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Photovoltaic Programme Edition 2003

Summary Report, Project List, Annual Project Reports 2002 (Abstracts)

elaborated by:
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Title page:

283 kWp Midfield Dock photovoltaics installation, Zurich Airport

(source: unique / Ralph Bensberg)

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Photovoltaic Programme Edition 2003

Summary Report, Project List, Annual Project Reports 2002 (Abstracts)

Contents

PHOTOVOLTAICS

Summary Report – 2003 Edition

Reporting period 2002

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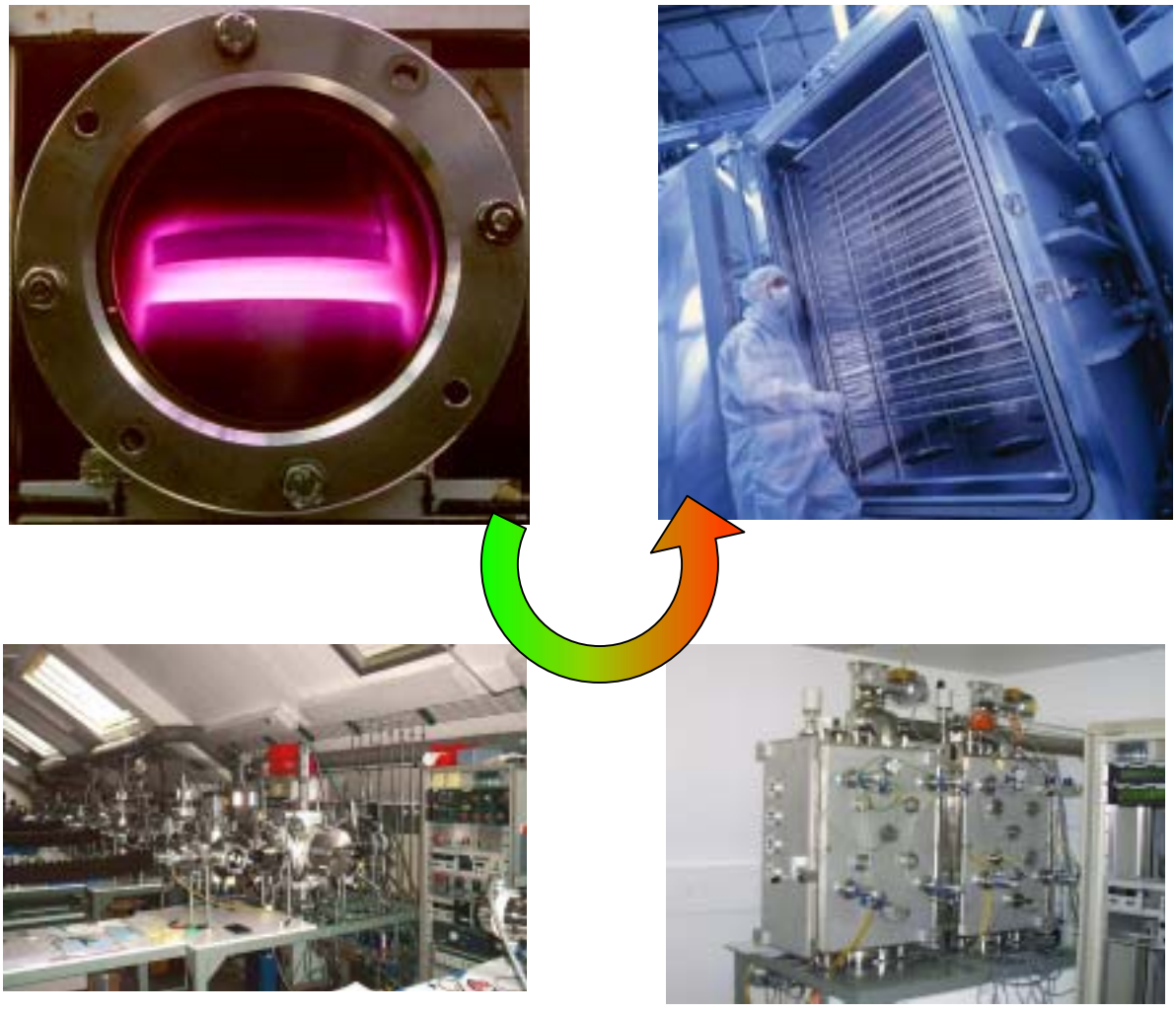

