Initial experiments to produce CdS films by physical vapor deposition (PVD) led to promising results. With the alternative ZnS technique, results were less encouraging. The structure of films produced by the 3-stage process in the FLEXIS project was investigated in PROCIS.

In the new **NANOCIS** [10] project under TOP NANO 21, new ways of producing CIGS cells from nanoparticles are being sought. The intention is to demonstrate the feasibility of simplified and inexpensive manufacture. In an initial step, separate films were produced using suitable precursors, and their structural characteristics established.

Dye cells

The development of dye-sensitized, **nanocrystalline solar cells** [11] was further pursued at ICP at EPFL. Work on solid-state heterojunctions continued over the report period, and initial photovoltaic cells were produced. This work is also the subject of a project under the TOP NANO 21 [12] programme. In a further TOP NANO 21 project in cooperation with Greatcell Solar, **indoor applications** [13] using dye cells were developed. In a PSEL project, **outdoor measurements** [14] on dye-sensitized solar cells were continued to clarify their behaviour under actual outdoor conditions. Of particular interest is their behaviour under UV radiation. Initial measurements under outdoor conditions were carried out at PSI.

Solaronix has completed work in the EU **LOTS-DSC** project on the long-term stability of dye cells [15]. The results indicate that cell stability under UV radiation is strongly dependent on the electrolyte, and may be improved by use of additives. Thermal cycles with temperatures up to 60°C result in a theoretical service life of at least 5 years under outdoor conditions. This result is a first milestone on the road toward an outdoor solar module having a service life of over 20 years.

Antenna solar cells

Fundamental work has continued at the University of Bern on **antenna solar cells** [16] under the solar chemistry programme, with the financial assistance of the Swiss National Science Foundation. It is also hoped to develop a new type of dye-sensitized solar cell based on dye-injected zeolite crystals.

SOLAR MODULES AND BUILDING INTEGRATION

The EU **PV en face!** [17] project on new designs for facade integrated solar cells was completed at the LESO laboratory at EPFL. Following completion of the conceptional and design phases of the Solface product the previous year, attention focused on implementation. Negotiations were taken up with two Swiss metal manufacturing firms who had indicated their interest in these applications. An initial facade (Fig. 3) was erected at the DEMOSITE at EPFL. The next step will be to find a suitable facade for a pilot project.

In the **DEMOSITE** [18] project, numerous variations on the theme of building integration of photovoltaics in flat roofs, gable roofs and facades may be seen in juxtaposition. The project forms part of the international IEA PVPS Task 7 programme. The opportunities it offers for practical comparison have already enabled several products and systems to be developed or improved in the course of projects. Four new stands were set up during the report period, namely Solgreen II, Solface (Fig. 3), Freestyle (Fig. 4) and Kawneer. The project may be visited in Internet (www.demosite.ch), where detailed information is given. It is also intended to provide an Internet course of further education on building integration in photovoltaics.

Fig. 3: *Solface photovoltaic facade (Demosite), (source: LESO / EPFL)*

Fig. 4: *Freestyle photovoltaic roof (Demosite), (source: LESO / EPFL)*

Enecolo continued its work on the EU **ENERBUILD** [19] project, which involved a 'thematic network' on energy in buildings (www.enerbuild.net) to list R+D activities and strengthen cooperation in the field. In this project, Enecolo is responsible for the photovoltaic in buildings basket. During the report period, information on current work on building integration of photovoltaics in Europe was gathered, enabling preliminary proposals for future strategies and the need for action to be assessed.

Following the bankruptcy of Atlantis in Switzerland, the EU **HIPERB** [20] project was continued by its successor, Swiss Sustainable Systems. The project concerns the application of CIGS cells to roofs and facades, and represents a tangible contribution to the integration of these thin film technologies in buildings.

Finally, several new designs and products for the integration of photovoltaics in buildings are being tested under P+D projects (see Chapter Pilot and Demonstration Projects).

ELECTRICAL SYSTEMS TECHNOLOGY

The **main emphasis in systems technology** lay on the quality assurance of components (modules, power inverters), systems (design, energy yield) and installations (long-term monitoring). Particularly in the current phase of rapid market growth, the experience gained from these implementation-related questions is vital to ensure the safety and reliability of future installations and the standardization of products. There is further need for action on the standardization and corresponding quality assurance of photovoltaic systems. This is particularly the case for building integration components, for which no standards are available despite the growing market.

During the report period the LEEE TISO Institute of SUPSI further pursued the latest phase in the project on **quality assurance and energy yield of photovoltaic modules** [21]. The seventh test cycle on 17 solar modules was completed, and an eighth series of measurements on 12 new module types (4 mc-Si, 5 pc-Si, 2 a-Si, 1 CIS) begun. The measurement procedure was modified to take account of degradation in the initial hours of operation. As from now, detailed measurements will be based following an iniatial accumulated energy of 20 kWh/m². The Class A solar simulator installed the previous year was certified by a registered institution under ISO 17025 for measurements of the I-V characteristic at 1000 W/m² insolation and 25°C, permitting measurements under the IEC 60904-1 standard to be made. The accuracy is ± 2.0%, and during the report period, a total of approx. 1000 measurements were carried out on the module; 10% of these were for commercial customers. Measurements on the 3 photovoltaic installations continued at the LEEE TISO. The latest events and results are now to be published in the new LEEE News [86] newsletter. In 2001, the LEEE TISO was awarded the Swiss Solar Prize for its extensive photovoltaic work.

In the joint **MTBF-PV** [22] project between LEEE TISO and the European test laboratory at Ispra, exhaustive measurements were carried out on the 252 modules of the almost 20-year old installation (10 kWp, 1982) using the solar simulator. It is interesting to note that despite changes in their outward appearance (discoloration, delamination, etc.), almost 60% of the modules showed a fall-off in performance of less than 10% below the manufacturers' specifications. From this it may safely be concluded that the majority of the modules will meet the specifications over the full 20 years of service. In-depth investigations of I-V characteristics, IR analysis and accelerated ageing were carried out on a number of cells and modules.

Measurements continued at PSI under **actual operating conditions** [37]. By comprehensive analysis, the energy yield characteristics of photovoltaic modules may be obtained for part load. This theme will be pursued in more detail in the **workshop** [38] to be organized by Enecolo in spring 2002.

Thanks to the support of the Mont Soleil Association, Localnet AG, Elektra Baselland and SFOE, the project on **long-term behavior of grid-coupled photovoltaic installations** [23] was continued at the photovoltaic laboratory of Burgdorf University of Applied Sciences (UAS). This involved 38 installations with 51 power inverters. During the report period, investigations on the 560 kWp installation at Mont Soleil were transferred to the precision measurement programme of Burgdorf UAS. Measurements indicate that the steady rise in power inverter availability observed in past years has now reached its peak. Following completion of the EU **PV-EMI** [24] project the previous year, the PV laboratory in Burgdorf carried out a number of supplementary tasks. Under these, the DC network simulation proposed in the original project was realized, and a further suggestion for the value of network impedance made based on the experimental experience gained. In addition, a 25 kW photovoltaic generator simulator for testing power inverters was built at Burgdorf (Fig. 5).

In the new EU **INVESTIRE** [25] project, Dynatex is cooperating with 19 other companies and 15 research laboratories in an extensive investigation of storage technologies for renewable energies, and in particular for photovoltaic island installations. A total of nine storage technologies that incorporate the principal types of battery (lead, lithium, nickel, metal-air) and alternative storage processes (supercaps, electrolysis/hydrogen/fuel cell, flywheel, compressed air, redox systems) will be studied, and their characteristics established under normal operating conditions. By this

means, the development potential of each system and the need for action in future can be assessed.

Fig. 5: *25 kW PV generator simulator (Burgdorf UAS), (source: Burgdorf UAS)*

OTHER PROJECTS AND STUDIES

The EU **PVSAT** [26] project on the remote monitoring of photovoltaic installations being carried out by Enecolo and its European partners was completed during the report period. The software prepared in the course of the project was validated on upwards of 50 photovoltaic installations in Holland, Germany and Switzerland. It was shown that for 60% of the installations, forecasts of actual yield may be made with an accuracy of better than ±10%. Although the reasons for deviations exceeding 10% are many and varied, some of these could nevertheless be pinpointed. The quality assurance method developed is now to be introduced by a photovoltaic manufacturer.

Meteotest is participating in the EU **SoDa** [27] project to provide worldwide solar data via Internet (http://soda.jrc.it). Suitable algorithms are to be developed based on the ESRA European Radiation Atlas, Meteonorm [87] and Satellight [88].

The CUEPE at the University of Geneva is participating in the EU **Heliosat 3** [28] project to determine solar energy content based on Meteosat data.

The system-relevant work on **thermophotovoltaics** [6] continued at PSI. The characteristics of the component parts of a small and a large 20 kW prototype burner were further investigated during the report period, and simulated by an analytical model. The work was rounded off by the preparation of cost estimates. The main outlet of this work is for the autonomous electricity supply of heating boilers.

In the EU **MSG: multi-user solar hybrid grids** [29] project, the University of Zurich continued its research on the social and scientific aspects of solar electricity generation in villages remote from the grid. During the report period, the social behavior model was modified to meet project requirements. The latest model takes account of the interaction between the physical data (e.g. battery charge) and social behavior.

INTERNATIONAL COOPERATION WITHIN IEA, IEC AND PV GAP

Over the report period, participation in the IEA (IEA PVPS) photovoltaic programme was characterized by continuity both at project level and regarding membership of the Executive Committee (ExCo). Following Italy and the Netherlands, Switzerland holds the 3rd chairmanship of this international programme. Numerous reports and publications on the programme may be

downloaded from the www.iea-pvps.org website. Generally speaking, 2001 was a very productive year from an IEA PVPS perspective.

In IEA PVPS Task 1, which is concerned with general **information work** [30], Switzerland is represented by Nova Energie. A further national report on the photovoltaic scene in Switzerland up to 2000 [89] was prepared during the report period. This formed the basis of the 6th edition of the annual international report on market developments in photovoltaics in IEA countries [90]. This report has now become a widely cited reference on developments and trends in the photovoltaic markets of IEA countries. The IEA PVPS Newsletter [91] provides information on the work of the IEA programme and on associated themes at regular intervals. A report on the 'added value' generated by photovoltaic power systems (added values of photovoltaic power systems) was completed during the report period [92].

TNC is responsible for the Swiss contribution to Task 2 on **operational experience** [31]. During the report period, the PVPS Performance Database [93] containing data from 256 photovoltaic installations in 11 countries (covering more than 8000 months' operating data) was distributed worldwide. A workshop [94] on the subject of operating characteristics, reliability and sizing of photovoltaic installations, which was held under the auspices of this project at the 17th European Photovoltaic Solar Energy Conference in Munich, proved a great success.

Dynatex is participating in the work on **stand-alone installations** [32] in Task 3. This project mainly concerns improvements in the quality and reliability of autonomous photovoltaic installations, and technical questions on hybrid systems and batteries. During the report period, work continued on a range of reports; the final versions should become available in the course of 2002.

ewz is responsible for the Swiss contribution to Task 5 concerning technical questions of **grid interconnection** [33] of photovoltaic installations. The project will be completed in the near future by the publication of several final reports. A wealth of useful information is available concerning regulations on grid-coupling of photovoltaic installations, islanding, and on larger numbers of PV systems in a distribution grid, and also addresses maximum grid capacity. Part of the information is also applicable to other distributed energy systems. In January 2002, a final international workshop [95] took place in Holland.

Task 7 on the theme of **integration of photovoltaics in the built environment** [34] is being managed by Enecolo. A database containing 450 projects on building integration can be accessed under www.task7.org. Information on products and applications in photovoltaics in the built environment may be accessed in a new database under www.pvdatabase.com. During the report period, a report on applications to non-building structures [96] was published. IEA PVPS Task 7 will be terminated in the near future by the publication of a further series of final reports. In this connection, note that 15 exceptional projects have already been published in the form of case studies. The latest knowledge on the integration of photovoltaics in buildings has been brought together in a new book [97]. Task 7 can justly claim to have expanded the theme of building integration of photovoltaic systems by the inclusion of many new aspects. Following completion of the above project, the IEA PVPS ExCo is now considering widening the theme of building integration in photovoltaics under a new Task 10. In this, it is not the intention simply to extend the previous Task, but to redefine objectives, the expertise required and the work areas under the new Task.

With the support of the State Secretariat for Economic Affaires (seco), Entec is responsible for the Swiss contribution to Task 9 on **photovoltaic development cooperation** [35], which is part of the Swiss Platform for Development Cooperation in Photovoltaics. Well-advanced drafts of final reports are now available in several areas of the work. This is a clear indication that the work of formulating recommendations on the application of photovoltaics in the developing countries has made substantial progress. Concrete results are expected in the course of 2002. Switzerland is responsible for coordinating the work of this project with bilateral and multilateral organisations. At national level, efforts are underway to strengthen the Swiss contribution in this important area. Thus a national workshop on Development Cooperation in Photovoltaics (PV DC) was organized with the support of SAEFL, seco and SDC. Switzerland's participation in selected PV DC projects is to be supported out of international project funds (e.g. Global Environmental Facility (GEF) and

Solar Development Group (SDG)). Moreover, SAEFL is financially assisting one of the pilot projects [39].

Alpha Real is representing Switzerland in TC 82 of IEC and is heading the working group PV systems to prepare and issue proposals for **international standards** [72]. Alpha Real is participating in the work of **PV GAP (PV Global Approval Programme)** [36], a worldwide programme on quality assurance and certification of photovoltaic systems. Over the report period, progress was made in terms of growing acceptance of PV GAP in industrial and financial circles. Differences do, however, exist between the exponents of IEC and PV GAP, and these are partly responsible for delays experienced in implementing essential standardization and quality assurance plans.

3. National cooperation

At national level, the diversity of cooperative effort was upheld over the report period within the projects and professional events. New projects were started in cooperation with private companies. The interest of these companies in photovoltaics has remained unbroken despite the attenuation in the Swiss market. There has, however, been an unmistakable reshuffle among the many parties involved, with certain exponents seeking strengthened cooperation with foreign partners. Indeed, attention is increasingly focusing on the international market. Workshops directed to specific themes have contributed to the interchange over the report period.

At programme level, cooperation was maintained with numerous federal agencies, cantons and the electricity industry. In this connection, the constant interchange with BBW, KTI, the Top Nano 21 programme, SAEFL, SDC and seco, and also with VSE, PSEL and the Mont Soleil Association, is worthy of special mention. All in all, these efforts helped to provide a broader base for project activities in the photovoltaic programme.

4. International cooperation

International cooperation continued over the report period in its many traditional ways. The institutional cooperation taking place within IEA, IEC and PV GAP has already been mentioned above. At project level, cooperation within the EU continued during 2001, and this concerned 16 projects in research and 4 projects in the EU energy programme. Further projects in the Altener programmes, with the ESA and in the EU IST programme are in progress. Regrettably, ratification of the bilateral agreements with the EU encountered further delay, so that the hoped-for improvement in the standing of the Swiss participants in EU projects has still not materialized. Intensive contacts were nevertheless maintained with responsible quarters in Brussels. From 2002 onwards, the new EU **PV-EC-NET** [40] project will improve networking among the various national photovoltaic programmes. Concerning development cooperation, further contacts were maintained with international organizations (World Bank, GEF, IFC, UNDP, GTZ, KfW, etc.). Thanks to the multiplicity of interchanges, and despite retardation of the Swiss market, Swiss photovoltaic has remained very prominent on the international stage.

5. Pilot and demonstrations projects

INTRODUCTION

During 2001, a total of 45 photovoltaic P+D projects were in progress. In addition, several projects were under review in the PV P+D programme at the beginning of 2002. The P+D activities comprised pilot plants, studies and tools, component development and measurement campaigns. The main emphasis was on full-scale pilot projects for testing new components in P+D installations, and this activity was intensified in comparison to the previous year. The increase occurred mainly in the area of **building integrated photovoltaic installations.** The degree of project orientation shifted with respect to the previous report period, with two-thirds of all projects now treating the theme of **building integration of photovoltaics.** The remaining projects concerned inverter technology, noise protection, stand-alone installations, measurements on various installations, quality assurance and PV planning tools.

Numerous Swiss products that had originated from P+D projects were able to maintain their market share both nationally and in other European countries. This applies especially to power inverters (Fig. 6), and to module integration and mounting systems. Where the two mounting systems SOLRIF and AluTec/AluVer are concerned, the clear indications of success the previous year were confirmed. By the end of 2001, SOLRIF profiles [82] (Fig. 7) for PV modules corresponding to a total rating of some 2 MWp had been delivered to customers in Europe, while for AluTec/Aluver [48] (Fig. 8), a volume corresponding to 3 MWp was exported. To judge by recent market developments, sales of the above two systems will remain at the same level or increase in the current year. These systems now rank among the highly successful P+D developments of recent years.

Fig. 6: *In recent years, European sales of power inverters from Sputnik Engineering have boomed (source: NET AG)*

Fig 7: *Full-area roof integration of SOLRIF (source: Enecolo AG)*

Fig 8: *Roof integration using Alutec/AluVer in Holland (source: NET AG)*

P+D PROJEKTS

New P+D Projects

In 2001, 11 new projects were begun in the PV P+D programme. The majority of these involve building integrated photovoltaics, particularly in roofs. Particular interest was raised by the construction of the Sunny Woods [52] (Fig. 9) passive solar apartment house in Zurich, which has a full-area roof integrated 16 kWp PV installation with amorphous cells. Detailed measurements on the project began in March 2002, and the first detailed results are expected at the end of 2002. It will be interesting to see what the reactions are to roof-integrated photovoltaics in the protected historic village center of Wettingen [83] (Fig.10) and to further developments in photovoltaic systems incorporated in green roofs. An example of the latter in the P+D programme is the Solgreen power station 1 in Zurich [54] (Fig. 11).

Fig. 9: *'Sunny Woods' PV installation with amorphous triple cells, (source: Kämpfen Architects)*

Fig. 10: *Roof integration using SOLRIF in Wettingen (source: H.-D. Koeppel)*

Fig. 11: *Solgreen power station 1, Zurich (source: Enecolo AG)*

The projects begun in 2001 were as follows:

Installations

↓# 12.75 kWp PV roof integration Wettingen (harmonious PV roof installation in the historic village center of Wettingen. Inexpensive system with standard components aimed at. Management: Owners Association P.P. Stöckli / H.-D. Koeppel and Energiebüro) [83], Fig. 10

↓# Newtech: comparison of three 1 kWp installations (direct comparison of three installations with different thin-film cells: a-tandem cells, a-triple cells, CIS cells. Management: Burgdorf CAT) [71]

↓# 25 kWp green roof integration Solgreen power station 1, Zurich (pilot application of a newly developed module mounting frame for green roofs. Management: Enecolo AG) [54], Fig. 11

↓# 16 kWp roof integration Sunny Woods (roof integrated PV pilot installation with amorphous triple cells in a passive solar apartment house. Management: Kämpfen Architects, Naef Energy Technology) [52], Fig. 9

↓# Zholar solar boat for hire on Lake Zurich (6-seater electric catamaran with an integrated autonomous 730 Wp photovoltaic installation for the electricity supply of the drive motor). Management: SSES Zurich regional group [61], Fig. 13

↓# 16.8 kWp photovoltaic installation St. Moritz with CIS modules (pilot application of modules with CIS technology for a plant of this size. Extensive measurement campaign. Management of installation part: Rätia Energie AG; measurement part: SUPSI-DCT, TISO) [62], Fig. 12

↓# 275 kWp photovoltaic installation Midfield Dock, Zurich Airport, of which 55 kWp form a PV demonstration installation (multifunctional photovoltaic building integration with shading function and special requirement on the mechanical stability of modules. Management: ARGE Zayetta) [63]

↓# Photocampa: multifunctional PV shading installations with a total capacity of 318 kWp (Parking de l'étoile, école de cirque, école de Lullier, Midfield Dock, Zurich Airport. Management: Windwatt SA) [66]

Fig. 12: *Installation in St. Moritz using CIS modules (source: TISO)*

Fig. 13: *Solar boat for hire on Lake Zurich (source: NET AG)*

Component development

↓# Inexpensive monitoring of photovoltaic installations (development of a simple and inexpensive monitoring unit for solar installations with wireless data transmission. Management: NewLink Anderegg) [84]

Studies – tools – various projects

↓# Quality is the Key to PV Market – accreditation / certification (preparation of quality assurance programmes for photovoltaics. Also see programme and standards [72], Altener project. Management: Alpha Real) [79]

↓# REMAC Renewable Energy Market Accelerator (measures to invigorate the market for renewable electricity. Management – Swiss contribution: NET AG) [78]

Current P+D Projects

In July 2001, the Mobicat Solar Catamaran [60] (Fig. 14), a passenger ship seating 150 persons, was inaugurated and taken into service. Initial operating experience indicates that the intended goal of low energy consumption was achieved. This enables operation to be maintained for several hours during bad weather or at night. Passengers were generally impressed by the exhilaration of almost noiseless gliding through the water.