Technology transfer from the laboratory to industrial production

The plasma deposition processes for thin film solar cells developed at IMT (University of Neuchatel) are transferred to the industrial scale

(source: IMT & Unaxis)

Contents

1. Programme priorities and targets for 2002

The photovoltaics (PV) programme in 2002 was characterised by almost unbroken continuity in research and an increasing volume of market related activities. These took on firm contours with the development of new industrial projects. In addition to the new implementation projects for thin film solar cells, new industrial activities were launched. The industrial basis for photovoltaics research and development in Switzerland is broadening, and this now represents a new link in the industrial value chain. The programme has a pronounced international orientation. In the period covered by this report, some 85 research, development and pilot and demonstration projects were in operation. This figure includes all projects enjoying public funding of which we are aware. The number of projects and the volume of funding were of the same order as the previous year.

The photovoltaics research programme 2000-2003 [81], 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, on **compound semiconductors** (CIGS, CdTe) and **dye cells.** New production processes are particularly prominent in the case of thin film silicon cells. Implementation efforts continued in all technologies, and several very important new projects entered the active phase in collaboration with private companies.

Modules and building integration

New manufacturing **processes** for improving the efficiency of solar modules and for cost reduction were developed. The **integration of photovoltaics** in the built environment continued to be the main focus of current applications. Satisfactory and appealing designs for integration into flat roofs, gable roofs and facades suitable for industrial production are the main priority. While the integration of crystalline solar modules in the building components has till now been the principal focus, thin film solar cells are now beginning to fill this role.

Electrical systems technology

Quality assurance of photovoltaics modules, power 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. Particular significance is attached to reliable prediction of the **energy rating** of solar modules. This is needed not only for commercial purposes, but also for the **standardisation** of products and systems, and in preparing the **standards** themselves. For island installations, the question of reliable and durable storage systems must also be addressed.

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**. **Thermophotovoltaics** represents an interstitial theme that has generated increasing interest in recent times and spurred new developments.

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 focus over the report period. International cooperation has led to a whole range of new and practical techniques. Satisfactory involvement of Swiss photovoltaics at the scientific and technical levels in international endeavours was achieved.

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. Fundamental work continued in the ETH Council's *TOP NANO 21* programme. Moreover, a rising number of industrial projects were supported by the CTI. Switzerland's intensive participation in EU projects serves to underline the international competitiveness of her solar cell research.

Thin film silicon

At the University of Neuchâtel, IMT completed an important phase of **micromorphous solar cells** [1] during the report period. This emphasizes industrial production techniques and processes. Work concentrated on improving the properties of transparent oxide films (TCO), optimisation of p-i-n and n-i-p film sequences using amorphous silicon, and manufacture of micromorphous minimodules. The results of the various tasks can be summarised as follows. The deposition rate for microcrystalline silicon could be increased to 25Å/s. Also, the stable efficiency of simple amorphous cells with a p-i-n film sequence could be increased to 9.5%. For micromorphous cells with p-i-n/p-i-n film sequence, a stable efficiency of 10.8% was realised. For micromorphous tandem cells with an intermediate TCO film, a comparable efficiency of 10.7% was achieved. An efficiency of 8.5% was achieved for minimodules of 8x8 cm^2 using amorphous p-i-n cells, and of 9.8% using micromorphous p-i-n/p-i-n cells. Reverse film sequences using n-i-p amorphous, n-i-p microcrystalline and n-i-p/n-i-p micromorphous cells were studied. Over the report period the work on micromorphous cells was also pursued in the EU **DOIT** [2] project. The objective is to produce a small micromorphous module measuring 30x30 cm^2 with a stable efficiency of 11%. IMT's main task is to achieve large-area deposition by means of VHF (Fig. 1). Microcrystalline silicon was deposited at a rate of 10 Å/s using 135 MHz VHF. An initial series of cells with this material was optimised during the report period, and an intermediate target of 5% set for the efficiency.