For grid-coupled installations, measurements on the PV Eurodach amorphous installation demonstrated the expected low temperature dependency of the voltage, and thus also of the energy yield [49], Fig. 15.

Fig. 14: *Inauguration of Mobicat (source: NET AG)*

Fig. 15: *PV Eurodach amorph, Flumroc (source: NET AG)*

On the 10 kWp Solgreen installation in Chur [53], Fig. 16, plant growth is as desired. The green roof and the PV installation harmonize well, and no shading due to plants was observed. Experience gained in erecting the system was applied directly in further developing the Solgreen system.

The 80 kWp noise barrier installation along the A1 in Safenwil [56], Fig. 17, commenced grid operation in 2000 and was officially inaugurated in spring 2001. The major part of the energy produced was accorded solar electricity status and sold as such. Credit is due to IG SOLAR Safenwil for the substantial efforts made in achieving this result.

The excellent stability and functionality of the LonWorks monitoring system was demonstrated in its first year of operation. The system with its 68 power inverters was installed in the 260 kWp

installation at Felsenau [50], Fig. 18. Final data evaluation and project assessment are planned following completion of the measurement phase around mid-2002.

Fig. 16: *Solgreen installation in Chur (source: ars solaris hächler)*

Fig. 17: *Noise barrier A1 Safenwil (source: SFOE)*

Current projects include:

Installations

↓# Héliotrope, 3 x 2 kWp PV installations in Le Locle (direct comparison of identical, but differently installed, systems (building integration, stand-alone, tracking). Management: EICN, Le Locle) [57]

↓# 10 kWp 'SolGreen' installation integrated in a grass roof (newly developed support structure for grass roofs, flat-roof integration. Management: ars solaris hächler) [53], Fig. 16

↓# Héliotram, 800 kWp PV installations Lausanne/Geneva with DC direct injection into the tram grid (management: Sunwatt Bio Energie SA) [65]

↓# 3 kWp installation at Amburnex Farm (mobile island installation with auxiliary diesel generator supplying electric power to an alp, autonomous installation. Management: Services Industriels Lausanne) [58], Fig. 19

↓# 3 kWp PV Eurodach amorph (thermally insulated PV metal jointed roof with amorphous triple cells, building integration. Management: PAMAG Engineering) [49], Fig. 15

↓# 80 kWp PV noise barrier installation A1 Safenwil (combination of photovoltaics with a wooden noise barrier in modular construction using partly premounted elements. Management: Ekotech AG) [56], Fig. 17

↓# 10 small-scale roof integrated PV systems (small-scale integrated PV installation (240 Wp), mostly in combination with a thermal installation, building integration. Management: Ernst Schweizer Metallbau AG) [51]

↓# Electrically driven passenger ship with auxiliary PV (catamaran seating 150 persons with an autonomous 20 kWp installation for supplying the drive motor. Management: Minder Energy Consulting) [60], Fig. 14

↓# 260 kWp PV installation fitted with LonWorks field bus power inverters (pilot installation of 68 PV power inverters with LON nodes for data exchange and installation monitoring. Management: Sputnik Engineering AG) [50], Fig. 18

Fig. 18: *Felsenau installation with LON monitoring (source: NET AG)*

Fig. 19: *Autonomous installation Alp Amburnex (source: Services Industriels Lausanne)*

Component development

↓# Sunplicity solar roof slates (development of a PV roof slate with particular attention given to high robustness, ageing resistance, simple mounting and cabling, building integration. Management: Alpha Real AG) [44], Fig. 20

Measurement campaigns

↓# Visualization and evaluation of PV installation on the Rothorn (Management: Chur University of Applied Sciences) [67]

↓# 1 megawatt NOK solar chain (normalized data 1997-2001. Management Axpo) [68]

↓# Mark I measurement campaign (100 kWp installation A 13. Management: TNC Consulting AG) [69]

↓# 47.5 kWp installation IBM (self-cleaning surface coating of modules, flat-roof installation. Management: awtec AG, Zurich) [70], Fig. 21

Fig. 20: *Test stand with Sunplicity roof slates (source: TISO)*

Fig. 21: *Flat-roof installation IBM Zurich (source: NET Ltd)*

Studies – tools – various projects

↓# Standardization work on PV systems (management: Alpha Real) [72]

↓# Integration of combined PV and thermal collectors in building systems (management: S. Kropf, ETH Zurich) [76]

↓# Electro college of further education PV programme 2001 (management: TNC Consulting) [A]

↓# Swiss Photovoltaic Statistics 2000 (management: Energiebüro) [B]

↓# Solar electricity from the utiltiy 2000/2001 (management: Linder Kommunikation AG) [C]

Projects Completed in 2001

Among the projects completed in 2001, the roof integrated 6.4 kWp installation with amorphous cells at IMT Neuchâtel [46] takes a prominent position by virtue of its consistently high yield (1000 kWh/kWp per year) and uninterrupted operation over the past 5 years. In the field of architecture, great interest was also raised by the installations at the Stadelhofen cantonal school [49], Fig. 22, and the Altstadt Unterseen PV roofs [47], Fig. 23. Following completion of several projects in the studies and tools sectors, efforts are now concentrating on practical implementation – a key objective of this P+D programme.

In 2001, the following P+D projects were completed:

Installations

↓# Hybrid 7 kWp PV installation in Domdidier, (hybrid electricity – hot air plant, building integration. Management: GEIMESA) [45]

↓# 6.4 kWp installation integrated in the roof of the Institute of Microtechnology in Neuchâtel (PV elements with amorphous cells, building integration. Management: IMT) [46]

↓# Three 10 kWp photovoltaic noise barrier installations along the expressway (combined photovoltaic and noise protection system, 3 prototype plants. Management: TNC Consulting) [55]

↓# 3 kWp roof installation with Sunslates (autonomous plant, building integration. Management: Atlantis Solar Systems AG) [80]

↓# 23.5 kWp PV installations Stadelhofen cantonal school (PV insulating glass and shading system, building integration. Management: TNC Consulting) [59], Fig. 22

↓# 6 kWp PV roofs Altstadt Unterseen (PV integration in historic buildings, building integration. Management: Industrielle Betriebe Interlaken) [47], Fig. 23

↓# PV installation at Wauwilermoos penitentiary (PV demonstration installation. Management: Cantonal Agency for Energy Questions, Lucerne) [81]

↓# 32 kWp installation EG Hünenberg (PV installation with new, inexpensive support structure for standard modules. Management: Urs Bühler Energy Systems and Engineering) [48]

↓# 151 small-scale grid-coupled PV installations (small-scale installations with phase power inverters, total capacity 200 kWp, including 30 kWp in Switzerland. Management of Swiss contribution: Phébus Suisse) [64]

Fig. 22: *Stadelhofen cantonal school, Zurich (source: NET Ltd.)*

Fig. 23: *PV roofs Altstadt Unterseen (source: NET Ltd.)*

Component development

↓# SOLight modular support structure (lightweight support structure for flat-roof installations. Management: Energiebüro) [42]

↓# Optimization of Solgreen system (optimization of system in respect of costs, easy mounting and material, building integration. Management: Enecolo AG) [43]

Studies – tools – various projects

↓# GRS guaranteed results for PV systems (EU Altener project, quality assurance. Management of Swiss contribution: Energiebüro) [73]

↓# Feasibility study of photovoltaic installation at Wankdorf Stadium (fundamental study on the realisation of a large PV installation with thin-film technology, study. Management: Hostettler Engineering Consultancy) [75]

↓# HORIZsolar Phase II (exact digital measurement and processing of the horizon for solar energy installations, PV tools. Management: Energiebüro) [74]

↓# PV City Guide, Phase 1: international studies, overall final report (realization of PV installations in an urban environment. Management Swiss contribution: NET AG) [77]

6. Assessment of 2001 and perspectives for 2002

In the wake of the referendum of 24 September 2000, the year 2001 must be regarded from several perspectives. Generally speaking, the Swiss photovoltaic market is expected to remain of the same order as the previous year. Developments are mainly dictated by the solar electricity exchanges. Though these serve to underpin market progress, they do not contribute to a significant extent to product innovation, the reason being that the cost factor mostly (if not always) dictates use of the simplest possible solutions. Following the shift of responsibility for photovoltaic promotion to the cantons, the picture now varies greatly from one region to another. Under such conditions, and due to the varied assessment of the situation by industry, a reshuffle among the parties is only to be expected. While some companies see recent developments in a negative light – there was one case of bankruptcy – others have adopted a more forward-looking policy, often with an international bias. Indeed, some companies and products have proved very successful. **In general therefore, the situation can be typified as one of 'consolidation'.**

Research, development and implementation funding was generally maintained at the same level as hitherto. **In view of the continuing tight financial situation, however, broadly-based programme support remains essential,** and this was expanded in 2001. From a technological standpoint, and as far as implementation and international cooperation are concerned, the year 2001 must be regarded as a success. This is clearly demonstrated by the examples given. Swiss photovoltaics was widely represented at the 17th European Photovoltaic Solar Energy Conference in Munich [98].

To judge by the projects now underway and those presently being launched, the **perspectives for 2002 are buoyant.** The difficult financial situation nonetheless calls for a decided market focus. Furthermore, the adoption of common goals and ideas by those involved will assist in further strengthening the Swiss photovoltaic industry. Larger projects, which would undoubtedly have a more intensive demonstration effect, need to be initiated in the P+D sector. Information exchange will be maintained and fostered by specialist workshops, and particularly by the National Photovoltaic Symposium in Lugano. The Swiss photovoltaic website www.photovoltaic.ch will come into full operation in 2002.

7. List of Research projects and Internet websites

(AR) Annual report 2001 available
(FR) Final report available

[1] A. Shah, (arvind.shah@unine.ch), IMT, UNI-Neuchâtel: **IMT 2000 - 2002 Technologische Weiterentwicklung der mikromorphen Solarzellen** (AR) / http://www-micromorph.unine.ch

[2] A. Shah, (arvind.shah@unine.ch), IMT, UNI-Neuchâtel: **DOIT: Development of an optimized integrated thin film silicon solar module** (AR) / http://www-micromorph.unine.ch

[3] A. Shah, (arvind.shah@unine.ch), IMT, UNI-Neuchâtel: **Advanced Solar Antennas (ASOLANT)** (AR) / http://www-micromorph.unine.ch

[4] Ch. Hollenstein, (christophe.hollenstein@epfl.ch), CRPP / EPFL-Lausanne: **Large area and high-throughput coating system (PECVD) for silicon thin-film solar cells** (AR)

[5] D. Fischer, (info@vhf-technologies.com), VHF-Technologies – Le Locle: **Procédé de fabrication industrielle de cellules solaires flexibles sur film plastique mince pour l'alimentation d'appareils électroniques** (AR) / http://vhf-technologies.com

[6] B. Bitnar, (Bernd.Bitnar@psi.ch), PSI-Villigen: **Entwicklung thermophotovoltaisher Zellen und Systeme für die Erzeugung von Wärme und Strom** (AR / http://www.psi.ch/LMN

[7] A.N. Tiwari, (tiwari@phys.ethz.ch), IQE, ETH-Zürich: **CADBACK: The CdTe thin film solar cell - improved back contact** (AR) / http://www.tfp.ethz.ch/

[8] A.N. Tiwari, (tiwari@phys.ethz.ch), IQE, ETH-Zürich: **FLEXIS: CIS thin film solar cells on flexible substrates** (AR) / http://www.tfp.ethz.ch/

[9] A.N. Tiwari, (tiwari@phys.ethz.ch), IQE, ETH-Zürich: **PROCIS: Production of large are CIS modules** (AR) / http://www.tfp.ethz.ch/

[10] A.N. Tiwari, (tiwari@phys.ethz.ch), IQE, ETH-Zürich: **NANOCIS: Nanomaterials for high efficiency and low cost Cu (In,Ga) Se2 thin film solar cells - TOP NANO 21** (AR) / http://www.tfp.ethz.ch/

[11] M. Grätzel (michael.graetzel@epfl.ch), ICP2 / EPF-Lausanne: **Dye sensitised nanocrystalline solar cells** (AR) / http://dcwww.epfl.ch/icp/ICP-2/icp-2.html

[12] M. Grätzel (michael.graetzel@epfl.ch), ICP2 / EPF-Lausanne: **Nanocrystalline Flexible Photovoltaic Cells based on Sensitized Heterojunctions - TOP NANO 21** (AR) / http://dcwww.epfl.ch/icp/ICP-2/icp-2.html

[13] M. Grätzel (michael.graetzel@epfl.ch), ICP2 / EPF-Lausanne: **Highly efficient nanocrystalline solar cells for indoor applications - TOP NANO 21** (AR) / http://dcwww.epfl.ch/icp/ICP-2/icp-2.html

[14] M. Grätzel (michael.graetzel@epfl.ch), ICP2 / EPF-Lausanne: **Freiluft - Messungen von Solarzellen neuer Technologie** (AR) / http://dcwww.epfl.ch/icp/ICP-2/icp-2.html

[15] T. Meyer, (toby@solaronix.com), SOLARONIX, Aubonne: **LOTS-DSC (Longterm stability of dye-sensitized solar cells for large area power applications)** (AR) / http://www.solaronix.ch/

[16] G. Calzaferri, (gion.calzaferri@iac.unibe.ch), UNI-Bern: **Photochemische, Photoelektrochemische und Photovoltaische Umwandlung und Speicherung von Sonnenenergie** (AR) **/** http://iacrs1.unibe.ch

[17] Ch. Roecker, (christian.roecker@epfl.ch), LESO / EPF-Lausanne: **PV en face! Low-cost, high-quality concepts for facade integrated PV systems** (AR) / http://lesomail.epfl.ch/

[18] Ch. Roecker, (christian.roecker@epfl.ch), LESO / EPF-Lausanne: **Demosite 2000 - 2002 Demosite and Demosite Flat Roofs (phase IV)** http://www.demosite.ch (AR) / http://lesomail.epfl.ch/

[19] P. Toggweiler, (info@enecolo.ch), ENECOLO - Mönchaltorf: **EnerBuild RTD: Energy in the built environment** http://www.enerbuild.net (AR) / http://www.solarstrom.ch

[20] P. Hofer, (ho@3-s.ch), 3S – Bern: **HIPERB: High performance photovoltaics in buildings** (AR)

[21] D. Chianese, (domenico.chianese@dct.supsi.ch), LEEE, SUPSI - DCT, Canobbio: **TISO 2000 - 2002 Qualità e resa energetica di moduli ed impianti fotovoltaici** (AR) / http://leee.dct.supsi.ch

[22] D. Chianese, (domenico.chianese@dct.supsi.ch), LEEE, SUPSI - DCT, Canobbio: **SOLAREC Mean time before failure of photovoltaic modules (MTBF-PVm)** (AR) / http://leee.dct.supsi.ch

[23] H. Häberlin, (heinrich.haeberlin@hta-bu.bfh.ch), HTA-Burgdorf: **Langzeitverhalten von netzgekoppelten PV-Anlagen 2** (AR) / http://www.hta-bu.bfh.ch/e/pv/pv-indd.htm

[24] H. Häberlin, (heinrich.haeberlin@hta-bu.bfh.ch), HTA-Burgdorf: **PV-EMI: Development of standard test procedures for electromagnetic interference (EMI) tests and evaluations on PV components and plants** (AR) / http://www.hta-bu.bfh.ch/e/pv/pv-indd.htm

[25] M. Villoz, (mvilloz@dynatex.ch), DYNATEX - Colombier: **INVESTIRE: Investigation on storage technologies for intermittent renewable energies: evaluation and recommended R&D strategy** (AR)

[26] P. Toggweiler, (info@enecolo.ch), ENECOLO - Mönchaltorf: **PVSAT: Remote performance check for grid connected PV systems using satellite data** (AR) / http://www.solarstrom.ch

[27] S. Kunz, (remund@meteotest.ch), Meteotest - Bern: **SoDa: Integration and Exploitation of networked Solar Radiation Databases** http://soda.jrc.it (AR) / http://www.meteotest.ch

[28] P. Ineichen, (pierre.ineichen@cuepe.unige.ch), CUEPE - Genève: **HELIOSAT-3: Energy-Specific Solar Radiation Data from Meteosat Second** (AR) / http://www.unige.ch/cuepe/intro.htm

[29] H.-J. Mosler, (mosler@sozpsy.unizh.ch), Universität – Zürich: **MSG: Combined project on multi-user solar hybrid grids** (AR) / http://www.sozpsy.unizh.ch/sozpsy-gutscher.html

[30] P. Hüsser, (pius.huesser@novaenergie.ch), NOVA ENERGIE, Aarau: **Schweizer Beitrag zum IEA PVPS Programm, Task 1** (AR) / http://www.novaenergie.ch/

[31] Th. Nordmann, (nordmann@tnc.ch), TNC CONSULTING - Erlenbach: **Schweizer Beitrag zum IEA PVPS Programm, Task 2** (AR) / http://www.tnc.ch

[32] M. Villoz, (mvilloz@dynatex.ch), DYNATEX - Colombier: **Participation Suisse à la Tâche III AIE - PVPS IEA Task 3** (AR)

[33] S. Taiana, (sergio.taiana@ewz.stzh.ch), EWZ - Zürich: **EWZ 2000 - 2002 Schweizer Beitrag IEA PVPS Task 5** (AR) / http://www.ewz.ch/

[34] P. Toggweiler, (info@enecolo.ch), ENECOLO - Mönchaltorf: **Enecolo 2000 - 2001 Schweizer Beitrag IEA PVPS Task 7 - Phase II Schweizer Beitrag IEA PVPS Task 7** (AR) / http://www.solarstrom.ch

[35] S. Nowak, (stefan.nowak.net@bluewin.ch), NET – St. Ursen: **Schweizer Beitrag IEA - PVPS Task 9 – seco** (AR) / http://www.photovoltaic.ch

[36] M. Real, (alphareal@access.ch), ALPHA REAL - Zürich: **Global Approval Programm PV GAP** (AR)

[37] W. Durisch, (wilhelm.durisch@psi.ch) PSI-Villigen: **Charakterisierung von PV Generatoren** / http://www.psi.ch/LMN

[38] P. Toggweiler, (info@enecolo.ch), ENECOLO - Mönchaltorf: **Workshop Energierelevante Kriterien für Solarmodule** / http://www.solarstrom.ch

[39] S. Nowak, (stefan.nowak.net@bluewin.ch), NET – St. Ursen: **Pilotmässige Unterstützung von GEF-Anträgen im Bereich Solarenergie – BUWAL** / http://www.photovoltaic.ch

[40] S. Nowak, (stefan.nowak.net@bluewin.ch), NET – St. Ursen: **PV-EC-NET** / http://www.photovoltaic.ch

8. List of P+D projects and Internet websites

(AR) Annual report 2001 available
(FR) Final report available
ENET: ENET Order number

[42] Ch. Meier, (christian.meier@energieburo.ch), Energiebüro, Zürich: **New Light-Weight Flat Roof Photovoltaic Module Mounting System** (AR, FR) / http://www.energieburo.ch

[43] P. Toggweiler, (info@enecolo.ch), Enecolo AG, Mönchaltorf: **SOLGREEN- Optimierung des Systems Solgreen** (AR, FR) / http://www.solarstrom.ch

[44] M. Real, (alphareal@smile.ch), Alpha Real AG, Zürich: **Solardachschiefer Sunplicity** (AR)

[45] J. Audergon, (jacques.audergon@geimesa.ch), GEIMESA, Fribourg: **Système hybride photovoltaïque et thermique de 7 kWp, Domdidier** (AR) / http://www.geimesa.ch

[46] R. Tscharner, (Reto.Tscharner@imt.unine.ch), IMT, Université de Neuchâtel: **Roof integrated amorphous silicon photovoltaic plant IMT Neuchâtel** (AR, FR) / http://www-micromorph.unine.ch

[47] F. Bigler, (fritz.bigler@ibi-interlaken.ch), Industrielle Betriebe Interlaken: **PV roofs in the old town of Unterseen** (AR, FR) / http://www.ibi-interlaken.ch, ENET: 210035

[48] U. Bühler, (u.bue_cham@bluewin.ch), Urs Bühler Energy Systems and Engineering, Cham: **Slopedroof- and façade – mounting-system AluTec / AluVer** (AR, FR)