Endeavours to achieve industrial implementation of IMT's know-how were intensively pursued with the support of ENET, and met with considerable success. Towards the end of 2002, and following intensive negotiations, Unaxis' executive board decided encouragingly to embark on extended cooperation with IMT, with the declared objective of achieving a leading position in the manufacture of industrial equipment for the production of micromorphous solar cells. For this, the *Unaxis Solar* unit is to be formed and an industrial laboratory established in Neuchâtel to facilitate the transfer of technology. The initial industrial investment phase will extend over 2 years (Fig. 2).

The joint CTI project on the **rapid large area deposition facility** [3] for thin film silicon solar cells of the CRPP at EPFL, IMT and Unaxis, was continued during the report period. Tests were performed using the Unaxis plasma deposition system at CRPP, while solar cells were produced in a similar installation at IMT. An important point requiring clarification is the boron contamination arising in single chamber systems, and for this, solutions could be found. A further problem concerned the deposition rate. During the report period it was possible to produce solar cells that met the project specifications at a deposition rate of 2 Å/s, and it is expected to further increase this value. The project represents an important facet of the transfer of technology to Unaxis mentioned above.

Fig. 1: *Single chamber 30x30 cm² VHF plasma deposition installation at IMT (DOIT project; photo: IMT / Univ. NE)*

Fig. 2: *Industrial plasma deposition plant (photo: Unaxis)*

Le Locle Technical College is working with VHF Technologies on a project for efficient light trapping by means of controlled **roughening of polymer substrates** [4]. The intention is to increase the efficiency of the (amorphous) solar cells. The process involves reactive ion etching using SF_6/O_2. With this, it was possible to adjust the roughness as a function of process parameters, but homogeneity still needs to be improved.

In a new *TOP NANO 21* project at IMT, the feasibility of **optical nano gratings** [5] for trapping light in nanocrystalline silicon cells was investigated in collaboration with VHF Technologies. This involved both uniform gratings and randomly generated surface structures. The most satisfactory results were achieved with random structures, enabling the short-circuit current in nanocrystalline cells to be increased by 16%.

The PSI project for developing **low bandgap cells** for thermo-photovoltaics applications [6] was completed during the report period. Work on the photovoltaic cell concentrated on the growth of SiGe quantum well structures and Ge islands on Si surfaces produced in a UHV-CVD reactor. The absorption coefficient of the SiGe films was determined.

Crystalline silicon

In the new EU **RE-SI-CLE** project, HCT Shaping Systems [7] is developing new processes to extract the silicon base material from silicon waste for reuse in the production process. The project is intended to contribute to waste avoidance in processes where crystalline silicon is used.

II-VI composites (CIGS, CdTe)

The thin film physics group at ETHZ has been working on EU projects involving solar cells based on compound semiconductors (CIGS, CdTe) for many years now. In the current EU **PROCIS** [8] project, production techniques for larger-area CIGS cells are being developed. The feasibility of increasing the efficiency of these by controlled sodium injection was investigated in detail. As a result of this work, sodium injection now ranks as an established technique. Various vacuum processes were used to produce CIGS solar cells with CdS buffer films. As far as the efficiency achieved was concerned, these were found to be superior to the ZnS and ZnSe films.

In the *TOP NANO 21* **NANOCIS** [9] project, novel techniques for producing CIGS cells from nano particles are being sought. The CIGS absorber film is produced by sintering suitable *precursor* films in a selenium atmosphere. Complete conversion of the precursor substance to the required CIGS compounds was observed. Initial solar cells showed an efficiency of at least 4% calculated from the current-voltage characteristic.

Dye cells

The development of dye-sensitised, **nanocrystalline solar cells** [10] was further pursued at ICP at EPFL. Work on solid-state heterojunctions continued over the report period. This work is also the subject of a project under the *TOP NANO 21* [11] programme. In this, **indoor applications** using dye cells are being developed in collaboration with Greatcell Solar. In a PSEL project, **outdoor measurements** [12] on dye-sensitised solar cells were continued to clarify their behaviour under real outdoor conditions. Of particular interest is their behaviour when subjected to UV radiation. The efficiency was found to depend on the air volume. In the new EU **NANOMAX** [13] project, alternative types of dye-sensitised solar cells involving new photoelectrode designs and materials, new dyes, enhanced transport properties and reduced recombination of the charge carriers are to be studied. It is hoped in this way to achieve an efficiency of 12%, with a possible increase to 15% and 9% over an area of 100 cm^2. The Australian licensee of the STI dye-sensitised cell recently presented a new pilot installation in which the cells were integrated within a building [82].