[49] H. Kessler, (hke.pamag@flumroc.ch), PAMAG AG, Flums: **3 kWp PV Eurodach amorph**, (AR) / http://www.flumroc.ch

[50] Ch. von Bergen, (sputnik@solarmax.com), Sputnik Engineering AG, Nidau: **LonWorks as Fieldbus for PV-Installations** (AR, Intermediary report) / http://www.solarmax.com

[51] A. Haller; (andreas.haller@schweizer-metallbau.ch), Ernst Schweizer AG, Hedingen: **10 Roof Integrated PV Small Scale Systems** (AR) / http://www.schweizer-metallbau.ch

[52] B. Kämpfen, Architekturbüro Kämpfen (kaempfen.arch@gmx.ch) R. Naef, (naef@igjzh.com), Naef Energietechnik, Zürich: **Sunny Woods** (AR)

[53] R. Hächler, (ars_solaris@freesurf.ch), Ars Solaris Hächler, Chur: **Pilot installation 10kWp Flat Roof System "SOLGREEN"** (AR)

[54] P. Toggweiler, (info@enecolo.ch), Enecolo; Mönchaltorf: **Solgreen Kraftwerk 1** (AR) / http://www.solarstrom.ch

[55] Th. Nordmann, (info@enecolo.ch), TNC Consulting, Erlenbach: **Three pilot 10 kWp integrated PV sound barrier fields** (AR, FR) / http://www.tnc.ch

[56] R. Hottiger, (ig-solar@bluewin.ch), IG Solar Safenwil: **PV / Noise Barrier Installation "Alpha A1" in Safenwil** (AR) / http://www.ekotech.ch

[57] G. Jean-Richard, (jeanrichard@eicn.ch), EICN, Le Locle: **PV Anlage Héliotrope EICN** (AR) / http://www.eicn.ch

[58] P. Favre, (pierre-pascal.favre@lausanne.ch),Services Industriels Lausanne: **Amburnex Solar Farm (3 kWp)** (AR) / http://www.lausanne.ch/energie

[59] Th. Nordmann, (nordmann@tnc.ch), TNC Consulting, Erlenbach: **27 kWp PV-Installation High School Zurich-Stadelhofen** (AR, FR) / http://www.tnc.ch

[60] R. Minder, (rudolf.minder@bluewin.ch), Minder Energy Consulting, Oberlunkhofen: **SolarCat - Solar-Electric powered Passenger Ship** (AR) / http://www.minder-energy.ch

[61] R. Schmid, (roli.schmid@gmx.ch), SSES Regionalgruppe Zürich: **Zholar, Mietsolarboot auf dem Zürichsee** (AR, FR)

[62] N Cereghetti, (nerio.cereghetti@dct.supsi.ch), TISO, Canobbio, F. Stöckli, Rätia Energie, Poschiavo: **PV Anlage St. Moritz mit CIS Zellen** (AR) / http://leee.dct.supsi.ch/PV/Welcome_TISO.htm

[63] M. Hubuch, (m.hubbuch@hswzfh.ch), Hochschule Wädenwil, Th. Gautschi, ARGE Zayetta, Zürich: **PV Anlage Dock Midfield Zürich Flughafen** (AR)

[64] R. Diamond, (phebus.suisse@swissonline.ch), Phébus Suisse, Genève: **151 small grid connected PV stations for a total of 200 kWp, of which 30 kWp in Switzerland** (AR) / http://www.ecotourisme.ch.

[65] M. Schneider, (schneider-m@bluewin.ch), Sunwatt Bio Energie SA, Chêne Bourg: **HELIOTRAM : 800 kWp PV power plants for direct injection in light train low voltage D.C. networks** (AR) / http://www.sunwatt.ch

[66] A. Main, (parkingsolaire@windwatt.ch) Windwatt SA, Genève: **PV Anlagen Photocampa** (AR) / http://www.windwatt.ch

[67] M. Schalcher, (Max.Schalcher@fh-htwchur.ch), Ingenieurschule HTA, Chur: **Visualisation and Analysis of the Data of the 4,1kWp PV-Power Plant Rothorn** (AR) / http://www.fh-htachur.ch

[68] S. Roth, (stefan.roth@axpo.ch), Axpo, Zürich: **NOK's 1-Megawatt Solar Chain, Normalized Data 1997 to 2001** (AR) / http://www.axpo.ch

[69] Th. Nordmann, (nordmann@tnc.ch), TNC Consulting, Erlenbach: **Messkampagne Mark I** (AR) / http://www.tnc.ch

[70] A. Schlegel, (andreas.schlegel@awtec.ch), awtec AG, Zürich: **Coating of PV-Modules** (AR) / http://www.awtec.ch

[71] Ch. Renken, (CHRISTIAN.RENKEN@isburg.ch), ADEV Burgdorf: **Newtech, Vergleich von 3 verschiedenen 1 kWp Dünnschichtanlagen** (AR)

[72] M. Real, (alphareal@smile.ch), Alpha Real, Zürich, **Normenarbeit für PV Systeme** (AR) / http://www.iec.ch

[73] Ch. Meier, (christian.meier@energieburo.ch), Energiebüro, Zürich**: Guarantee of Solar Results for Grid-Connected-Photovoltaic-Systems 'GRS-PV'** (AR, FR) / http://www.energieburo.ch

[74] Ch. Meier, (christian.meier@energieburo.ch), Energiebüro, Zürich: **HORIZsolar** (AR; FR) / http://www.energieburo.ch

[75] Th. Hostettler, (hostettler_engineering@compuserve.com), Ingenieurbüro Hostettler, Bern: **Feasibility Study "PV installations with Thin-film Cells integrated into football stadiums"** (AR, FR)

[76] S. Kropf, (sven.kropf@freesurf.ch), ETH Zürich: **Integration von kombinierten PV- und thermischen Kollektoren in Gebäudesystemen** (AR, FR Phase1) / http://www.airflow.ethz.ch

[77] S. Nowak, (stefan.nowak.net@bluewin.ch), NET AG, St. Ursen: **PV City Guide** (AR, FR) / http://pvcityguide.energyprojects.net

[78] S. Nowak, (stefan.nowak.net@bluewin.ch), NET AG, St. Ursen: **REMAC Renewable Market energy accelerator** (AR)

[79] M. Real, (alphareal@smile.ch), Alpha Real, Zürich: **Quality in the Key of the PV Market - PV Training, Accreditation & Certification** (AR)

[80] B. Bezençon, SGI, Lausanne: **3 kW_p stand-alone hybrid (PV-Diesel) installation in Soyhières (JU)**

[81] R. Durot, (r.durot@tic.ch), ZAGSOLAR; Kriens: **PV-installation Wauwilermoos** (AR 2000)

[82] P. Toggweiler, (info@enecolo.ch), Enecolo AG, Mönchaltorf: **SOLRIF (Solar Roof Integration Frame)** (FR) / http://www.solarstrom.ch, ENET: 200160

[83] H.-D. Koeppel, (hans-dietmar.koeppel@skk.ch), Eigentümergemeinschaft P.P. Stöckli / H.-D. Koeppel, Wettingen: **PV Dachintegration Dorfkernzone Wettingen**

[84] E. Anderegg, (ean@newlink.ch), Newlink Anderegg, Füllinsdorf: **Einfach und kostengünstige Überwachungseinheit für Solaranlagen**

[A] Th. Nordmann, (nordmann@tnc.ch), TNC Consulting, Erlenbach: **PV on vocational Colleges in Switzerland, 9 Years Experience in Training and Education** (AR) / http://www.pv-berufsschule.ch

[B] Ch. Meier, (christian.meier@energieburo.ch), Energiebüro, Zürich, **Photovoltaic Energy Statistics of Switzerland 2000** (AR) / http://www.energieburo.ch

[C] E. Linder, (linder@linder-kom.ch), Linder Kommunikation AG, Zürich, **Solar electricity from the utility** (AR) / http://www.linder-kom.ch **/** http://www.strom.ch/deutsch/ch-strom/solarstrom-ew.asp

9. References

[85] **Forschungskonzept Photovoltaik 2000 – 2003**, Bundesamt für Energie, 2001, http://www.photovoltaic.ch

[86] **LEEE-News, Newsletter of the Laboratory of Energy, Ecology and Economy**, zu beziehen bei TISO, Fax 091 935 13 49, Email: leee@dct.supsi.ch

[87] **Meteonorm 4.1, Global Meteorological Database for Solar Energy and Applied Meteorology**, http://www.meteotest.ch

[88] **Satellight, The European Database of Daylight and Solar Radiation**, http://satellight.entpe.fr

[89] **Swiss national report on PV power applications 2000**, P. Hüsser, (pius.huesser@novaenergie.ch), Nova Energie, 2001

[90] **Trends in Photovoltaic Applications in selected IEA countries between 1992 and 2000**, IEA PVPS Task 1 – 10: 200, http://www.iea-pvps.org

[91] **IEA PVPS Newsletter**, zu beziehen bei Nova Energie, Schachenallee 29, 5000 Aarau, Fax 062 834 03 23

[92] **Added values of Photovoltaic Power Systems**, IEA PVPS Task 1 – 09: 200, http://www.iea-pvps.org

[93] **Performance Database**, IEA PVPS Task 2, Version 1.19, July 2001, http://www.task2.org

[94] **Workshop Operational Performance, Reliability and Sizing of Photovoltaic Power Systems**, IEA PVPS Task 2, 17th European Photovoltaic Solar Energy Conference and Exhibition, Munich, October 2001

[95] **Workshop Impacts of PV Penetration in Distribution Networks – Network Aspects on High Penetration Level of PV Systems and Islanding Analysis**, IEA PVPS Task 5, January 2002

[96] **PV in Non Building Structures – a design guide**, IEA PVPS Task 7 - 02: 2000, http://www.iea-pvps.org

[97] **Building with Solar Power**, IEA PVPS Task 7, to be published by Images Australia

[98] **17th European Photovoltaic Solar Energy Conference and Exhibition in München** – aus Schweizer Sicht, BFE, 2002, http://www.photovoltaic.ch

10. Further information

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11. Abbreviations (and Internet websites)

General terms

HES	Haute Ecole Spécialisée	
HTA	Institute of Engineering and Architecture (University of Applied Sciences)	
PV EZA	Photovoltaics – development cooperation	http://www.photovoltaic.ch

Funding institutions

FOGA	Forschungs-, Entwicklungs- und Förderfonds der schweizerischen Gasindustrie	
PSEL	Fund for Projects and Studies of the Swiss Electric Utilities	http://www.psel.ch

National institutions

ATAL	Amt für technische Anlagen und Lufthygiene des Kantons Zürich	
BBW	Federal Office for Education and Science	http://www.admin.ch/bbw
CORE	Swiss Federal Energy Research Commission	http://www.energie-schweiz.ch/bfe/de/forschung/core/
CRPP	The Plasma Physics Research Centre of Switzerland EPFL	http://crppwww.epfl.ch
CUEPE	Le Centre universitaire d'étude des problèmes de l'énergie	http://www.unige.ch/cuepe
EAWAG	Swiss Federal Institute for Environmental Science and Technologie	http://www.eawag.ch
EICN	Ecole d'Ingénieurs du Canton de Neuchâtel	http://www.eicn.ch
EMPA	Swiss Federal Laboratories for Materials Testing and Research	http://www.empa.ch
EPFL	Ecole Polytechnique Fédérale Lausanne	http://www.epfl.ch
ETHZ	Swiss Federal Institute of Technology Zurich	http://www.ethz.ch
EWZ	Elektrizitätswerk der Stadt Zürich	http://www.ewz.ch
HTA Burgdorf	University of Applied Sciences Burgdorf	http://www.hta-bu.bfh.ch
HTA Chur	University of Applied Sciences Chur	http://www.fh-htachur.ch
ICP	Institut de Chimie Physique EPFL	http://dcwww.epfl.ch/icp/ICP-2/icp-2.html
IMT	Institut de Microtechnique Universität Neuchâtel	http://www-imt.unine.ch
IQE	Institute of Quantum Electronics ETHZ	http://www.iqe.ethz.ch
KTI	Kommission für Technik und Innovation	http://www.admin.ch/bbt/d/index.htm
LEEE - TISO	Laboratory of Energy, Ecology and Economy - Ticino	http://leee.dct.supsi.ch
LESO	Laboratoire d'Energie Solaire EPFL	http://www.lesomail.epfl.com
OPET	Federal Office for Professional Education and Technology	http://www.admin.ch/bbt
PSI	Paul Scherrer Institut	http://www.psi.ch
SAEFL	The Swiss Agency for the Environment, Forest and Landscape	http://www.umwelt-schweiz.ch/buwal/de/
SDC	Swiss Agency for Development and coorperation	http://www.deza.admin.ch
SECO	State Secretariat for Economic Affairs	http://www.seco-admin.ch
SFOE	Swiss Federal Office of Energy	http://www.admin.ch/bfe
SI Lausanne	Services Industriels Lausanne	http://www.lausanne.ch/energie/epsilon/default.htm
SUPSI	Scuola universitaria professionale della Svizzera Italiana	http://leee.dct.supsi.ch
VSE	Verband Schweizerischer Elektrizitätsunternehmen	http://www.strom.ch

International institutions

EU (RTD)	European Union (RTD-Programme) Community Research & Development Information Service	http://www.cordis.lu
EESD	Energy, Environment and Sustainable Development	http://www.cordis.lu/eesd/
IST	Information society technologies	http://www.cordis.lu/ist/
ESA	European Space Agency	http://www.esa.int
GEF	Global Environmental Facility	http://www.gefweb.org
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit	http://www.gtz.de
IEA	International Energy Agency	http://www.iea.org
IEA PVPS	Photovoltaic Power Systems Implementing Agreement (IEA)	http://www.iea-pvps.org
IEC	International Electrotechnical Commission	http://www.iec.ch
IFC	International Finance Corporation	http://www.ifc.org
KfW	Kreditanstalt für Wiederaufbau	http://www.kfw.de
PV GAP	PV Global Approval Programme	http://www.pvgap.org
SDG	Solar Development Group	http://www.solardevelopment.org/
UNDP	United Nations Development Programme	http://www.undp.org

Private institutions and companies

ESU	Environmental consultancy for business and authorities	http://www.esu-services.ch
EWE	Elektrowatt Engineering	http://www.ewe.ch
NOK	Nordostschweizerische Kraftwerke	http://www.nok.ch

12. Further Internet websites

	Swiss Photovoltaic Website	http://www.photovoltaic.ch
	Swiss Energy	http://www.energie-schweiz.ch
	Energieforschung des Bundes	http://www.energieforschung.ch
SNF	Swiss National Science Foundation	http://www.snf.ch
GWF	Swiss Science Agency	http://www.gwf-gsr.ch/
ETH-Board	Board of the Swiss Federal Institutes of Technology	http://www.ethrat.ch
Top Nano	Technology Oriented Programme Top Nano 21	http://www.ethrat.ch/topnano21/
FOS	Federal Office for Statistics	http://www.statistik.admin.ch/
IGE	Swiss Federal Institute of Intellectual Property	http://www.ige.ch
	Swiss Federal Office of Metrology and Accreditation metas	http://www.metas.ch/

	Swiss Academic and Research Network Switch	http://www.switch.ch
Swissolar	Swiss Task Force for Solar Energy Swissolar	http://www.swissolar.ch
SOFAS	Sonnenenergie Fachverband Schweiz	http://www.sofas.ch
PROMES	Association des professionnels romands de l'énergie solaire	http://www.promes.ch
SSES	Swiss Solar Energy Society	http://www.sses.ch
	US Department of Energy, Photovoltaic Program	http://www.eren.doe.gov/pv/
ISES	International Solar Energy Society	http://www.ises.org
ESRA	European Solar Radiation Atlas	http://www.helioclim.net/esra/

Annual Report 2001

Technologische Weiterentwicklung der "mikromorphen" Solarzellen

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Project- / Contract -Number	36487 / 76286
Duration of the Project (from – to)	1.1.2000 - 31.12.2002

ABSTRACT

The present 3-year project is concerned with the further development of the micromorph tandem solar cell technology with the view to obtain industrially relevant manufacturing processes. During 2001, the following main results were obtained:

- The deposition rate of microcrystalline silicon has been investigated using IMT's novel "compact VHF electrodes"; thereby, an enhancement of the deposition rate (to ~10 Å/sec at a pressure of 0.3 mbar) was achieved.
- NREL confirmed an initial cell efficiency of 10.6 % for a single-junction p-i-n amorphous silicon solar cell (1 cm^2) deposited on IMT's in-house LP-CVD ZnO. This cell has a thickness of only 0.25 µm and a relative degradation (as previously measured by us) of about 15 %.
- In the p-i-n configuration, IMT's high-quality amorphous silicon p-i-n cells could be combined with microcrystalline bottom cells of high open circuit voltage leading thereby to a record high open circuit voltage (V_{oc}) of 1.413 mV (and a fill factor FF of 73 %).
- Comparative spectral response measurements of micromorph tandem solar cells deposited on IMT's in-house ZnO and on the best available commercial SnO_2 (Asahi type U) confirm the superiority of IMT's in-house ZnO w.r.t light-trapping: with IMT's in-house ZnO one can estimate a stabilized tandem efficiency of 11 % with a 2 µm thick µc-Si:H bottom cell.
- Two novel back reflectors with light-scattering properties were developed for the n-i-p configuration: The first one based on stainless steel - rough silver - sputtered ZnO has a haze factor of 90 % and more between 700 and 900 nm; the second one based on the use of PET - silver - sputtered ZnO has a haze fator of 50 % between 700 and 900 nm. Microcrystalline n-i-p solar cells with current densities of 24 mA/cm^2 were deposited on the first type of back reflector.
- In the n-i-p configuration, a micromorph tandem with V_{oc} = 1.368 mV and a fill factor of 64 % (initial efficiency 9.6 %) was realised.

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Annual Report 2001

DOIT

Development of an Optimized Integrated Thin-film silicon solar module

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Project- / Contract -Number	BBW 00.0337 / ENK6-2000-00321
Duration of the Project (from – to)	1.1.2001 – 31.12.2003

ABSTRACT

This European project aims at the development of an innovative silicon thin film solar module, exhibiting a stabilised active area efficiency of 11% on a substrate size of 30x30 cm^2. The device consists of an amorphous silicon/microcrystalline silicon tandem solar cell (so-called micromorph cell) prepared on a low cost TCO coated glass substrate. In view of industrial production, a deposition rate of at least 4 Å/s will be achieved for the intrinsic layer of the microcrystalline silicon (µc-Si:H) bottom cell. Besides the scale-up of state-of-the-art small area micromorph cells prepared by Very High Frequency Glow Discharge (which is the main task of IMT), an alternative approach will be followed using lower excitation frequencies (by the Forschungszentrum Jülich); this approach is are more compatible with current a-Si:H production technology. Implementation of advanced plasma control tools should here ensure a successful scale-up.

The development of this innovative solar module also includes the module fabrication technology with monolithic integration of the electrical series connection, and the study of efficient light trapping schemes. For the latter objective, this project focus on the choice of the most appropriate transparent conductive oxide (TCO) layer available (either on the market or from running European projects) rather than on the development of new TCO layers; it relies on extensive optical characterisation techniques and modelisation in order to optimise light trapping within the solar cells.

During the first year of this project, IMT has successuflly completed the construction of a large-area (30x30 cm^2) two-chamber reactor for the deposition of a-Si:H and µc-Si:H layers and cells. Using this deposition system, µc-Si:H intrinsic layers have been deposited with uniformity better than 10% (30x30 cm^2) at deposition rates between 3 and 4 Å/s. The optimisation of doped layers is underway and the deposition of the first µc-Si:H cells in this large-area system are expected at the beginning of 2002.

Annual Report 2001

Design and breadboarding of advanced solar antennas (ASOLANT)

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Project- / Contract -Number	ASOLANT, AO/1-3543/99/NL/SB
Duration of the Project (from – to)	01.05.2000 – 02.04.2001

ABSTRACT

Solar cells and high-gain antennas are often in competition for the available surface in satellite systems. The aim of this project is to use antenna surface in order to produce electricity, thanks to solar modules integrated in the antenna. The precedent project SOLANT 6 showed that it is possible to use the antenna surface without deteriorating the antenna performance and thereby to obtain solar modules with a very good power/weight ratio. In this new project, a real space application was considered. Antenna and solar modules were designed, built, and measured in order to show the minimum functionalities required for a real space application. The antenna design had to satisfy electrical and geometric criteria which were defined by the space requirements. In this project GaAs solar cells are required to be integrated in an antenna and compared with the amorphous silicon solar cells integrated in a similar antenna. Up to now, the GaAs solar cells could not be integrated in the antenna, therefore no comparison was so far possible.