Antenna solar cells

Fundamental work has continued at the University of Bern on **antenna solar cells** [14] 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-sensitised solar cell based on dye-injected zeolite crystals.

Solar modules and building integration

Building integrated installations continue to represent the most important field of application of photovoltaics in Switzerland. Whilst the least expensive flat roof designs are often utilised by the solar stock exchanges, work on reducing the costs of more fully integrated systems is continuing. Several mounting systems have now been successfully developed (also see P+D section), so that developments now increasingly concentrate on the solar modules themselves. Swiss companies are presently engaged in a range of new EU projects for this.

VHF Technologies and Alcan Technology & Management are collaborating with Le Locle Technical College on a new CTI project to develop a **PV composite module** [15] for building integrated applications using *Alucobond®*. A manufacturing process for large-area modules, together with the necessary lamination technology, was established. Till now, a stable efficiency of 3% was achieved, and a number of prototype modules of 2m x 1m are now available for testing (Fig. 3).

Fig. 3: *Large-area demo PV facade element using Alucobond® (2000mm x 1000mm) (Photo: EIAJ)*

Fig. 4: *Lamination line for PV modules with feed table, laminator and cold press (Photo: 3S)*

Swiss Sustainable Systems is engaged in a range of EU projects on PV building integration. The **HIPERB** [16] project concerns the application of CIGS cells in photovoltaics roof and facade systems. Over the report period, prototype CIS modules were presented. The intention is to combine these with the *Megaslate®* product (Fig. 4). The object of the **AFRODITE** [17] project is to develop aesthetically appealing systems for PV building integration using rear contact crystalline cells.

Kurth Glas & Spiegel is participating in the EU **ADVANTAGE** [18] project, which is also addressing the rear contacting of solar cells for PV building integration applications.

Alcan Packaging is engaged in the EU **HIPROLOCO** [19] project to develop new and inexpensive techniques for encapsulating solar cells in modules.

The **DEMOSITE** [20] project at the EPFL in Lausanne was completed during the report period. The project involves numerous variations on the theme of building integration of photovoltaics in flat roofs, gable roofs and facades. The project forms part of the IEA PVPS Task 7 project, which has now also reached completion. The opportunities it offers for practical comparison have enabled several products and systems to be developed or improved during the lifespan of the project. Final work over the report period concentrated on the dissemination of information. The project may be visited in internet (www.demosite.ch), where detailed information is given.

Enecolo was engaged in the EU **ENERBUILD** [21] project, which involves a 'thematic network' on energy in buildings (www.enerbuild.net) to register R+D activities and strengthen cooperation in the field. Enecolo is responsible for the *photovoltaics in buildings* basket. During the report period, two *Enerbuild newsletters* and several project specifications were prepared, and recommendations made for future strategies in the 6 priority areas. The recommendations concerning building integration of photovoltaics are aimed mainly at the need for further R+D work, standardisation of building components, intensified marketing and more specific professional training.

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

Electrical systems technology

The **main emphasis in systems technology** generally continues to lie 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 standardisation of products. There is further need for action on the standardisation and corresponding quality assurance of photovoltaics 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 pursued the project on **quality assurance and energy rating of photovoltaic modules** [22]. The eighth test cycle on a total of 12 solar modules was completed, and a ninth series of measurements on 14 new module types (3 sc-Si, 9 mc-Si, 2 a-Si) begun (Fig. 5). The so-called performance matrix P(G, Ta) method was improved during the report period and has proved to be a valuable aid in characterizing solar modules. It will also prove a useful tool for designers in the future. In May 2002, the 10 kWp LEEE-TISO installation surpassed 20 years of fully documented operation, and this probably represents an international record for grid coupled PV installations. The laboratory, certified the previous year for measurements on the Class A solar simulator under ISO 17025, continued reliable operation. Some 100 I-V characteristic curves were measured for private customers. Also, measurements on the 3 LEEE-TISO photovoltaic installations were continued.