In this project, the antenna size and the electrical power requirements were defined by Carlo Gavazzi Space SpA (Italian manufacturer of satellites) in function of the Italian satellite “MITA”. According to these requirements, solar modules were designed and fabricated. The design of the “strings” of series-connected solar cells, depends on the required voltage and on the antenna geometry. One of the problems encountered was due to variation in the geometrical design of the antenna which had to be changed in order to optimise the antenna. Two kinds of antennas were fabricated because with the specifications mentioned above. It appears that to fulfil the MITA requirements, a very small antenna would be enough (i.e. a single Circular Polarisation (CP) patch or a slot resonator). Nevertheless, in order to demonstrate the possibilities and the performances of the ASOLANT concept, a large antenna with a lot of surface available for the solar cells is more appropriate; therefore two antenna concepts were followed up : a single CP patch (which is omni-directional), and a directional CP array.

At the end of the project, prototypes were built with the two antennas and with corresponding amorphous silicon solar modules partially mounted. The integration was successfully demonstrated; furthermore, the extrapolated total power sum of each solar module fulfils the requirements.

Annual Report 2001

Large area and high-throughput coating system (PECVD) for silicon thin-film solar cells

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Project- / Contract -Number	KTI 4559.1
Duration of the Project (from – to)	April 2000 - April 2002

ABSTRACT

The goal of the project is the design and development of a large area and high throughput coating system for silicon thin-film solar cells, based on plasma enhanced chemical vapour deposition (PECVD).

In a first phase, the optimisation of the deposition rate and homogeneity of the amorphous silicon intrinsic layer of the solar cell with respect to electrode gap and plasma excitation frequency has been performed at the CRPP. Solar cell production relevant deposition rates and material quality have been obtained. Various topics concerning the plasma technology of large area solar cells have been treated. This includes modelling of segmented electrodes, reactor impedance, matching design, power transfer efficiency and also some scaling up issues. Current work is concentrated on demonstrating that the RF plasma reactor is capable of producing thin film solar cells in an industrial single chamber process environment.

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Annual Report 2001

Procédé de fabrication industriel de cellules solaires flexibles sur film plastique mince

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Project- / Contract -Number	CTI 4622.1
Duration of the Project (from – to)	1.1.2000-31.3.2001

ABSTRACT

VHF-Technologies SA was founded in February 2000 to industrialize the amorphous silicon on flexible substrate solar cell technology developed by the IMT of the University of Neuchâtel over the years 1996-1999.

The goal of this research project was to transfer the IMT technology to a pilot-line level, thereby enabling VHF-Technologies to serve as soon as possible a growing market demand in the field of wireless and autonomous electronics.

This transfer was achieved as planned thanks to a very close collaboration between VHF-Technologies SA and the Ecole d'Ingénieurs du Canton de Neuchâtel (EICN) on the site of EICN in Le Locle, in the laboratory of Prof. Herbert Keppner.

As a result, a roll-to-roll reactor for continuous VHF-deposition of amorphous silicon cells on a 30 cm wide flexible polyimide substrate was designed, built and taken into operation.

This reactor has a nominal annual capacity of 2000 sqm, and was shown to produce amorphous silicon solar cells in continuous rolls of 30 meters x 30 cm.

Based on such a roll, VHF-Technologies and EICN were able to demonstrate in May 2001 a world record length flexible monolithically series connected solar module (28 meter long, 30 cm wide, 2 kg weight)

Solar cell efficiencies, based on a p-i-n structure without light-trapping and without a window-layer, were shown to reach consistently values between 3 to 4 %.

BFE OFEN UFE SFOE

Annual Report 2001

Entwicklung thermophotovoltaischer Zellen und Systeme für die Erzeugung von Wärme und Strom

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Project- / Contract -Number	22819 / 68060
Duration of the Project (from – to)	10/1998 – 10/2001

ABSTRACT

We present a thermophotovoltaic (TPV) prototype system, based on a 2 kW butane burner, which functions with an Yb_2O_3 selective emitter and silicon photocells. The system was characterised in detail, including the measurement of the emitter radiation spectrum and all components were systematically optimised. We achieved an electricity output of 48 W with 2 kW thermal power. This corresponds to a ratio of electrical to thermal power of 2.4 %, a record for a silicon TPV system.

Using the geometry of the prototype and the optical spectra of all its components, a simulation model was developed, which allows the detailed study of the system. We could calculate the electrical output power with an agreement better than 3 % to the experimental system. Using the model, the influence of the axial reflectors, an infrared reflecting filter and the heat recuperation from the exhaust gas on the electricity output to heat input ratio could be studied. We found for our system a maximum electricity to heat ratio of about 10 %, which could be achieved by applying recuperation and a selective filter.

An application of the TPV is its integration into domestic heating systems to produce the electrical power needed for the operation of the boiler including the recirculation pump. Especially in rural regions, a TPV boiler would provide heat and hot water with a very high security of supply. We built a demonstration system heated by a 20 kW methane burner. This system produced 121 W electrical power at 12 kW thermal power and 164 W at 20 kW. This system was integrated into a domestic boiler from HOVAL AG. Detailed tests of the TPV boiler are planned for the near future.

In parallel to the development of the TPV systems, investigations on SiGe layers as infrared absorbing material in Si photocells were carried out. These cells should show an increased efficiency for radiation of emitters with a temperature at 1300 – 1500°C. We used an UHV-CVD system to grow SiGe quantum well structures on silicon. The growth rates for SiGe layers with different Ge contents was determined, as well as the critical layer thickness of these structures on a silicon substrate. We achieved an epitaxial growth, even of multilayers with high Ge content, close to the critical layer thickness, demonstrated with TEM pictures. As a first result, we could measure the absorption of a 10 layer wave-like SiGe structure with 35 % Ge content.

BFE OFEN UFE SFOE

Annual Report 2001

The CdTe thin film solar cell-improved back contact (CADBACK)

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Project- / Contract -Number	EU project-BBW Nr. 97.0397-1
Duration of the Project (from – to)	01.06.1998 to 31.12.2001

ABSTRACT

We have developed efficient and stable electrical contacts on CdTe layers grown by close space sublimation (ANTEC GmbH process) and high vacuum evaporation (ETHZ process). Different type of buffer layers and metal layers were investigated. Sb or Sb_2Te_3 buffer and Mo metallisation layers yield the best results, cells with efficiency upto 12.7% were obtained. High efficiency cells were obtained when the CdTe surface was modified. Different methods were used to produce Te-rich CdTe surface; the photovoltaic properties of solar cells developed on using those layers were characterised. Accelerated stability tests on non-encapsulated solar cells prove the long term stability of solar cells. Effect of impurity diffusion was investigated with SIMS and quantum efficiency measurements.

Annual Report 2001

CIS Thin Film Solar Cells on Flexible Substrates (FLEXIS)

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Project- / Contract -Number	EU project-BBW Nr. 97.0398
Duration of the Project (from – to)	01.07.1998 to 30.06.2001

ABSTRACT

Flexible CIGS solar cells with conversion efficiency of 12-13% were developed on polyimide films. For the development of such solar cells on polymers the absorber layers should be grown at a low substrate temperature (450 °C). Therefore, a “three-step” CIGS co-evaporation process, for a substrate temperature of 450 °C, was developed. The structural properties of the CIGS layers were compared to the layers grown with constant evaporation rates of elements. The three-step process was found to enhance the grain nucleation. An efficiency of 14.0 % has been achieved with this process for solar cells grown on soda lime glass substrates. The effect of NaF co-evaporation on the structural properties of CIGS was investigated. Polymers in general do not contain Na, while an optimum concentration of Na in CIGS is needed for efficient solar cells. Incorporation of Na in CIGS by diffusion from a NaCl layer through a polyimide was demonstrated.

BFE OFEN UFE SFOE

Annual Report 2001

Production of Large Area CIS Modules (PROCIS)

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Project- / Contract -Number	EU project-BBW Nr. 00.0402
Duration of the Project (from – to)	01.01.2001 to 31.12.2003

ABSTRACT

High efficiency $Cu(In,Ga)Se_2$ (called CIGS) solar cells have been obtained with chemical bath deposited (CBD) buffer layers. However, vacuum deposited buffer layers are preferred for industrial production of large area modules. We have developed CIGS solar cells with vacuum evaporated buffer layers of II-VI semiconductors. Growth and properties of buffer layers and the photovoltaic performance of solar cells have been investigated. Another topic of investigation is the low temperature deposition of CIGS absorbers and addition of Na by means of a precursor. We have shown that the co-evaporation NaF can be used for the controlled and reliable incorporation of Na during the growth of the CIGS layers.

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Annual Report 2001

Nanomaterials for high efficiency and low cost $Cu(In,Ga)Se_2$ thin film solar cells (NANOCIS)

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Project- / Contract -Number	TOPNANO21: 5491.3 TNS
Duration of the Project (from – to)	1. July 2001 to 30. June 2003

ABSTRACT

The chemical and microstructural properties of $CuInSe_2$ and $Cu(In,Ga)Se_2$ layers, called CIS, deposited with nanoparticle precursors have been investigated. Three categories of nanoparticles, namely oxide, selenide and metal particles were selenized with elemental vapours of Se in a N_2 purged reactor and in a vacuum chamber at different selenium partial pressures. Transformations of (Cu + In) metal and Cu(In,Ga)-oxides into selenides have been shown with X-ray diffraction; peaks corresponding to the chalcopyrite crystal structure were observed. Densification, cracking and formation of large grains in layers depend on the conditions of selenization.

BFE OFEN UFE SFOE

Annual Report 2001

Dye sensitised nanocrystalline solar cells

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Project- / Contract -Number	Project No. BBW 95.0703
Duration of the Project (from – to)	Indeterminate - noncontractual

ABSTRACT

The standard photovoltaic devices developed and applied over recent decades are solid state devices, with semiconductor layers absorbing light and thereby producing electron-hole pairs, which are subsequently separated to provide a photovoltage by junctions, either with other semiconductors or Schottky contacts with metals. It is recognised that sensitised photoelectrochemical devices offer the only technically and economically credible alternative concept to this solid-state approach. The processes of optical absorption and charge separation take place on distinct sites within these photovoltaic cells. In consequence oppositely charged species are restricted to separate phases, so conventional recombination losses are suppressed. Therefore device photoconversion efficiency is maintained even at low light levels. A hybrid variant is also under investigation, the dye-sensitised solid state heterojunction, where the semiconductor provides the charge separation as in the conventional approach, but not the optical absorption. Significant progress has been made during the past year, particularly with the heterojunction device.

BFE OFEN UFE SFOE

Annual Report 2001

Nanocrystalline Flexible Photovoltaic Cells based on Sensitized Heterojunctions

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Project- / Contract -Number	TOP NANO 21, project 4994.1
Duration of the Project (from – to)	Sept. 2000 - March 2001

ABSTRACT

The project aims to demonstrate the feasibility of fabrication of thin-film dye-sensitised heterojunction solar cells on flexible plastic substrates, the materials forming the junctions being, for the photoanode a nanocrystalline porous titania semiconductor, and for the cathode an organic p-type " hole conductor ". Both materials are in the solid state. Consequently the cell contains no liquid or gel electrolyte, and as a result there is a much reduced problem of cell sealing, since only a barrier against humidity and oxidation is required. The device is not only more rugged and with a greater mechanical reliability than the electrochemical system, but is better adapted to fabrication on a flexible substrate, such as a plastic film. In consequence there is the prospect of further cost reduction.

Annual Report 2001

Highly efficient nanocrystalline solar cells for indoor applications - TOP NANO 21

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Project- / Contract -Number	TOP NANO 21, project 5480.3
Duration of the Project (from – to)	Mai 2001 - April 2003

ABSTRACT

The goals of this project are the up-scaling, and technology transfer of key nanoparticle based technologies for the production of dye solar cells which have been developed in the laboratory of Prof. Grätzel at EPFL, to the recently founded company Greatcell Solar SA. These technologies involve the synthesis of nanoparticulate semiconductors, and methods of preparing mesoporous layers from these materials on transparent conducting oxide coated glass substrates. Dye and electrolyte development also enters into the project. This action is critical to the start-up company Greatcell Solar, as it will furnish key information and technology required for the industrial production of dye solar cells for indoor applications.

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Annual Report 2001

Freiluft-Messungen von Solarzellen neuer Technologie

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Project- / Contract -Number	PSEL 168
Duration of the Project (from – to)	1999 - 2002

ABSTRACT

The project deals with the development of dye-sensitized nanocrystalline solar cells for outdoor use and test in natural environment. Such measurements are of great interest to judge the energy conversion yields of these new photovoltaic devices under realistic reporting conditions. The project has started in the spring of 1999 with preparative work at EPFL. A container for the solar cells was constructed and has been tested at EPFL in open-air experiments. It has meanwhile been installed at the Mont Soleil photovoltaic test station. In parallel, new organic redox electrolytes were developed and tested in the EPFL laboratory to ascertain stable operation of the cells under outdoor conditions. The effect of temperature on the cell performance was measured at full sunlight (AM 1.5, 1000 W/m^2) and one tenth of a sun (AM 1.5, 100 W/m^2). In full sunlight the efficiency remained practically stable over a temperature range from 0°C to 70°C. This distinguishes the nanocrystalline cells from con-ventional solid state devices whose efficiency declines significantly, i.e. ca 35%, over the same temperature range. A new sealant was identified that is compatible with the electrolyte. Cells were constructed showing stable indoor operation under UV light and/or temperature stress. A new series of experiments were conducte outdoors with these cells to establish the effect of the air mass number on the photovoltaic conversion efficiency. The conversion efficiency varied from 8.76 % at AM 2 to 7.3 % at AM 3.47 and 6.09 percent at AM 9.11 (sun setting). A first series of cells has been placed in the box at Mont Soleil for ouside aging tests.

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Annual Report 2001

LOTS-DSC

Long Term Stability of Dye Solar Cells for Large Area Power Applications

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Project- / Contract -Number	EU: JOR3-CT98-0261
Duration of the Project (from – to)	01.07.1998 to 30.07.2001

ABSTRACT

The Dye Sensitized Solar Cell (DSC) technology uses the principles of the regenerative photoelectrochemical solar cell: A dye stained nanocristalline titanium oxide (TiO_2) electrode deposited on a conductive oxide coated glass forms the photoanode, which faces the platinum coated counter-electrode. The gap between the electrodes is filled with an organic electrolyte containing the redox couple iodide/tri-iodide (I^-/I_3^-) necessary for the charge transport within the cell. A rim sealing encloses the system. The DSC technology could allow a significant cost reduction of solar energy as the materials and processing employed is rather simple and low cost compared to traditional technologies based on silicon.

To be able to commercialize Dye Solar Cells for large area power applications it needs to be clear what module lifetimes and efficiencies can be obtained. Therefore there are two main objectives of this project:

a) To demonstrate that a 10 year outdoors module lifetime is feasible
b) To demonstrate that a module efficiency of 10 % is theoretically feasible

The stability results can be summarized as following:
In artificial high intensity irradiation (ca. 2500 W/m^2) no degradation in the output power was observed after 8300 hours light exposure (it actually went up by ca. 5 %). When the temperature was elevated to 45°C, the maximal degradation was less than 10 % after 4000 hours at 1000 W/m^2 irradiation.

In pure UV irradiation at 10 mW/cm^2 intensity (340-390 nm) and ca. 38°C, the stability behavior was strongly depending the electrolyte composition. Best stability was obtained with electrolytes containing magnesium iodide or calcium iodide, with no degradation observed after 3300 hours without any UV-filter. The only drawback of those modified electrolytes is there lower performance (by ca. 30%) compared to the standard electrolyte containing no MgI_2 or CaI_2.

In thermal testing without light or UV irradiation, the cells remained stable over a period of 2200 hours at 60°C, the performance degraded only marginally, starting from 5.25 % efficiency (measured in artificial calibrated sun at 1000 W/m2) and ending at 5.1 % at the end of the thermal exposure. At 85°C, the output degradation was important with 30% after 875 hours of testing – using glass frit sealed cells.

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Annual Report 2001

Photochemische, Photoelektrochemische und Photovoltaische Umwandlung und Speicherung von Sonnenenergie

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Project- / Contract -Number	76645 / 36846
Duration of the Project (from – to)	2000 – 2002

ABSTRACT

Thin AgCl layers photocatalytically oxidize water to O_2 under appropriate conditions. The nanostructured silver chloride layer acts as photocatalyst in the presence of a small excess of silver cations, with a maximum evolution rate between pH 4 and 6. The photoactivity of AgCl extends from the UV into the visible light region in a process known as self-sensitization, which is due to the formation of silver during the photoreaction. Real time characterization of the AgCl electrode is possible with in-situ UV-Vis reflectance spectroscopy. The reduced and reoxidized silver species are spectroscopically visible. Spectra were taken in-situ during the course of a typical Ag/AgCl electrode experiment. Considerable improvement of sensitivity has been observed with AgBr sensitized Ag/AgCl photoanodes. Theoretical investigations helped us to find an explanation for the conductivity of silver doped AgCl clusters. To test its water splitting capability, the Ag/AgCl photoanode was combined with platinized silicon solar cells or p-$GaInP_2$ as photocathode. Despite the fact that the Ag/AgCl photoanode has still to be polarized, the combination with a photocathode makes the overall water splitting photoassisted.

Host-guest composites with photonic antenna properties have been prepared. The materials consist of cylindrical zeolite L crystals the channels of which are filled with chains of joined but electronically non interacting dye molecules. Light shining on a crystal is first absorbed and the energy is then transported by the dye molecules inside the tubes to the desired part. Data on crystals in the size range of 30 nm up to 3000 nm are reported. The synthesis principle we are using is based on the fact that molecules can diffuse into individual channels. This means that given the appropriate conditions, they can also leave the zeolite by the same way. In some cases, however, it is desirable to block their way out, for stability reasons. This is done by adding a closure molecule. The general approach to connect the antenna function to its surroundings is to add "stopcock" molecules which generally contain of a head, a spacer and a label. They can either trap excitation energy on the external surface or inject excitation energy into the dye-loaded crystal. The stopcock molecules act as a bridge between the dye molecules inside the channels and the outside world. Functionalisation of the closure and the stopcock molecules is an option for tuning e.g. wettability, refractive index, and chemical reactivity. The wide-ranging tunability of the dye-zeolite L composites makes them useful for many applications, e.g.: Applications as high quality and non-toxic pigments, strongly luminescent pigments applicable as colour-changing media for LEDs, options for realising nanoscaled laser materials, and finally the challenge for realising a solid state solar cell based on sensitisation of a thin semiconductor layer by energy transfer, the reversal of which can also lead to a new generation of LEDs.

Annual Report 2001

PV en Face !

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Project- / Contract -Number	97.0479/ JOR3-CT98-0225
Duration of the Project (from – to)	from 1.8.1998 to 30.10.2001

ABSTRACT

PV en Face ! was contracted as part of the Joule III program of DG XII (JOR3 - CT98 - 0225). Partners are ECOFYS (NL), EPFL (CH), BP (GB) and TFM (ES).

PV en face aimed at the development of a number of facade integration design concepts, applying a design strategy with strong emphasis on low-cost, yet high-quality, building integration techniques. Main achievements to be reached included a cost level of 8 - 10 E / Wp and improved market acceptance.

Within this project, the LESO designed an add-on concept for blind walls. This concept is based on a multifunctional frame for PV modules, holding standard PV laminates and providing an easy-to-mount interface to the facade.

The main activities for 2001 were the following:

- Start marketing process (publications, industry contacts)
- Prospect possibilities for building a pilot plant
- Build a demonstration façade at the Demosite

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Annual Report 2001

Demosite 2000 - 2002
Demosite (phase IV)

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Project- / Contract -Number	37468 / 77205
Duration of the Project (from – to)	From 1st of April 2000 to 31th of March 2002

ABSTRACT

In 2001, DEMOSITE continued to promote and stimulate the development of Building Integrated Photovoltaic:

- Numerous contacts were established through PVPS Task 7 (Photovoltaic Power System, PV in the Built Environment), of the International Energy Agency - PVPS Programme
- Several group visits were organised on the site location in Lausanne,
- A particular attention was dedicated to the development of the Website.

DEMOSITE also organised in November a workshop to present BIPV to architects and building owners. A wide variety of PV products, mounting techniques and building integration methods have been presented. The result of this presentation was to provide, discuss and disseminate the results on show at DEMOSITE.
A large documentation choice was also on display.

This year four new pavilions have been built, and one dismantled.

- **Solgreen II**, a modular mounting system for the integration of PV panels on grass covered roofs.
- **Solface,** a new fastening system for PV laminates built on facades.
- **Freestyle,** a brand new flexible roof system for sloped roofs.
- **Kawneer,** a new integration of PV on façade with PV louvres.