Work on the 20 year old 10 kWp installation in the joint EU **MTBF-PV** [23] project involving the LEEE-TISO and the European Test Laboratory at Ispra continued during the report period. Extensive measurements demonstrated an average fall-off in performance of -0.2% per annum over 20 years, illustrating the high reliability achieved for the modules. Detailed investigations were performed on individual cells and modules based on I-V characteristics, IR analysis and accelerated ageing tests. This enabled the phenomena of discoloration, delamination, hot spots and oxidation of contacts to be more precisely quantified. From experience to-date, it is predicted that the installation can continue operation for a further 10-15 years.

Fig. 5: *TISO PV module test stand (photo: LEEE TISO)*

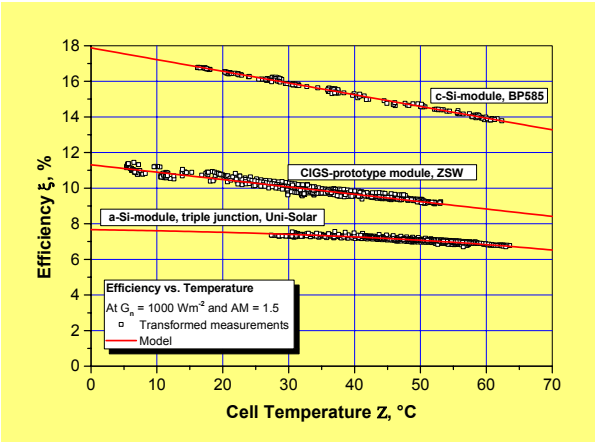

Fig. 6: *Dependency of cell efficiency on temperature for three module technologies (photo: PSI)*

Based on measurements on several solar modules, PSI developed a **method for the calculation of the annual yield** [24]. This enabled the behaviour of various technologies (mc-Si, a-Si, CIS, CIGS) to be quantified. The analytical model permits the influence of temperature, radiation intensity and air mass on the efficiency to be calculated (Fig. 6).

The **energy rating of solar modules** [25] was treated in several projects during the report period, and also by a national workshop organised by Enecolo. During the workshop, various measurement and analytical methods for determining the energy yield were compared and the need for practical tools identified.

Thanks to the support of the Mont Soleil Association, Localnet AG, Elektra Baselland and SFOE, the project on **long-term behaviour of grid-coupled photovoltaics installations** [26] was continued at the photovoltaics laboratory of University of Applied Science Burgdorf. In this project, 42 installations comprising 55 power inverters are covered. Contrary to expectations, it proved possible to further increase power inverter reliability during the report period. The reliability and energy yield of the 560 kWp installation at Mont Soleil was also increased during the report period. However, certain installations showed a marked fall in performance. Overall, the installations displayed a gradual decline in annual energy production.

In the EU **INVESTIRE** [27] project, Dynatex is cooperating with 19 other companies and 15 research laboratories in an extensive evaluation of storage technologies for renewable energies, especially for photovoltaic island installations. The total of 9 storage technologies comprise the principal types of battery (lead, lithium, nickel, metal-air) and alternative storage techniques (supercaps, electrolysis/hydrogen/fuel cell, flywheel, compressed air, Redox systems). The characteristic parameters of these were brought together in a form suitable for comparison. Results show that from an economic point of view, replacement of the lead accumulator will not be easy for the primary applications. The only promising method is that using compressed air. For certain applications (e.g. portable appliances, short-term storage and high energy capacity), other techniques may prove more favourable.

Supplementary projects and studies

Meteotest is engaged in the EU **SoDa** [28] project to provide solar data worldwide via internet (http://www.soda-is.com). During the report period a prototype internet service was produced. SoDa is not solely a (simplified) on-line version of *METEONORM*, but a combination of simulation procedures and databases from *METEONORM* [83] with the *ESRA European Solar Radiation Atlas* [84]. Prototypes are also available in the form of simple analytical models for the simulation of photovoltaic installations.

The CUEPE at the University of Geneva is engaged in the EU **Heliosat 3** [29] project to determine the specific energy content of solar radiation based on Meteosat data. The MSG satellite (Meteosat Second Generation http://www.esa.int/msg/), which went into operation in autumn 2002, will be used in the project. Data from the new satellite should provide more precise radiation data.