- **Shell's** installation was removed, to make room for newer technology.

BFE OFEN UFE SFOE

Annual Report 2001

Enerbuild
Energy in the Built Environment

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Project- / Contract -Number	BBW Nr. 00.0308
Duration of the Project (from – to)	2000 - 2003

ABSTRACT

The EnerBuild RTD Thematic Network aims to enhance co-operation and the exchange of knowledge between co-ordinators of building sector energy research and development projects supported in the European Commission's Fourth and Fifth Framework programmes. With the overall objective of contributing to the reduction in fossil fuel derived energy use and consequent environmental emissions, EnerBuild RTD will deliver the results of past and current research in this area to potential users in the most important sectors with the greatest dissemination potential.

State of the art reviews will focus on enhancing the technical and industrial content and prioritisation of future European energy-related building research and links with other R&D actions and Thematic Networks will be fostered to help optimise research effort and encourage synergies and collaboration at European and national levels. The effectiveness of different dissemination strategies and media will be evaluated.

Thematic Networks bring together manufacturers, users, universities and research centres around a given scientific or technical objective, and include co-ordination networks between EC funded projects. This Network comprises about 50 current and recently completed building-related renewable energy and energy saving R&D projects, and will include similar new projects from the Fifth Framework programme. Projects are grouped in carefully-constructed dynamic Thematic Groups co-ordinated by internationally-respected experts, and considerable emphasis will be accorded inter-cluster opportunities and horizontal dimensions such as socio-economic and other cross-cutting objectives at the European level.

In the reporting year there was a Thematic Group 4 Meeting in Freiburg (DE), a Steering Committee meeting in Brussels and a project workshop with more than 60 participants in Malmö.

Further information is available on www.enerbuild.net.

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Annual Report 2001

HIPERB High Performance photovoltaics in buildings

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Project- / Contract -Number	EC: NNE5-1999-0233
Duration of the Project (from – to)	(1. April 2000); 1. Oktober 2001

ABSTRACT

The aim of the project is to develop high performance, high quality and stable thin-film PV modules for the integration into buildings (façades as well as roofs) forming a fully integrated part of the outer skin of the building. The work includes modules for the façade and modules suited for the replacement of roofing tiles and slates in an advanced manner resulting in performance and cost improvements as compared to the existing technologies and designs. All the aspects from cell and module technology to assembling and electrical interconnection and life-time testing are included. An important goal is to increase the public acceptance of PV in buildings by covering of aesthetic aspects, architectural ideas and demands of protection of historic buildings. Security aspects and building regulations are also being considered.

Cost reduction is aimed at mainly by standardisation of products and parts, process optimisation and by giving the modules the potential to adopt multiple functions in the building (replacement of expensive decorative elements of façades and customary roof parts). The range of module sizes extends from small sized roof tile size to standard production module size (e.g. 1200mm x 600mm) and larger sizes which will be realised by assembling of submodules. Technologies used in structural glazing are being adapted for framing and fastening elements of the façade modules. Long-term stability will be analysed by procedures according to international standards.

The consortium combines manufacturers and developers of PV cells and modules with glass-manufacturers, producers of manufacturing equipment, partners providing materials and processes for module encapsulation (lamination with glass and/or polymers and cast resins) and an authority in the field of testing and module evaluation.

BFE OFEN UFE SFOE

Annual Report 2001

Qualità e resa energetica di moduli ed impianti PV TISO - periodo VI: 2000-2002

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Project- / Contract -Number	36508 / 76324
Duration of the Project (from – to)	1 January 2000 - 31 December 2002

ABSTRACT

This year the LEEE-TISO has completed the 7th test-cycle of the modules and has begun a new (8th) test using 12 new types of modules chosen and bought anonymously from those available on the Swiss market (4 sc-Si; 5 mc-Si; 2 a-Si; 1 CIS). The test procedure has been modified so as to take into account the initial degradation present during the first hour of exposure to light; the modules are tested after having been exposed to the equivalent of 20 kWh/m^2 of incident radiation. One stand has, in addition, been set aside for a control-test of the temperature of Evergreen photovoltaic roof tiles.

During the month of February, the class A solar simulator in operation at the LEEE-TISO, was accredited in accordance with the ISO 17025 norm of the Swiss office of Accreditation (SAS) for the measurements of the characteristic I-V at 1000 W/m^2 and 25°C (IEC 60904-1). The accuracy of the power measurement was ±2.0% without correcting the spectral mismatch. Throughout the year 1000 measurements of modules were performed, of which about 100 were for external clients.

The measurements of the 3 TISO plants are continuing (10, 4 and 0.5kW). The European project MTBF for the detailed observation and measurement of the degradation of the 10kW plant modules has been prolonged for a final year and a half. In the 4 kW plant, the a-Si modules that have been thermally insulated at the back have shown a maximum increase in performance of approx. +10%.

A newsletter “the LEEE News” has been created so as to keep the public informed of the activities of the LEEE, in particular the TISO. This will be distributed in English every six months, either via e-mail or on paper. The Web page has been brought up to date and enriched with a programme to determine the distant horizon. The access to this page is by request only.

The LEEE-TISO has been awarded the Swiss Solar Award 2001 in the category “Institutes” in recompense for the work performed so far as centre for photovoltaic module testing.

Annual Report 2001

Mean Time Before Failure of Photovoltaic modules (MTBF-PVm)

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Project- / Contract -Number	BBW 99.0579
Duration of the Project (from – to)	17.04.2000 – 16.04.2003

ABSTRACT

The MTBF project is a collaboration between the LEEE-TISO and the ESTI laboratory (JRC, Ispra) to determine the Mean Time Before Failure of the 10 kW PV plant installed on the roof of the University of Applied Science of Southern Switzerland (SUPSI). The importance of this study is improved by the fact that it concerns the first grid-connected PV plant in Europe (1982).

The combination of systematic monitoring and laboratory measurements provides a unique opportunity to study the plant; investigating the physical degradation mechanisms in action, comparing field performance with indoor performance measurements and correlating field reliability with accelerated lifetime tests.

20 months have been elapsed from the beginning of the MTBF project and interesting results have been obtained, giving the possibility to draw first conclusions on plant conditions and on its hypothetic lifetime; and, on the other hand, to find other aspects to analyse and in which to go deep.

The indoor performance measurement of all 252 modules of the plant (with the LEEE-TISO Sun Simulator) was one of the most important works executed in 2001. Obtained data gave the possibility to correlate visual defects with module electrical characteristics and to accurately estimate their power degradation. The most remarkable result shows that 59% of the modules exhibit a variation of less than –10% to the stated nominal power, meaning that, after 20 years, the larger part of the modules respects the guarantee limits (-10%) declared by the manufacturer.

Another interesting result concerns the effect of overheated areas on module performance: hot-spots represent the principal cause of power degradation, for example the least efficient module of the plant, with a maximum power of 26.2 W (-29% with respect to the nominal value) has a hot-spot.

Evident visual defects, like yellowing and sealant infiltration, seem not to affect the module performance and its insulation level.

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Annual Report 2001

Langzeitverhalten von netzgekoppelten Photovoltaikanlagen 2 (LZPV2)

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Project-Number	39949
Duration of the Project (from – to)	01.06.2000 – 31.08.2003

ABSTRACT

Purpose and Goals of the new project during 2001

- Installation of analytical monitoring system at 555kWp PV plant Mont Soleil (1'270 meters above sea level) with Siemens M55 modules and 500kW ABB inverter. The monitoring system has been working successfully since 1st June 2001.
- Measurements of all PV plants in the project (38 PV plants with 51 inverters at present) have been made without interruptions.
- Repair work at the PV plant Jungfraujoch. Two damaged modules had to be replaced.
- Shutdown of the PV plant EBL Liestal for more than 2 months in summer 2001. The plant was disassembled for roof renovations. After rebuilding, the shadowing situation of the plant is worse.
- In a student's project a new software for online data presentation of all PV plants equipped with analytical monitoring systems was developed by HTA Burgdorf.

Most important results in 2001

- Inverter reliability decreased slightly in the last 2 years. The majority of defects were observed at older inverters that have been operated for several years.
- Energy production of PV plant Jungfraujoch in 2001 was lower than in previous years, because of massive snow coverage at the plant over a 3 month period in spring 2001 and maintenance work at the façade causing additional shadowing in summer 2001.

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Annual Report 2001

PV-EMI:

Development of standard Test Procedures for Electromagnetic Interference (EMI) Tests and Evaluations on PV Components and Plants

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Project-Number	JOR3 CT98 0217 , BBW 97.0301
Duration of the Project (from – to)	01.06.1998 – 31.08.2000

ABSTRACT

Purpose and Goals of project during 2001

This EU-project (partners: FhG / ISE (BRD), HTA Burgdorf (CH) and KEMA (NL)) was terminated in August 2000. In principle, as the project was over and no funding for any work available from the funding institutions, there would have been no obligation at all to do any further work in this field. However, as there were a few interesting open questions, the following goals remained:

- Development of a new DC-line-impedance stabilisation network (DC-LISN) with the new values agreed upon by the project group at the end of the project (common mode impedance Z_{CM} = 250Ω, differential mode impedance Z_{DM} = 100Ω)
- Publications of the most interesting project results found by the PV laboratory of HTA Burgdorf (it was agreed by the project group that during the project, only common publications could be made)
- Establishment of a common proposal about the impedance of a DC-LISN and applicable limits with the other EU-project group (ESDEPS) co-ordinated by ISET.

Most important results in 2001

- Realisation and successful test of a new DC-LISN (1000V / 75A) with the new values agreed upon by the project group (common mode impedance Z_{CM} = 250Ω and 150Ω, differential mode impedance Z_{DM} = 100Ω) in the frequency range 150 kHz to 30 MHz.
- Common proposal about the impedance of a DC-LISN and applicable limits with the other EU-project group (ESDEPS) presented at the 17. EU PV conference in Munich in October 2001.
- Additional measurement of effect of a metallic frame at “SOLRIF” PV modules on voltages induced by simulated lightning currents. Results are comparable with other framed and unframed modules.
- Conference contributions about results obtained at the PV conference in Staffelstein/Germany and the 17. EU PV conference in Munich. Extended publication about lightning protection of PV plants in 6 parts in a professional journal in Switzerland (“Elektrotechnik”). A shorter publication about the same subject in SEV/VSE-Bulletin.

BFE OFEN UFE SFOE

Annual Report 2001

INVESTIRE

Investigation on Storage Technologies for Intermittent Renewable Energies

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Project- / Contract -Number	ENK5-2000-20336 / BBW 01.0256
Duration of the Project (from – to)	7/01 - 12/03

ABSTRACT

INVESTIRE is a **NETWORK** of 35 European partners from 20 companies and 15 research centers which will share their knowledge in order to review and assess existing storage technologies in the context of renewable energy applications, to facilitate exchange of information between the main actors and to propose appropriate RTD actions for the future.

More detailed objectives can be listed as follows :

1. To review all possible storage technologies the most suited to renewable energy systems, mainly wind and photovoltaic systems.
2. To compare and assess the most relevant features and then to propose the best scope of application of each storage technology.
3. To deliver the results of past and current research carried out on a national or international basis to potential users (laboratories, PV or wind systems suppliers, renewable energy project managers).
4. To facilitate collaboration and exchange among EC-supported research projects in this field.
5. To help identify research priorities and publish a 5/10 years RTD roadmap.
6. To encourage the formation of new RTD partnerships.
7. To foster cooperation between battery manufacturers and renewable energies system designers or suppliers.

From electricity to electricity, 9 different storage technologies are addressed : Lead-Acid, Lithium Battery, Supercapacitors, Nickel Battery, Electrolyser + Hydrogen Storage + Fuel Cell, Flywheels, Redox Systems, Compressed Air Systems, and Metal Air Battery.

This work will start with a brief review of the available storage technologies and the main actors. The requirements of the main types of renewable energy systems will then be listed. This will result in a list of technical criteria, which will form the basis to compare in a harmonized situation the performance of all the storage technologies.
The project will finally include the writing of a strategy document for future R&D, and the dissemination of all the information made available.

BFE OFEN UFE SFOE

Annual Report 2001

PVSAT
Remote Performance Check

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Project- / Contract -Number	BBW Nr. 97.0542
Duration of the Project (from – to)	1998 - 2001

ABSTRACT

2000 was the last half year of the project. This represents the last 5 month of the test phase, the evaluation and the final report. Most of the goals have been achieved. The PVSAT procedure was tested during 12 month from Mai 2000 to May 2001. More than 50 systems in the Netherlands, Germany Switzerland and Austria were included. The evaluation shows among other experiences the difference between predicted (target) value and the real production. The goal was to be in most cases within +/- 10 % between real and predicted yields. This was achieved in about 60 % of all data sets. There are many different reasons causing the errors to be above 10%. Sometimes it is the malfunction of the system, in other cases the shading issue was not considered sufficiently and others. It was further found that the accuracy should be expressed in absolute values, such as Kilowatthours per month and per kilowatt installed PV power. The results shows an error band of about +/- 10 kWh/kWp in one month.

The procedure is going to be offered by Shell/Siemens in Germany to all of their future clients. It is used as a tool for quality control and monitoring instrument.

There is also an extension option in preparation, where the produced energy is transferred to a central control unit in order to make the check of the proper function automatically.

The final report has been accepted and is available on request.

Annual Report 2001

SoDa

"Integration and Exploitation of networked Solar Radiation Databases"

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Project- / Contract -Number	40049/79864
Duration of the Project (from – to)	1.1.2000 - 31.12.2002

ABSTRACT

It's the aim of SODA to deliver solar data in a even easier way (as today) to costumers. The instrument to do it is the internet. SODA runs in the EU framework program "Information Society Technologies" (IST). The aim of the project is to run a prototype. A first version is already running since June. Aside the development of the internet tools, the state of the art of scientific work is gathered and partly new algorithms were proposed. The main inputs are the databases ESRA (Europ. Solar Radiation Atlas), METEONORM and Satel-light.

Meteotest works mainly in the scientific part. Here algorithms for parameter like radiation on inclined planes or clear sky radiation or fundamentals like the worldwide distribution of the turbidity of the atmosphere are investigated. The work will be finished until the end of next year.

Das Ziel von SODA ist es, weltweite Solardaten noch einfacher an verschiedenste Kunden zu vermitteln. Als Mittel dazu dient das Internet. SODA läuft im EU-Rahmenprogramm IST. Das Ziel des Projektes ist es, einen Prototypen zu erarbeiten. Ein erster Prototyp steht seit Mitte Jahr zur Verfügung. Neben der Internet-Entwicklung werden wissenschaftlichen Grundlagen zusammengetragen und teilweise ergänzt. Als Grundlagen dienen die Datenbanken ESRA (europ. Strahlungsatlas) METEONORM und Satel-light.

Meteotest arbeitet weitgehend im wissenschaftlichen Bereich. Dort werden die Algorithmen für Parameter wie Strahlung auf geneigte Flächen, Schönwetterstrahlung oder Grundlagen wie die weltweite Verteilung der Trübung der Atmosphäre zusammengetragen und allenfalls ergänzt. Die Arbeiten werden im Laufe des nächsten Jahres beendet.

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Annual Report 2001

Energy specific Solar Radiation Data from Meteosat Second Generation: The Heliosat-3 project

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Project- / Contract -Number	BBW 00.0364
Duration of the Project (from – to)	2001 to 2004

ABSTRACT

Remote Sensing from satellites is a central issue in monitoring and forecasting the state of the earth's atmosphere. Geostationary satellites such as Meteosat provide cloud information in a high spatial and temporal resolution. Such satellites are therefore not only useful for weather forecasting, but also for the estimation of solar irradiance since the knowledge of the light reflected by clouds is the basis for the calculation of the transmitted light. Additionally an appropriate knowledge of atmospheric parameters involved in scattering and absorption of the sunlight is necessary for an accurate calculation of the solar irradiance.

An accurate estimation of the downward solar irradiance is not only of particular importance for the assessment of the radiative forcing of the climate system, but also absolutely necessary for an efficient planning and operation of solar energy systems. Within the EU funded HELIOSAT-3 project solar irradiance data with a high accuracy, a high spatial and temporal resolution and a large geographical coverage will be provided, using the enhanced capabilities of the new MSG satellite. The expected quality of the solar irradiance data will be a substantial improvement with respect to the available methods and will better match the needs of customers of the resulting products.

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Annual Report 2001

MSG: Combined project on multi-user solar hybrid grids

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Project- / Contract -Number	NNE5/483/1999 – BBW 99.0494
Duration of the Project (from – to)	Jan 2000 – Apr 2003

ABSTRACT

The University of Zurich is one (of 9) Partner in a Project in the EU Programme 'Energy, Environment and Sustainable Development,' Key Action 5: cleaner energy systems, including renewable energies. The project leader is Petra Schweizer from Fraunhofer ISE in Freiburg i.Br. (Germany). The task of the team of the University of Zurich (Departement of Psychology, Division of Social Psychology) is to develop social strategies to introduce MSGs (multi-user solar hybrid grids). The objective is to develop new social means to overcome the existing problems in using a multi-user solar hybrid grid with different renewable energy sources in a sustainable and environmentally friendly, resource saving way. This means, on one hand, to improve the knowledge about the users of hybrid systems and their consumption behaviour as well as the knowledge about their environmental consciousness and their social cohesion and on the other hand to overcome some of the social problems related to the fair distribution of electricity and its use in the time where 'renewable energy' is available and the others do not use it.

An important subtask is the development of a social simulation tool for MSGs. This includes to develop and apply a social computer model of human resource use to the case of the common use of the limited resource 'electricity from renewable energies'. Standardised data will be taken from the investigated villages for characterising the social structure and energy use behavior of different villages. Criteria will be found to design an optimal energy use behaviourand social strategies will be worked out how to reach this behavior. The target is to give the users limits as much as necessary and as less as possible to use the renewable energy as efficient as possible.

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Annual Report 2001

Schweizer Beitrag zum IEA PVPS Programm, Task 1

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Project- / Contract -Number	11427
Duration of the Project (from – to)	Since 1998

ABSTRACT

Task 1's aim – to guarantee the exchange of information between the countries involved in the PVPS- Program – was supported with the following publications, meetings and workshops:

- A new report "Added Values of PV Power Systems" [3] was published in spring 2001
- The National Survey Report NSR [1] (Basis for the International Survey Report) shows a stagnation in new installations compared to 1999:
  In 2000 about 1.9 MWp of new PV has been installed in Switzerland. Switzerland has lost its leadership in per capita installed PV-Power to Japan and ranks second. PV system-prices increased sligthly due to a very strong market in Germany and Japan.
- The International Survey Report [2] was published by the end of September, the earliest date in the year since its existence.
- On behalf of Task 1, Switzerland presented the "Added Values of PV" -Report in a plenary session at the European PV Conference in Munich (Oct 2001) [4]
- Task 1 met in Aarhus (DK) and Long Beach (USA)

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Annual Report 2001

IEA PVPS Programm, Task 2 (Schweizer Beitrag 2001)

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Project- / Contract -Number	14805 / 67820
Duration of the Project	1. January 2001 - 31. December 2001

Abstract:

Switzerland has committed itself to take part in the Photovoltaic Power Systems (PVPS) programme of the International Energy Agency (IEA), Task 2. The aims of the IEA-PVPS-Task 2 are outlined in the IEA PVPS Implementing Agreement of April 1994.

The overall objectives of the Task II is to provide technical information on operational performance, long-term reliability and sizing of PV-Systems to target groups. The actual activities of the task are (subtasks):

- Maintenance of the existing IEA database and collection of new PV system data
- Evaluation of PV Systems
- Improving PV System performance
- Sizing of PV Systems

The first phase of the work was completed in 2000. The final report of these activities was approved by the ExCo and published May 2000.

In spring 1999 a new workplan for the continuation of Task II was presented to the ExCo. At the PVPS Executive Committee meeting in May 99 it was agreed to extend the activities of Task 2 for another five years, starting in 1999.

This annual report gives an overview of the Task 2 main activities for the year 2001. Which where:

- Two expert meetings
- Distribution of the new „Performance Database“
- Task 2 Workshop at the 17th European Phovoltaic Solar Energy Conference and Exhibition, Oct. 2001 in Munich, Germany
- Analysis of the data collected
- Implementation of the Task 2 WWW-Homepage

Duration of Task 2 activities, phase II: 1999 to 2004

This project is supported by the Swiss Federal Office of Energy.

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Annual Report 2001

IEA PVPS Task 3

Use of photovoltaic systems in stand-alone and island applications

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Project- / Contract -Number	35550 / 75310
Duration of the Project (from – to)	9/01 - 12/03

ABSTRACT

From Solar Home Systems (SHS) until large hybrid photovoltaic systems for rural electrification, IEA PVPS Task 3 main objective is to improve the reliability and cost effectiveness of PV systems in stand-alone application.

To reach these objectives, the task has been divided into the two main following categories :

- Subtask 1 : Quality insurance, schemes for improving the reliability, lower the cost and increase the lifetime of SAPV systems.
- Subtask 2 : Technical issues, technical recommendations for cost reduction of systems.

In Subtask 1, the main work in 2001 has been the first draft of **"Management of the Quality of SAPV systems : recommended practices",** paper which resumes the experience of what works best in the field in order to get a PV system that is cost effective, reliable and last long. This paper deals not only on technical issues but also details what are the main points to respect in the design, organization and maintenance to get the best system.

In Subtask 2, many works have been improved and brought close to their conclusion :

- Two papers on hybrid systems will allow prospective users of SAPV systems to find what system meet best their needs and how they can measure and follow their system in order to lower its cost and improve its reliability.
- **"Management of batteries to be used in Stand Alone PV Power Supply Systems"** is close to being published and presents the most recent knowledge on battery regulators.
- **"Problems related to appliances in autonomous PV applications"** has been presented in October 2001 in Munich and details all the problems arising from the mismatch between a PV system and the loads.
- A first draft on **" Demand Side Management "** has been presented dealing on the way to optimize a system from the point of view of the load (the user).

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Annual Report 2001

IEA PVPS Task 5

Grid Interconnection of Building- Integrated and other dispersed Photovoltaic Power Systems

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Project- / Contract -Number	20552 / 60155
Duration of the Project (from – to)	1st January 1999 to 31st December 2001

ABSTRACT

Task V is a expert group of the International Energy Agency (IEA), Implementing Agreement on Photovoltaic Power Systems (PVPS). The title of the expert group is "Grid Interconnection of Building Integrated and Other Dispersed Photovoltaic Power Systems" and started its activity in 1993 to investigate the grid interconnection issues through international collaborations. The subtasks 10, 20 and 30 concluded successfully end of 1998.

The Task V extension (Subtask 50 "Study on Highly Concentrated Penetration of Grid Interconnected PV Systems") has following objectives. To assess the net impact of highly concentrated PV systems on electricity distribution systems and to establish recommendations for both distribution and PV inverter systems to enable widespread deployment of solar energy. Switzerland is involved as co- working country in reporting of PV system grid- interconnection technology, evaluation of islanding detection methods, maximum penetration level of PV systems and financial aspects for PV systems.

Clearly one of the highlight in the Subtask 50 work is the one-year measurement in the Netherlands to determine the probability of an islanding situation with a multiple PV system in a normal residential grid. Measurements were taken and stored every second. The number of possible islanding conditions, categorised by how well loads are matched to PV output, are determined for several penetration levels of PV. Information was also obtained on the length of time that an island condition could be sustained. The risks of islanding will be determined via fault-tree analysis. Detection schemes for islanding are obtained via an international survey. Together with the results from islanding tests at Sandia National Laboratories conclusions can be given on the effectiveness of these detection schemes. Thanks to all these information, adequate detection methods for islanding will be studied and reported on.

Based on the results a workshop will be held on the new islanding experiences. The workshop will take place in Arnhem (NL) in 24. / 25. January 2002. The outcome of the workshop work will provide a better understanding of the probability of the islanding phenomena and should lead towards cost- effective and safe methods for the detection.

In most activities draft reports were presented, which will be finalised till the workshop in January 2002.

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Annual Report 2001

IEA PVPS Task 7

Photovoltaic Power Systems in the built environment

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Project- / Contract -Number	20552 / 76586
Duration of the Project (from – to)	1st January 1997 to July 2002

ABSTRACT

Task 7 is a working group of the International Energy Agency (IEA) which started its activity in 1997 and will run them till July 2002 with the final conference in Amsterdam. The activities are organised in 4 subtasks (architecture, system technologies, non-technical barriers, demonstration and dissemination). The task objectives are to enhance the architectural quality, the technical quality and the economic viability of PV systems in the built environment and to assess and remove non-technical barriers for their introduction as a significant energy option. It is expected that the successful integration of PV systems into the built environment will contribute significantly to the future spread of PV.

Primary focus is on the integration of PV into the architectural design of roofs and facades of residential, commercial and industrial buildings and other structures in the built environment (such as noise barriers, parking areas and railway canopies). Further focus is put on other market factors, both technical and non-technical, that need to be addressed and resolved before wide-spread adoption of PV in the built environment will occur.

Task 7 formally concludes 31st December 2001 and will present some outstanding activities as reports and on the Internet. In subtask 1 'Architecture' is a database jointly developed by Bear Architekten, NL and Enecolo AG, CH. The database is accessible for the public under www.pvdatabase.com and presents in one section world-wide PV applications in different building areas. Further a second section presents an overview of available BIPV system technologies today. Certainly a highlight will be the Task 7 book, targeting architects, engineers and the PV community with high-profile case studies and several general information on BIPV issues.

In subtask 2 'System technologies', which is lead by Enecolo AG, five reports will be published. The public reports are ready to order from the homepage of Task 7 (www.task7.org). The PV potential report is prepared by NET AG and will be included in an overall Subtask 3 'Non- technical barriers' report. The report contains issues like economics, PV potential, marketing and publicity strategies concerning non- technical barriers.

An important topic in the subtask 4 'Demonstration and dissemination' work remains the DEMOSITE in Lausanne, co-ordinated by EPFL- LESO. The site has now around 32 systems on display and is also available for "virtual visits" on www.demosite.ch. Further a 'Training and education' package has been developed and will be added as CD- ROM in the Task 7 book or can be ordered on the Task 7 homepage.

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Annual Report 2001

Swiss Platform PV Development Cooperation and Contribution to IEA PVPS Task 9

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Project- / Contract -Number	seco RK V/HAFO/11141
Duration of the Project (from – to)	October 1999 – December 2002

ABSTRACT

With the support of the State Secretariat for Economic Affairs (seco), this project provides the Swiss contribution to IEA PVPS Task 9. The objective of Task 9 is to further increase the overall rate of successful deployment of PV systems in developing countries. This will be achieved by:

1. identification of existing information and experience
2. exchange of information between PVPS participants
3. exchange of information with and between target groups
4. workshops for and information exchange with donor agencies
5. development of Recommended Practice Guides based on existing information
6. improved techno-economic performance of PV in developing countries
7. identification of areas where further technical research is necessary.

Beyond the contribution to Task 9, this project aims at:

1. creating a network of users involved in PV technology co-operation
2. increasing information and access to international initiatives
3. co-ordinating activities between different actors involved in the subject of PV technology co-operation

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Annual Report 2001

Global Approval Program PV GAP

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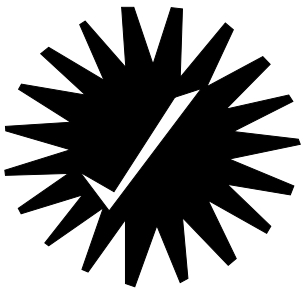
Project- / Contract –Number	23783/77264
Duration of the Project (from – to)	2000-2001

ABSTRACT

PV GAP promotes the utilization of quality PV products and PV systems. To distinguish easily quality PV products and systems from products of unknown quality PV GAP established:

- a PV Quality Mark to identify quality PV components, and
- a PV Quality Seal to identify quality PV systems.



The PV GAP program assures that manufacturers do not have to test every product separately, but can test only one from a range of products which have structural similarity. It also helps manufacturers and users by defining what changes in the production or materials will require that the product should be retested, thereby eliminating conflicting requirements and unnecessary expenses.

The PV GAP system requires no more quality or testing requirements than is customary. It only adds at very minimal expense for verification, but it provides savings in testing requirements, reciprocity of the test results and eliminates the need for country-by-country re-certification.

Annual Report 2001

New Light-Weight Flat Roof Photovoltaic Module Mounting System

Especially for Use on Roofs with Extreme Low Static Structure Reserve

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Project- / Contract -Number	27703 / 69120
Duration of the Project (from – to)	January 1999 - July 2001

ABSTRACT

Almost all of the mounting systems for solar PV modules available on the market require additional weight to withstand heavy wind loads. As the roof of many building is not used for any other purpose, it is an ideal place to mount solar PV modules. However, many modern buildings are built to reduce material and labor to build the roof structure, therefore reducing the cost of the building. They are built to just satisfy the demands of structural engineering, but most of the time hardly allow any additional weight on them.

These roofs prohibit any placing of PV-solar modules on them. Many roofs in Switzerland, however, furbish as an uppermost surface a layer of 3 to 8 cm of loose gravel. This gravel functions as an Uvprotection and wind load proofing of the watertight foil below it.

The main goal of the project was to find a way of incorporating the weight of the already-there gravel into a holding structure for PV-modules. At the same time, this PV-module holding structure itself should have almost no weight, so the additional weight brought onto the roof would remain minimal. It was found, that some technical approaches not yet investigate are possible. As a last step in the project, some prototypes will be tested for verification purposes.

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Annual Report 2001

SOLGREEN
Optimisation of the System

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Project- / Contract -Number	37527 / 77266
Duration of the Project (from – to)	April 1st 2000 – November 30th 2001

ABSTRACT

Solgreen represents a new trend using flat roofs covered with vegetation for PV installations. If it is done in a proper way, benefits for the roof, the PV and the ecology are possible. EPFL-LESO, Enecolo, Ernst Schweizer and Solstis have jointly developed a number of suitable mounting systems. The aim was to offer a high quality, low cost mounting system for all sorts of PV modules. 4 test- and 3 demonstration-installations have been realised up to now. The construction experience and the first operation time show very positive and promising results. Most of the targets are achieved. Some further improvements and optimisations are under way. Solgreen roofs in Zurich and Basel will be observed and monitored over a five year period in order to know also the long term behaviour. In that context the vegetation, the fauna and the effects related to the electricity production are of special interest. Composition of soil material and seeds may be different compared to green roofs without PV.

More than 5 systems have been installed up to now. The results and the response from the persons involved are very positive. The combination of PV with roof vegetation works well. Several improvements and adjustments are still to be done in order to optimise the application in term of investment cost and operational results. The composition of the soil substrate and the seeds on the roof has to be selected carefully. Slow and low growing plants may be preferred. Another important point is about the fertilising components: If there are too many of them the plants will grow too intensive and too high. However, also under these circumstances, the cutting of the plants twice a year is usually sufficient to avoid significant energy losses.

As mentioned before, the system is subjected to improvements. Some earlier designs are on the market and work well. Main focus of the current activities are the cost reductions while keeping the high quality level. Installations done in Zurich and Basel will be monitored over a period of five years. This allows the detailed analysis of the changes over the time and the micro effects of plants, animals and the soil. Another issue is the corrosion of the structure due to the more aggressive humidity. In general the system is ready to be used and further demonstration systems are required in order to promote the promising application.

Fig. 1: „C-Shape installation“

Annual Report 2001

Solar roof shingle Sunplicity ™

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Project- / Contract -Number	37528/77267
Duration of the Project (from – to)	1999-2001

ABSTRACT

The goal of the project SUNPLICITY is to develop a new solar building element for tilted roofs which fits exactly in every conventional roof built from fibre cement shingles, being widely used in northern Europe. It is a combined effort of the partners Glas Trösch Solar, Alpha Real AG, Gebrüder Müller AG and Evergreen Solar Inc. The design is based on European shingle standards, the lamination based on Evergreen's unique encapsulant design.

The objective is to design a shingle which geometrically fits in every dimensions exactly to the conventional shingle, not only both in length and width, but also in thickness. The new solar roof shingle is absolutely plane and flat, as is a normal fibre cement shingle. The integration into existing roofs is therefore straightforward: wherever the roofer wants solar shingles, he replaces conventional shingles with the new solar shingles. Even the electrical connections are in the same plane. The integrated connecting cable eliminates the roofer's design and installation obstacles and permits the roofer to do the electrician's job for interconnection on the roof also.

Shingles on sloped roofs have a large area of overlap. In fact, the overlap is more than 2,16. The unique polymer used in this design allows the tempered glass to be the structural substrate for the entire shingle while protecting the glass in this large overlap region. Cost and market acceptance influenced the design size of the solar shingle. Several sizes of conventional shingles are used in the market, but the most common ones are 40*60 cm. However, in order to become more competitive with clay tiles, somewhat larger shingles of 40*72 are used for almost all new roofs, except for windy areas. This larger size was selected for SUNPLICITY because larger size reduces production cost and the larger conventional shingle is gaining in market penetration. While even larger shingles would further reduce fabrication cost, this would likely be more than offset by higher installation costs due to special instruction, handling and mounting procedures for any non-standard sizes.

Three pilot test stands have been erected in 2001, in order to verify the concept under different conditions with different roofers and different shingles. The final test stand was mounted in September at LEEE, a highly qualified Lab in Lugano, in the south of Switzerland. Since Temperature measurements are of major importance for further decision to market the product, the final report of the project had been postponed until after summer 2002, and will be due in November 2002. This allows to include one full year of temperature readings.

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Annual Report 2001

Système hybride simple PV/T 7 kWp à Domdidier - Centre d'entretien N1

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Project- / Contract -Number	Project Number : 14'556 Contact Number : 54'108
Duration of the Project (from – to)	October 1995 to December 2001

ABSTRACT

Simple Hybrid System (PV/T) 7 kWp at N1 Motorway Maintenance Center, Domdidier/FR (PV/T = simple hybrid system Photovoltaic/thermic)

The project of the system PV/T 7 kWp consist to put a set of photvoltaics cells on a strip of the building. It is constituted of 33 simple window panels and each carry 144 photovoltaics cells ASE Alzenau, as a replacement for the normal garage's skylight of the ″ Motorway Maintenance Center ″ in Domdidier/FR. The installation's power is 6'700 Wp.

The heat produced by the PV elements is recuperated by 2 ventilators, which blow the warm air down (on the garage floor) in order to avoid frost of hall during winter. When the temperature is too high, the warm air is directly expelled outside of the building. This is a simple hybrid system PV/T.

The result of measures shows that the simple hybrid system brings a plus to the heating of the garage. But it is very difficult to quantify this contribution. In conclusion, such a system can be only compared with an opaque wall on the side of skylight exposed to the sun. A significant improvement could be the addition of a air conduit behind the inside face of PV.

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Annual Report 2001

Roof integrated amorphous silicon photovoltaic plant IMT Neuchâtel

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Project- / Contract -Number	17862 / 57447
Duration of the Project (from – to)	01.08.1996 – 31.12.2001

ABSTRACT

The grid-connected PV plant of 6.4 kWp at the Institute of Microtechnology Neuchâtel was the first of its kind in Switzerland : Here, large-area amorphous silicon panels are aesthetically integrated into the roof of a sixty years old building. The plant was implemented and commissioned in autumn 1996. A data logger monitors energy production and system performance with regard to irradiation, temperature and light-induced degradation.

The plant showed excellent reliability and performance during the five years of operation:

- availability since start-up of 100%
- cumulated energy production of 32 MWh
- annual production yield around 1'000 kWh/kWp
- performance ratio of 0.76

During the summer period the panels operate at relatively high temperatures resulting from the roof integration without rear side ventilation. Amorphous silicon modules have, thus, proven to be particularly suitable for building integration: At higher operation temperatures they show production yields that are 15 to 20 % superior to those of crystalline silicon modules of identical nominal power rating.

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Annual Report 2001

PV-roofs in the old town of Unterseen (Interlaken)

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Project- / Contract -Number	33046 / 73003
Duration of the Project (from – to)	1997 - 2001

ABSTRACT

Unterseen, a part of the city of Interlaken, located on the river Aare between the two lakes of Thun and Brienz, has a historical centre, which is marked by an old town house and other historical monuments. The integration of photovoltaic modules into the roof of a newly designed building in an old town, taking historical aspects into account, represented a special challenge in terms of a combination of modern technology and a traditional townscape. A clever module design and lot of convincing was necessary in order to have the photovoltaic project approved by the local townscape authority, the cantonal as well as the national preservation of historical monuments.

The installed power is 6 kWp and the energy production so far meets the expected output. The results of the monitoring campaign, which was running until summer 2001, are available as a final report.

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Annual Report 2001

Slopedroof- and façade – Mounting-system AluTec / AluVer

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Project- / Contract -Number	35715 / 75454
Duration of the Project (from – to)	December 1999 until June 2002

ABSTRACT

Projekt targets:

- Realisation of a potovoltaic power plant with an installed power of 32,56 kWp with the new developed mounting system AluTec / AluVer
- Verification of the saving of working time with the application of the AluTec / AluVer – system
- Testing of the resistance against wind power
- What about the liability of dirt deposition on the generator during operation
- Keep the modules lying save in the profiles
- Effectivness of the demonstrations on the visiting public

The potovoltaic power plant was connected to the grid on April 19, 2000. It is working as expected exept of two moduls whose circuit have broken within the connection-box.
Based on these two moduls it was possible to show the simple exchange of moduls without the need of any tools and without removal of other moduls.

Wind resistance: The maximum registrated wind speed during 2001 was 99 km /h and the calculated wind resistance has been fullfilled in practice.

P&D Project Completion For further information please refer to the detailed final project-report, which is published.

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Annual Report 2001

PV Eurodach amorph

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Project- / Contract -Number	37526 / 77265
Duration of the Project (from – to)	July 1999 – December 2001

ABSTRACT

EURODACH is the effective combination of a folded metal roof and full-area thermal insulation with rock wool. The combination with PV solar elements is a new development of FLUMROC Inc. and SCHNEIDER mounting systems.

The goals of this project are to get a multifunctional roof as weather protection, thermal insulation, and electricity production, to get experience with the mechanically connected materials having different temperature coefficients, and to learn about the energy yield of the PV installation with amorphous triple cell modules.

The development of the system is now going on to optimize the module sizes, the fastening of the modules on the roof, and to reduce shadowing due to the folds of the roof

BFE OFEN UFE SFOE

Annual Report 2001

LonWorks as Fieldbus for PV-Installations

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Project- / Contract -Number	32 443 / 72 340
Duration of the Project (from – to)	01.06.99 – 31.03.02

ABSTRACT

The growing market for photovoltaics increasingly requires suitable quality controls covering plant operators, planners and installers, as well as the electric utilities. Additionally, the interest of the general public in the behaviour of PV plants is growing. This includes information from everyday practice. Alongside data retrieval, other themes such as the operative management of the unit and energy management become increasingly important for grid connected PV systems. Todays measuring systems are not compatible with each other. Data communication between different PV plants with computer aided analysis- and visualisation programmes is very complicated.

The goal of this project is to introduce the very popular LonWorks-technology as a new standard for PV-applications. The first objective was to develop a LonWorks-interface for our Convert inverters and to connect them into a small network. In a second step we installed a lonworks-system at the 260 kWp pv-plant Felsenau in Berne. All 68 inverters are controlled over power line with LonWorks. The on-site PC acts as LonWorks-DataServer and making remote information monitoring and data gathering possible. As soon as a functional error occours, an alarm will be transmitted via modem to the SMSC (Short Message Service Centre).
After one year of oparation we can say that all request were fulfilled by our new system.

LonWorks was introduced by Motorola and Toshiba in 1991. Today it leads the world market for field bus systems. With plug&play, components by several manufacturers can easily be incorporated into a LonWorks network.Today more than 3‘500 companies use LonWorks technology.

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Annual Report 2001

10 Roof Integrated PV Small Scale Systems

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Project- / Contract -Number	37546 / 77283
Duration of the Project (from – to)	Sep 2000 – May 2002

ABSTRACT

Roof integrated small scale PV systems were recognised as potential niche market [1]. The use of an adapted roof integration system designed for thermal collectors enables detached but visually combined PV/thermal installation.
The proposed and evaluated small scale PV system has a modular design. Each PV module consists of a large area PV laminate (2.25 m^2) and a dedicated DC/AC converter with 240 W maximum power output.
Besides the PV laminate the proposed system uses commercially available components. All used components are ready made for plug-and-play installation by non-electricians. The focus of this project is on the evaluation of system aspects.
During the first month (September 2000 – March 2001) of the project, the aim was to sell and install 10 systems and to set up the performance monitoring scheme. Unfortunately, market response was low and only two systems were sold in this period suitable for performance evaluation.
For these two installed systems performance was monitored on a monthly base and compared with the energy gains predicted by the PVSAT [2] prediction programme.

In general, the evaluated small scale PV systems did not show any problems and operate according to specification. However, the deviation in energy gains between the different systems are significant. Several factors may be responsible for this:

- Cell and module performance
- AC/DC converter performance
- Different operating temperatures influenced by the surroundings of the modules

The comparison between the measured and the predicted solar energy gains show a significant deviation, too. The reason(s) for this effect are not known, yet.

Annual Report 2001

Fotovoltaikanlage Sunny Woods Zürich-Höngg

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Project- / Contract -Number	42203 / 82131
Duration of the Project (from – to)	07/2001 - 03/2002

ABSTRACT

The condominium "Sunny Woods" is located on a south-facing hill in Zurich. It contains six apartments and is designed for a zero-energy-concept.

The special solar-architectural design is combined with different technical features to reduce the consumption of energy of the whole building. The energy needed for heating and warm water is as low as 15kWh/m2a, it matches the "Passivhausstandard". This small amount of energy is produced by the photovoltaic modules on the roof.

The whole roof is covered with 504 amorphous triple cell modules of Unisolar. The roof is a multifunctional part of the house, it not only protects the inhabitants against the rain and the cold, but also supplies the building with electrical power. To guarantee the supply of electricity also in periods of bad weather, the system is connected to the grid of the local power company. The photovoltaic system is an integral and important part of the skin of the building.

Annual Report 2001

Pilot Installation 10kWp Flat Roof System "SOLGREEN"

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Project- / Contract -Number	23703/68140
Duration of the Project (from – to)	October 1998 – May 2002

ABSTRACT

Green flat roofs as water retension reservoirs usually do not allow to install PV on the same place. The SolGreen flat roof mounting system has been developed by LESO-EPFL in co-operation with Enecolo AG.

The development of the system is now going on to reduce the material costs.

Due to optimal exposition (tilt angle, no shadowing by plants etc, snow gliding and wind cooling), an excellent performance ratio could be registered (May-Nov 2001, >83%).

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Annual Report 2001

Solgreen Kraftwerk 1 Zürich

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Project- / Contract -Number	42920 / 82869
Duration of the Project (from – to)	1st July 2001 – Summer 2006

ABSTRACT

The Research and Demonstration plant `Solgreen Kraftwerk 1, Zürich, was built in June 2001 and realised the experiences of the Development Project `Optimierung des Systems Solgreen` in practice. The Solgreen system permits the integration of photovoltaics on green flat roofs with considerable advantages.

The Project aims to investigate and demonstrate the quality and durability of the developed construction by optimised assembling and material cost at the same time. Furthermore the interacting influences of roof vegetation and photovoltaic modules should be examined scientifically during a long period by external expert starting in spring 2002.

Purposes of the Project are to test and to demonstrate the new system Sogreen; the optimisation of construction details as a result of measurements and operation experiences; documentation of influences between the system and the roof vegetation and further influencing factors , collecting of experiences during building and operation of the system, as well as analysing specific operation data in comparison to other installations in Zürich, Basel and Lausanne.

First results were made under construction and operation of the new plant. To the construction process it can be said that the work flow did not result in negative results. Only the fixing of the Deltatec plates had to be coordinated with the spreading of gravel and substrate.

An important subject of observation is the metal parts of the construction with direct contact to the soil, but no corrosion was detected up to now.

In order to able to make a qualitative predication about the produced power in comparison to other plants more data are necessary.

Participants: Bau- und Wohngenossenschaft KraftWerk1, Enecolo AG, TISO, E. Schweizer AG, M. Maier, S. Brenneisen

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Annual Report 2001

Three pilot 10 kWp integrated PV sound barrier fields

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Project- / Contract -Number	17225 / 59391
Duration of the Project (from – to)	1. January 1997 - 31. December 2001

ABSTRACT

After an ideas competition in 1996, six companies where given the opportunity to construct a prototype of their newly developed integrated PV-soundbarrier concepts. The main goal was to develop highly integrated concepts, allowing the reduction of PV soundbarrier systems costs, as well as the demonstration of specific concepts for different noise situations.

This project is strongly correlated with a German project. Three of the concepts of the competition are demonstrated along a highway near Munich, constructed in 1997. The three swiss installations had to be constructed at different locations, reflecting three typical situations for soundbarriers.

The first Swiss installation was the world first Bi-facial PV-Soundbarrier. It was built on a highway bridge at Wallisellen-Aubrugg in 1997. The operational experience of the installation is positive. But due to the different efficiencies of the two cell sides, its specific yield lies somewhat behind a conventional PV installation.

The second swiss plant was finished in autumn 1998. The zig-zag construction is situated along the railway line in Wallisellen in a densely inhabited area with some local shadowing. Its performance and its specific yield is comparatively low due to a combination of several reasons (geometry of the concept, inverter, high module temperature, local shadows).

The 3rd installation was constructed along the A1 at Brüttisellen in 1999. Its vertical panels are equipped with amorphous modules. First findings show, that the performance of the systems is quite high, but the mechanical construction has to be improved strongly. A small trial field with cells directly laminated onto the steel panel, also installed at Brüttisellen, could be the key development for this concept.

This annual report focuses on the evaluation and comparison of the monitored data of the last 12 months of operation.

This project was financed by the Swiss Federal Office of Energy, the Swiss Federal Office of Motorways and the special electricity saving fund by the city of Zurich (EWZ).

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Annual Report 2001

PV / Noise Barrier Installation „Alpha A1“ in Safenwil

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Project- / Contract -Number	Project-Number 37146 / Contract-Number 76903
Duration of the Project (from – to)	2001 - 2003

ABSTRACT

Annual report on a combined PV / Noise Barrier installation with a capacity of 80 kWp which has been installed in Safenwil on the motorway Zürich – Berne. The Installation is the first privately owned PV power installation on a motorway noise barrier in Switzerland. The project was initiated by IG SOLAR Safenwil, a local co-operative for the promotion of solar energy. The installation is operated by the Ekotech AG company, whose shares are held by IG SOLAR and a (growing) number of companies and private persons. The power produced is being sold to persons, utilities and institutions interested in buying „green“ power.
The main events in 2001 were:

- Initial commissioning of a data-collection system in January
- Addition of a GSM-data connection in March, temperature and irradiance measurements in April
- Intensive testing and trouble-shooting in March and April
- Observation and assessment of shadowing effects in the summer months
- Comparison of energy production with the theoretical values calculated using irradiance data from a local weather station and own measurements
- Comparison of the installation’s power as measured by an independent body and confirmed using the monitoring system with the values originally planned

Annual Report 2001

Projet Héliotrope EICN

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Project- / Contract -Number	DIS 17482 / 57068
Duration of the Project (from – to)	1997 - 2002

ABSTRACT

As previously foreseen at the onset of this first project, we have installed two solar trees in August 1997. One is a fixed model, the other follows the sun on one axis and both are located at the Le Locle Community Center. However, the “Héliotrope EICN” project is comprised of a third sector which is centered on incorporating this technology in the Le Locle’s athletic complex’s infrastructure. We finally started up the third sector in October 2001.

Since then, these three installations are delivering clean energy to the Le Locle electricity network. These three production units are also supplemented by a weather station.

This complex includes the teaching and development laboratory of the canton of Neuchatel’s School of Engineering.

This is a multidisciplinary project. There are students from several branches such as: mechanics, electrical engineering, electronics, computer sciences and telecommunications. Highly motivated students participate in the framework of semester projects, studies for their degrees and development achievements. Scientific and development assistants have equally contributed to the project. All have gained invaluable experience for their education and future work.

This achievement is the fruit of collaboration between the Engineering School and the Le Locle Industrial Service Division. Financial support is offered by the ENSOL club, Neuchatel’s Energy Service and the Swiss Federal Office of Energy.

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Annual Report 2001

Amburnex Solar Farm (3 kWp)

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Project- / Contract -Number	32405 / 72282
Duration of the Project (from – to)	1999 - 2002

ABSTRACT

This off-grid installation (PV panels – batteries – inverters – charger – diesel generator – control unit) has been run throughout the 2001 summer, with all the components activated. However, it turns out rapidly that in order to fulfill the new requirements from the more powerful electrical equipment recently installed by the farmer the resizing of both the inverters and the diesel generator was to be done.
As to the controlling strategy, mainly based on the real-time variation of the voltage of the batteries pack, it appeared not to be well adapted . Therefore an energy balance method (computed from the measured loads and gains (solar + diesel generator)) was developped, tested and finally adopted.
It's efficiency will be demonstrated next year.

View from above view from below

Photovoltaïc roofing over the batteries-van, on the left of the farm.

Annual Report 2001

27 kWp PV-Installation High School Zurich-Stadelhofen-Plant Monitoring

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Project- / Contract -Number	32990 / 72908
Duration of the Project (from – to)	April 1999 - Dezember 2001

ABSTRACT

When the gymnasium hall of the high school Stadelhofen in the city of Zurich was renovated and rebuilt, a PV installation was integrated into the roof and the facade. The project was one of the winners of the Swiss solar prize in 1999, for the best integrated architectural design and the use of PV modules as multifunctional elements. The solar cells are integrated into the specially manufactured double glazed highly insulated roof windows. These roof modules have a nominal capacity of 13.7 kWp. On the south/west facade of the building special laminated solar modules with a total capacity of 12.8 kWp serve as a louvred shading device for the building.

Measurements of the electric output power of randomly selected single modules in independent laboratories have shown a difference between the nominal contracted and the delivered power of the modules. The delivered power is 23.5 kWp, that is 11.3% less then designed. The module price had to be adjusted and the expected annual yield had to be reduced from 18'500 kWh to 16'360 kWh.

The installation started operation in July 1999. In 2001 the plant monitoring was completed. In this period the installation produced on average 15'800 kWh/a, or 670 kWh/kWp/a, based on the adjusted (measured) nominal power of the modules. The cell temperatures showed high values in summer of up to 85 °C and a yearly weighted average temperature of 50 °C. This is considerably more than in a well ventilated installation, causing an additional loss of about 7 % of the yield. Despite of this, the installation operated very well. There was one interruption of 12 days in 2000, when the plant stopped after a grid fault and no trained operator was there. A partial disconnection was also recorded in 2001.

The self-cleaning capability of the little sloped roof was of some concern, as the dirt is not washed away by the rain. This effect was not observed up to now.

This annual report focuses on the evaluation of the monitored data from August 1999 to December 2001.

This project was financed by the state of Zurich, the Swiss Federal Office of Energy and the special electricity saving fond by the city of Zurich (EWZ). The monitoring campaign is fully financed by the Swiss Federal Office of Energy.

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Annual Report 2001

SolarCat
Solar-Electric Passenger Ship

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Project- / Contract -Number	36407 / 77803
Duration of the Project (from – to)	June 2000 - December 2002

ABSTRACT

The project SolarCat includes engineering design, construction and operation of a solar-electric powered passenger ship for inland waterways. The ship named “MobiCat” is of the catamaran type and has a length of 33 m and a width of 11 m. The electric energy is produced by 20 kWp of photovoltaic panels and stored in two batteries of 480 V and 240 Ah each. The ship is powered by two 81 kW industrial AC drives. With a passenger capacity of 150 persons MobiCat is the largest solar-powered ship worldwide.

The ship was inaugurated and put into service on July 6, 2001 in Biel/Bienne, Switzerland. Since then the ship has transported over 4000 passengers and achieved a total distance of more than 1500 km. During the first months of operation the main characteristics of the ship could be evaluated by means of an onboard data collection system. In this report some first results of the measurements are presented.

The project is financed largely by sponsors, mainly by the insurance company Schweizerische Mobiliar, the utility BKW-FMB Energie AG and the watch company Certina. The remaining costs are borne by the navigation company of the Lake of Biel/Bienne, BSG, the owner and operator of the ship. The Federal Office of Energy is co-funding the project as a pilot and demonstration activity. Data collection and evaluation is being sponsored by the Société Mont-Soleil.

The ultimate goal of the project is to demonstrate the feasibility of large solar-powered passenger ships and to present new solutions towards sustainable mobility on inland waterways.

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Annual Report 2001

Miet-Solarboot auf dem Zürichsee

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Project- / Contract -Number	41241/81227
Duration of the Project (from – to)	1.6.2000 - 31.12.2001

ABSTRACT

In the year 1999 the SSES (Swiss Association for Solar Energy) could celebrate their 25th birthday. For this event a solarboat for 25 passengers has been chartered. The SSES invited their members for a trip on several Swiss lakes. It had a good success also on the lake of Zurich. Therefore the idea of a solarboat for everybody has been born in the regional group of Zurich which led to a solarboat to rent. There was no real good designed solarboat on the market that fit the idea of the project group "Solarboot Ahoi". So the project group began to make a concept, project descriptions for a complete new boat and found one partner and several sponsors for the solarboat project. The partner is the utility of Zurich (ewz) and among the sponsors are the City of Zurich, Federal office of Energy (BfE) and various private persons. The catamaran boat with inflatable hulls has been built by the members of the project group with the aid of several experts in various fields. The propulsion system has been optimised through students from the Engineering school of Rapperswil.

In the first summer ZHolar has been rent during 100 hours. The passengers emphasised the quietness, the successful design of the boat and the speed that is comparable to the one of a standard-rental fuel-powered motorboat. The handling with the steering wheel and the "gas"-lever did not cause troubles. Only one small accident and once a small energy shortage occurred when the batteries were empty. The passengers could slower but safely return to the rental station powered only by the solarcells. The energy consumption of one hour is approximately 720Wh that are about equal to the installed solarcell-power of 732Wp.

The overall energy consumption was 106.7kWh whereas 89.2kWh came from the solarcells and 17.5kWh from the solarenergy grid of the ewz.

The summary of all involved person is very encouraging and ZHolar "The first Solarboat to rent on lake of Zurich" showed its reliable operation in the first season. The project team is convinced that the season 2002 is going to be successful and everybody hopes for another nice solarboat-summer.

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Annual Report 2001

Monitoring of the 16.8 kWp PV-plant with CIS modules in St. Moritz

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Project- / Contract -Number	41239, 81207
Duration of the Project (from – to)	1 May 2001 – 31 August 2003

ABSTRACT

This 16.8 kWp grid-connected PV plant, currently the largest in Europe using CIS (Cupper Indium diselenide) modules, went into operation on the 22nd December 2000. The plant, made up of 420 ST40 modules (40 Wp) manufactured by Siemens & Shell Solar, is situated on the roof of the Ludains ice rink in St Moritz.

The aim of this project is to observe CIS module behaviour when connected to the grid and under extreme environmental conditions (at altitude).

The PV array of this plant consists of 7 sub-arrays connected to the public grid by 7 Sunrise Maxi inverters manufactured by the Fronius company. Each sub-array comprises 6 strings of 10 modules in series.

The measuring equipment for detailed monitoring, installed at the plant on the 27th July 2001, enables collection of local climate data (irradiation at two different points on the plant and ambient temperature), measurement of currents of all the strings, of voltages DC and powers AC (at inverter exit) of each sub-array and of temperature at the back (Tbom) of 3 plant modules

In September, apart from a thermographic analysis of the plant, outdoor measurements of the I-V characteristics of the 42 strings were carried out. Extrapolation at STC reveals that the average nominal power (after initial degradation) of the plant modules is around 40 Wp, the same as that declared by the manufacturer.

Measurement at STC of 4 reference modules using a pulsed solar simulator did not reveal values of any significance.

An analysis of plant PR values shows a similar behaviour of CIS modules to the crystalline ones and that some strings produce less due to partial shadows (near buildings).

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Annual Report 2001

Photovoltaikanlage Dock Midfield Zürich Flughafen

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Project- / Contract –Number	37006 / 81193
Duration of the Project (from – to)	1.2.2001 - 15.12.2003

ABSTRACT

The Dock Midfield is a new terminal-building at the intercontinental airport of Zurich, Switzerland. The building is nearly 500 m long and is topped of a pergola roof. The Dock Midfield was designed to be a ecological and technical most advanced building, which provides a very high comfort for the passengers.

The roof of the building is constructed with a wide pergola roof of about 5'000 m^2. This pergola has three functions:

1. It is a important part of the architectural design of the building and gives the building its impressive look.
2. It functions as a shading device for the attic and partly for the facades.
3. It is equipped with photovoltaic elements and is therefore a source of electric energy.

This multifunctional use and the perfect integration of the active solar cells in the lamellas of the pergola makes this project unique and gives new inputs for the production of renewable energy. The unframed solar modules are designed to stand very high wind loads. This high loads can particularly occur from turbulences caused by aeroplanes at their take off.

The costs of this photovoltaic installation could be reduced because all structural work would have been done anyway, and the solar modules replace conventional glass lamellas. Therefore the gained electricity is relatively cheep, compared to other solar installations.

The installed nominal power of the solar cells is total 290 kW. The produced direct current is transformed by 10 static inverters to alternative current, which can be delivered to the grid. The expected energy gain is about

This solar plant will be measured after it is going to be operable in spring 2002, to see the production and performance. The measured data will be published, also in the European research project "PV grid connected system in parking and roof „Photocampa“.

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Annual Report 2001

151 small grid connected pv stations for a total of 200 kwp, of which 30 kwp in switzerland

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Project- / Contract -Number	BBW 97.0393-1
Duration of the Project (from – to)	du 01/08/97 au 30/04/01

ABSTRACT

The general objective of the project is the conception of small grid connected PV stations with a total power of 200 kWp, of which 30 kWp in Switzerland

The objective is an application of integrated module solution. This solution consists in the realisation of many roofs with waterproof PV modules instead of tiles. 10.7 kWp were installed in this way in 1999, and 20.6 kWp in 2000, completing the Swiss program part.
Smalls PV plant are installed by private individuals and companies. This small PV plants can be done by the customer himself. Their peak power range from 1,08 to 11,52KWp.

Also, we have implemented monitoring systems on some of these installations, and widely used PVSYST software for production forecast.

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Annual Report 2001

HELIOTRAM PARTIE LAUSANNE

800kWp Power Plant For Direct Injection In Light Train low voltage D.C. networks

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Project- / Contract -Number	n° projet SE./00146/96 n° Contrat BBW 96.0344-2
Duration of the Project (from – to)	du 01/08/97 au 31/08/00

ABSTRACT

Public transportation low voltage D.C. networks are particularly well suited for direct connection of PV systems because of their electrical characteristics, since the load of the network coincides with the PV production. Very simple and therefore reliable PV power stations can be built to inject the solar production into such networks, without power conditioning.

In the framework of the Thermie 96 programme, Sunwatt Bio Energie SA presented and developed the project called Heliotram, which is aimed to the connected PV large Plants for injection in light train low voltage D.C. networks.

The purpose of this project is to manufacture and install such PV power plants in Germany (250 kWp at Hannover) and in Switzerland (150 kWp at Geneva and 100 kWp at Lausanne). This implies:

- Direct connection of series of PV modules to 600-750V DC grid, i.e. peak voltages up to 1'500V at open circuit by cold weather.
- Incite the manufacturers to certify their PV modules for a high voltage usage.
- Testing high speed circuit breakers and power contactors, for DC high voltages.

The system of TPG was developped by Sunwatt Bio Energie SA, at Geneva - 154 kWp - has started operating in July 1999. Some results on the system behaviour and performances are presented. The same concept of security is used in Hanover for 250kWp.

The Lausanne project was developped by the Service Industriels and is presently divided in three installations totalising 45,4 kWp. The first one is in operation since March 2000, the two other ones are just starting in December 2000. The partner in Lausanne didn't find convenient roofs for constructing the the last 54,6 kWp plant (without shadow and very near from the 600VDC grid and with a roof in good condition for the next 20 years).

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Annual Report 2001

PV GRID CONNECTED SYSTEM IN PARKING AND ROOF "PHOTOCAMPA"

P+R l'Etoile de Genève, Aéroport de Zurich, Parking école de cirque de Chêne, Ecole d'ingénieur de Lullier

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Project- / Contract -Number	
Duration of the Project (from – to)	du 01.10.2000 au 31.12.2001

ABSTRACT

PHOTOCAMPA is a project of PV-grid connected systems proposed jointly by Spain and Switzerland. The aim of the project is to encourage the use of grid-connected PV systems in built environment, especially on parking structures. This type of PV integration has the advantage that no extra-area is consumed, and civil works devoted has no extra cost, contributing to reduce the required investment.

The project consists in the installation of 318 kWp grid-connected PV plants in each mentioned country. The Spanish installation is situated at Tarragona (Catalonia). The Swiss part of the project is split into four plants, also totalising 318 kWp.

The general objectives and criterions have been established jointly, and will be the same for each partner. One of the important features of the project will be a wide diffusion of information among the public, about PV installations as renewable energy production contributions. Also the "pilot" character should provide guidelines for multiplying such PV-installations on the numerous parking and other public areas in the cities.

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Annual Report 2001

Visualisation and Analysis of the Data of the 4,1kWp PV-Power Plant Rothorn

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Project- / Contract -Number	14578 / 63527
Duration of the Project (from – to)	1997 until 2002

ABSTRACT

The 4,1kWp PV-Power Plant is part of the building on top of the Rothorn (2865 m). It is an attraction to the public because the PV-panels are situated directly in front of the visitors terrace.

The aims of the present project are:

- Provide information to the public in order to familiarize interested persons with the possibilities and the qualities of the photo-voltaic technology.
- Analyze the effects of high altitude and severe weather conditions to the production of electrical energy considering the fact that the PV-Power Plant is part of the building.

The data logging for about one year is finished and the measurement data evalutation is now being started.
The final report will be finished by the end of March 2002.

Annual Report 2001

1 MW-Solarkette der NOK Normierte Daten 1997 - 2001

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Project- / Contract -Number	26'746 / 66'583
Duration of the Project (from – to)	January 1997 – July 2002

ABSTRACT

The aim of the project **„NOK's 1 Megawatt-Solar Chain, Normalized Data 1997 to 2001"** is the calculation of the monitored operational data of all pv-installations of the **1 MW-Solar-Chain** according to the current guidelines of the ESTI at Ispra and the IEA. It is the continuation of the preceding project "NOK's 1 Megawatt-Solar Chain, Normalized Data 1992 - 1996 (PSEL-project No. 81, BFE-project No. 14'516 / 54'074).

The report **"Normalized Data 2000"** was completed and distributed to the clients by August this year. It contains detailed evaluation of 2000's data as well as summaries over the whole period from 1992 until 1997. The reported stations are: NOK-Headquarters Baden, ISOKW Brugg, Alp Findels, Church of Steckborn, Disentis-Caischavedra (Desertasol), Migros-Winterthur, Neu-Technikum Buchs and Vorderberg (Electricity Supply Company of Buchs).

All the monitored photovoltaic installations work well with no significant power loss or frequent breakdowns whatsoever. Still, first difficulties have now been encountered with spare parts supply and service for components from manufacturers no longer existing on the market anymore.

The detailed observation of the photovoltaic plants over their lifetime provides important experience concerning aging, degradation and long-term reliability of the components used.

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Annual Report 2001

100 kWp PV-Netzverbundanlage A13 Messkampagne, Periode 99-2001

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Project- / Contract -Number	32046 / 71920
Duration of the Project (from – to)	Jan. 1999 - Dec. 2001

Abstract

12 years ago this 100 kWp PV-Plant built on top an existing sound-barrier structure along the A13 motorway in the Swiss Alps went into operation. At the time this project was unique, as it was the first PV-plant along a motorway worldwide and the largest PV-plant in Switzerland.

The purpose of this project is to gain information on the long-therm behaviour of a large gridconnected PV-plant and its components under real operating conditions. The monitoring and evaluation is carried out in accordance with the EU-Guidelines for PV Monitoring.

The plant produces on average 110'000kWh per annum at a specific annual yield of 1'030 kWh/kWp. The plant operated for the first 10 years without any mayor interruptions. In the 11nt year (2000) however, through a series of unfortunate events there was a mayor interruption and as a consequence one third of the annual energy production was lost.

In the 12th year of operation (2001) some additional problems with the inverter resulted in reduced operation and energy output. Almost 60% of the energy was lost. Since November 2001 the plant is in full operation.

In the year 2001 the plant produced 43'104kWh or 404kWh/kWp with a performance of 29 % and an availability of 42%.

This project is supported by the Swiss Federal Office of Energy.

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Annual Report 2001

Beschichtung von PV-Modulen

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Project- / Contract -Number	35527 / 75305
Duration of the Project (from – to)	Sept. 1999 - Jan. 2004

ABSTRACT

Purpose and Goals of the Project:

To Quantify the effect of different PV-module coatings on:

- cost reduction on cleaning expenses (less frequently, less detergent, etc.)
- positive effect on long-term degradation
- increase of module efficiency due to improved transmission

The project is performed as two parallel investigations: laboratory investigations for a systematic screening of different glass/coating combinations and a "real term" investigation in an existing power plant. One of the coating/glass combination agrees with the combination tested in the "real term" investigation, so that results can be compared and laboratory data can be interpreted into real data.

Most important results in 2001:

Laboratory investigations:

Preparations of a full set of samples finally completed. Material problems during exposition of the original set forced to order and prepare a large new batch for exposition. Exposition, Cleaning and Measurements can now be performed as planned.

"Real term" investigations:

First full year of measurements has been collected and evaluated. The data akquisition system has proven its reliability. Since all effects investigated are longterm effects, there is not yet enough data available to come to conclusions in terms of the project purpose. Nevertheless, the data is of high quality and more detailed results are expected for 2002.

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Annual Report 2001

Newtech – Vergleich 3 x 1kWp Dünnschichtzellenanlagen

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Project-Number	43849 / 83893
Duration of the Project (from – to)	01.04.2001 – 30.09.2003

ABSTRACT

Purpose and Goals of the new project

- Comparison of the operation and energy yield of 3 grid connected 1kWp-photovoltaic plants with different thin film solar cells-technologies (a-Si-triple-cells, a-Si-tandem-cells and $CuInSe_2$-cells). The 3 PV plants are at the same location and each of them is operated with an own, identical inverter (ASP Top Class Spark).
- HTA Burgdorf has installed an analytical monitoring system for detailed analysis of the 3 PV plants.
- Initial degradation of the modules will be measured. Therefore the monitoring system and the PV plants started operating at the same time.
- Analysis of thermic capture losses of these modules compared to c-Si-modules with higher temperature-coefficient.
- Comparison of long term behaviour and energy yield of the different PV plants.
- Operation of the PV plant and the monitoring system started successfully on 17.12.2001.

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Annual Report 2001

Normenarbeit für PV Systeme

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Duration of the Project (from – to)	2000-2001

ABSTRACT

Global recognition of the quality and legitimacy of its technical work as an international standards organization is among the IEC's major strengths. But this is not yet always perceived by the PV industry management, which does not always fully appreciate what the IEC is and why its work, with that of its National Committees, makes a major contribution to the continuing rapid growth of trade in PV electrotechnical products and systems. The only globally accepted electrotechnical standardisation body is the IEC. The PV industry, which is now 28 years old, is producing a multiplicity of components and systems for terrestrial uses. It is however very unfortunate, that there are only two (2) IEC PV component International Standards issued, the latest in 1995 (6 years ago) and they both are for PV modules. There are no IEC International Standards for any other PV components or systems. TC 82 drafts exist for components and systems but are only at the CD stage.

For the Photovoltaic (PV) Industry and users, International Standards for PV products: components (e.g. modules, charge controllers, inverters, batteries, lights, connectors, switches, pumps, etc.,) and systems (small home, grid connected, water pumping, etc.) are extremely important for two reasons:

- the utilisation of PV, which was growing for 25 years at an amazing average rate of 17% per year, was growing in the past 2 years even more, about 40% per year, and it is now supply, and not demand, limited;
- PV is being used everywhere on this planet, and there are hardly limitations, although the sun belt obviously may ultimately be the largest market for those systems. It is important to stress the point, that PV components and systems are assembled and produced not only in the industrialised countries but also at least in 20 to 30 developing countries, and the number of those countries is growing fast. Standards are a key prerequisite for attaining quality.

In this environment, the lack of International Standards for PV is critical because

- it leads to uncontrolled quality products, which are causing failures,
- it creates difficulties in obtaining bank participation,
- it leads to the establishment of trade barriers, and
- instead of decreasing prices, it results in increasing prices for the user.

TC 82 is working on different standards, but unfortunately, the process is slow, and TC 82 has not yet fully succeeded in focusing on standards really needed by the market. It is planned that by 2003 several important standards concerning charge controllers, inverters ,solar home systems, batteries etc. should get finalised.

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Annual Report 2001

Guarantee of Solar Results for Grid-Connected-Photovoltaic-Systems 'GRS-PV'

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Project- / Contract -Number	29946 / 69842
Duration of the Project (from – to)	July 1999 – January 2001

ABSTRACT

The installation of 500.000 grid-connected PV systems needs a contractual framework that ensures high-quality, high guarantee PV systems. Once properly established the GRS-PV model can provide this framework for PV systems ranging from AC-modules to multi megawatt systems. The GRS-PV concept is easily understandable and convincing for investors. For a further utilisation mainly installers hesitate to do so as it was not clear on how to determine the costs and measures connected with certain guarantees.

The main objective of this project is the validation of the GRS-PV concept. The first step was the establishment of a mutually agreed structure on aspects impacting the quality of PV-systems. In addition, an assessment of would-be benefits for a contractual agreement between PV-installer and PV-investor was created.

In a second step the would be benefits and the possible implementation of the concept in new projects with interested companies will be addressed. Following the development of the model in previous GRS-contracts, and the first attempts to apply the model in projects, the concept shall be validated, in particular the cost effectiveness and its appropriateness for PV industry. This task will be realised in close cooperation with specialised companies and projects which want to utilise the GRS-concept. It is expected that a validated GRS-PV concept will have a positive impact on the deployment of PV systems. In the reporting period 2001, the project documents were finalized and the project determined.

BFE OFEN UFE SFOE

Annual Report 2001

HORIZsolar II – Validating, improvement and accommodation of the horizon-take-up product to practical fitness

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Project- / Contract -Number	35547 / 75306
Duration of the Project (from – to)	September 2000 – December 2001

ABSTRACT

HORIZsolar II is the advancement of the new 360°-panorama-tool and the picture-handling software (for the photometric determination of the horizon Ą com. HORIZsolar I) to the practice fitness.

Starting from the winter 2000/01 the software horizON was revised completely and was improved. The final version horizON v2.0 is available on the market since middle of November 2001. In the 2nd Half-year of 2000 the prototype III was developed and a first small series of 30 copies (panoramaMASTER) were produced in 2001.

The market-suited product satisfy the request at the functionality and customer friendliness. In accordance with evaluation the basic usefulness of the tool is recognised and appreciated by solar engineers and some architects.

The new work tool set horizON software and panoramaMASTER camera tool has been found popular and helpful to improve accuracy in planning and analysis, to visualise presentations and work as a sales argument for potential customers.

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Annual Report 2001

Feasibility Study PV installation football stadium Wankdorf

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Project- / Contract -Number	38268 / 78044
Duration of the Project (from – to)	July 2000 – December 2001

ABSTRACT

The dimensioning of big photovoltaic installations (P > 100 kWp), based on cristalline silicon and the rules for a good integration into the skin of the buildings are well-known today and used successfully. But in one field, experiences are still not made: The electrical and mechanical dimensioning of big PV installations based on Thin-Film-Cells, for example amorphous silicon odr CIS (Copper-Indium-Diselenide).

The goals of this feasibility study are as follow:

- Clarification the feasibility of big PV installations based on amorpous silicon
- Starting-help for negotiations with Investor, Energy-distributor and Building-owner
- Collect experience by Up-Sizing PV installations based on Thin-Film-Cells
- Demonstrate this new technologies at many people

The next table shows the results of the electrical and mechanical dimensioning for 5 different variants:

Nr.	Variant	Technology	Installed power [kWp]	Yield [MWh/a]	Costs [kFr.]	Energy-price [Fr./kWh]
1	REFERENZ	c-Si (mono)	1‘220	1‘073	16‘300	1,40
2	MILLENIA	a-Si (Tandem)	510	454	6‘600	1,40
3	MODULVERBUND	a-Si (Tandem)	460	411	9‘500	2,20
4	SCHINDEL	a-Si (Triple)	570	514	9‘500	1,75
5	MIKROMORPH	a-Si / µc-Si (hybrid)	830	748	13‘400	1,65

Two questions are still open at the moment: One of them is the behavior of the temparature in the wing-profile, the other is the elctrical behavior of the Thin-Film-Cells in backward. This questions will be answered in the detail-dimensioning.

With the results of this feasibility study the discussions with Investor, Energy-distributor and Building-owner can start with a new round to reach contracts for energy-selling and roof-using. To realize a big PV-installation with Thin-Film-Cells would be a signal, that demonstrate the big potential of these kind of technology.

BFE OFEN UFE SFOE

Annual Report 2001

Integration von kombinierten PV- und thermischen Kollektoren in Gebäudesystemen

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Project- / Contract -Number	55 300010 / 80 065
Duration of the Project (from – to)	1.1.2001 - 31.3. 2003

ABSTRACT

The project's main target is to optimise the ventilation of PV shingle roofs and façades for co-generation of electrical and thermal energy (warm air). Studies concerning the accurate use of the produced energy are a part of this project.

In 2001, measurements on a 1:1 model mounted on the roof of the Technical School of Engineering and Architecture, in Luzern, Switzerland, confirmed previous measurements carried out in the laboratory. The measurements in progress will be completed in Spring 2002.

The first small project, based on the measurements mentioned above, will be realised in 2002. It is a multifunctional PV roof (13 m^2) for the combined generation of electrical and thermal energy, integrated in the roof of a summer house. The thermal energy is used to supply an air/air heat pump which produces hot water.

On the basis of different simulations and tests, the combination of building integrated, ventilated PV systems and air/air heat pumps seems promising. In collaboration with national an international institutes, some reference systems will soon be defined to determine the maximal attainable performance.

BFE OFEN UFE SFOE

Annual and Final Report 2001

PV City Guide - Solar Photovoltaic Power in European Cities

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Project- / Contract -Number	BBW 99.0569
Duration of the Project (from – to)	01.01.2000 - 31.12.2001

ABSTRACT

Purpose of the work: The objective of the project PV City Guide is to provide local and regional authorities as well as related professionals (urban designers and developers, project developers and builders) with the necessary information and instruments to define, evaluate, plan and implement PV projects in an urban environment.

Approach: The PV City Guide is being designed for practical use by the target groups in order to facilitate the implementation of future PV projects. Draft guides have been produced after consulting local experts and actors regarding local need. These drafts are being improved through feedback from local and national target groups and consultation in relation to ongoing BIPV projects. The PV City Guide will achieve objectives in terms of contribution to European Union (EU) policies regarding renewable energy systems (RES) and also to community social objectives by attention to local involvement and replicability. PV City Guide partner cities are Barcelona, Basel, Bristol, Brussels, Florence, Gothenburg, Malmö, The Hague and Zurich. By concentrating on the needs of and strong interaction with the defined target audience, the PV City Guide is providing a new approach towards future activities in this field.

Results: An international workshop on Solar Photovoltaic Power in European Cities was successfully held in Basel, Switzerland. The Solar ElectriCity Guide comprises most relevant information, checklists, etc. for the integration of photovoltaics in the urban environment and planning. All this information and more can also be viewed on the project website http://pvcityguide.energyprojects.net.

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Annual Report 2001

REMAC 2000

Renewable energy market accelerator 2000

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Project- / Contract -Number	NNE5-2000-00012, BBW 00.0088
Duration of the Project (from – to)	01.11.2000 - 31.10.2002

ABSTRACT

The purpose of the REMAC 2000 project is to identify policies and strategies that are suitable for accelerating the growth of renewable energy (RE) markets in the European Union member states and world wide. This aim is being pursued through a co-ordinated series of activities, which will also engage senior decision makers from public administrations and the RE industry in exploring new market stimulation initiatives.

The project is carried out by a team of experts from CESI (Italy – co-ordinator), NET (Switzerland), ECN (The Netherlands) and CNRS-IEPE (France), with sponsorship from the European Commission, the International Energy Agency (IEA), the Swiss Government and the RE industry (BP Solar). The project can therefore also be a demonstration of closer working between the European Union, the IEA and the RE industry on the development of guidelines for enhancing the EU and global markets for renewable energy.

The project is also reviewing the extent to which all these changes and mechanisms have been taken into account in the existing models for forecasting future RE markets. Gaps or uncertainties will be identified, and recommendations made for how to address these aspects in the future.

Lastly, the project will develop a Roadmap, namely a list of priority policies and actions needed to accelerate the market growth in order to attain the targets deemed as feasible over the next 20 years.

BFE OFEN UFE SFOE

Annual Report 2001

Quality is the Key of the PV Market-accreditation / certification

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Project- / Contract -Number	17967/57555
Duration of the Project (from – to)	2000-2001

ABSTRACT

Both projects target at a development and large scale dissemination of knowledge about PV system quality standards and about PV system design and implementation skills competency. The Project "European PV Training Accreditation and Certification" addresses the industry organisations and programmes which develop courses for electricians and engineers to design, install and maintain quality PV systems in Europe. The Project "Quality is the key to the PV Market" addresses the industry and manufacturers in order to become aware about and to make use of PV System Quality Control Standards and Manuals which are developed in the framework of this project in four languages and which are made visible in several training courses in Europe.

Accreditation of Training Programs: Developing a community of qualified practitioners requires both supervised training and on-the-job practical experience. To ensure that the available training meets the needs of the industry and its customers, it is important to have a means to provide an objective, third-party assessment of a training program's resources and capabilities. This provides potential certification candidates with a means to assess the competencies of the available training programs; it provides customers and employers with a tool to evaluate program graduates; and, it provides the training programs with a set of metrics against which to develop and deliver their training programs.

Certification of Practitioners: While engineers and electricians have valuable and useful skills that may be transferred to working on PV systems, there are significant differences between working with conventional electrical systems and working with PV systems. And, these differences can mean the difference between a safe system and a dangerously deficient one. Certification of practitioners to consensus standards of knowledge and skills competencies, through testing and documentation of experience, provides assurances that the practitioner is qualified to perform the work to the appropriate standards, codes, and practices. Recognising the importance of practitioner certification standards, the ISO and IEC have drafted a document, Draft 17024, specifically to address the quality framework necessary for the Certification of Persons.

BFE OFEN UFE SFOE

Annual Report 2001

PV on Vocational Colleges in Switzerland, 9 Years Experience in Training and Education

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Project- / Contract -Number	10230 / 50191
Duration of the Project (from – to)	August 1992 - December 2001

ABSTRACT

Within the framework of the Swiss Photovoltaic Programme for Vocational Colleges, 21 of the 60 vocational school centres in Switzerland have been equipped with photovoltaic installations. A total capacity of 215.8 kW PV has been reached. There is a broad range of individual installations between 1.8 kW (school of Dietikon) an 50.2 kW (school of Lucerne). Approximately 40 % of all electricians beeing educated attend schools in one of these vocational colleges.

Because there are no new photovolatiac installations on vocational school centers, the main area of the programm has shifted an focuses in the developpement and application of edicational tools in the area of Photovoltaics.

The ERFA group and the internet homepage has been continued. The data aquisition campain, ongoing since 9 years, has been finished and terminated end of 2001.

The data beeing collected in these data aquisition compain has also been used as part of the Swiss Cooperation in the IEA PVPS Task II. The data is encorperated in the international database.

Before 2002 the activity of the Swiss Photovoltaic Programm for vocational colleges will be made part of the activity portfolio of Swissolar, the national body of solar organisation. This will allow more synergie and poitive interaction with other ongoing activities in the field of solar energy promotion.

BFE OFEN UFE SFOE

Annual Report 2001

Photovoltaic Energy Statistics of Switzerland 2000

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Project- / Contract -Number	
Duration of the Project (from – to)	

ABSTRACT

The project reported on in this paper is the follow up work of the PV Energy Statistics and Quality Assurance Project mutually funded by the Swiss Federal Office of Energy and the Swiss Electricity Producer and Distribution Union of Switzerland. The work carried out has revealed key figures for both PV performance and overall electric energy contribution of PV in Switzerland.

It was shown, that the annual average yield of all PV installations in Switzerland is at above 840 kWh/kWp, changing slightly from year to year due to changing irradiation and other effects. The systems overall reliability and operational availability is with around 98 % considered very good for technical systems.

BFE OFEN UFE SFOE

Annual Report 2001

Solar electricity from the utility

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Project- / Contract -Number	
Duration of the Project (from – to)	Since 1996

ABSTRACT

"Solar electricity from the utility" is the name of an action within the Swiss National Action Programme Energy 2000, aimed at providing customers of utilities with the service of solar electricity. The action is supported by Energy 2000 and the Swiss Electricity Supply Association (SESA) since 1996. As from 2001, the Swiss National Programme SwissEnergy, which followed the Programme Energy 2000, is supporting the action "Solar electricity from the utility" continuously. The fundamentals of the action can be described as a marketing approach towards both utilities and their customers in order to deploy the market for solar electricity for customers willing to buy this product at generation costs. After five years of operation, this action has achieved remarkable results: About 130 utilities participate in the action as of end of 2001, more than half of the Swiss population now has access to this service, 5 MWp of photovoltaic power systems have been installed within this concept and 4 GWh of electricity are subscribed annually. A marketing survey has shown that the market potential for this service is by far not yet saturated and highlights successful marketing strategies.

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