The system related work on **thermophotovoltaics** [6] under the new CTI **HEAT** [30] project was continued at PSI in collaboration with Hoval, Solaronix and the EMPA. The main application of this work is to autonomous operation of heating boilers remote from the grid. In the report period, mantle emitters were produced from rare earths, their optical characteristics measured, suitable filter materials based on conducting transparent oxides investigated, and these finally tested in a TPV demonstration facility in which commercial silicon cells were implemented.

E4TECH was engaged in the EU **Euro-Islas** [31] project, which was completed during the report period. The objective is to improve the conditions for the application of renewable energies, in particular to island areas of Europe. For this, case studies were performed to assess the opportunities for practical application, implementation potential, and possible scenarios for the broader use of renewable energies in island areas.

In the EU **MSG: Multi-user solar hybrid grids** [32] 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 computer software based on the social behaviour simulation model was completed. The model takes account of the interaction between the physical data (in particular the charge level of the batteries) and social behaviour. Initial results indicate that this computational tool is able to simulate the effects of solar generating plant in a local community.

International cooperation within IEA, IEC AND PV GAP

Over the report period, participation in the IEA (IEA PVPS) photovoltaics programme was characterised by continuity both at project level and regarding membership of the Executive Committee (ExCo). Switzerland continued to chair this international programme during the report period. In the course of 2002 the second phase of the IEA PVPS programme was successfully completed. Over the 5 years' duration of the second phase of the programme from 1998 to 2002, more than 50 publications, books, databases, 10 PVPS newsletters, and the www.iea-pvps.org website were issued, and some 25 professional events with about 1600 participants organised. This illustrates the formidable standing of this international research cooperation programme [85]. International cooperation within IEA PVPS is now to be extended by a further 5 years.

In IEA PVPS Task 1, which is concerned with general **information work** [33], Switzerland is represented by Nova Energie. A further national report on the photovoltaics scene in Switzerland up to 2001 [86] was prepared during the report period. This formed the basis of the 7th edition of the annual international report on market developments in photovoltaics in IEA countries [87]. This report has now become a widely cited reference on developments and trends in the photovoltaics markets of IEA countries. The *IEA PVPS Newsletter* [88] provides information on the work of the IEA programme and on associated themes at regular intervals. The expert group held one of its project meetings in Basel, permitting an increased exchange of knowledge and experience with the Swiss protagonists. Current work concerns the 'added value' generated by photovoltaic systems.

TNC is responsible for the Swiss contribution to Task 2 on **operational experience** [34]. The PVPS *Performance Database* [89] was expanded by new data, and now covers 316 photovoltaic installations from 12 countries, involving over 10 000 monthly data values and 10.8 MWp installed capacity (Fig. 7). Using the database, specific parameters (radiation data, performance, shading effects, temperature effects and reliability in operation) are being analysed in greater detail.

Fig. 7: *IEA PVPS Task 2 database*

Fig. 8: *Display of IEA PVPS Task 7 with training material for architects*

Dynatex is participating in the work on **island installations** [35] in Task 3. This project mainly concerns improvements in the quality and reliability of autonomous photovoltaics installations, and technical questions on hybrid systems and batteries. In 2002, the reports on battery testing and operation [90, 91], and on island installation equipment, were completed [92].

EWZ is responsible in conjunction with Enecolo for the Swiss contribution to Task 5 on the technical aspects of **grid connection** [36] of photovoltaic installations. The project was completed in 2002 with the publication of a comprehensive series of final documents, concerning particularly the safety aspects [93-99]. A prominent outcome of this cooperation were the investigations on islanding of PV installations in an electricity grid. It was shown that this undesired phenomenon is very unlikely to occur under normal operating conditions, and does not therefore represent a serious problem. Task 5 was

successful in demonstrating how a consensus may be reached through international cooperation, and how meaningful implementation procedures at national level may be developed.

Task 7 on the theme of **integration of photovoltaics in the built environment** [37], headed by Enecolo, was also completed with the presentation of a wide range of new results [100-109]. A database with photovoltaic products and applications of these to the built environment can be accessed via www.pvdatabase.com. Task 7 can justly claim to have extended the range of photovoltaics building integration systems in a comprehensive way, and contributed both to the technical and non-technical aspects. A CD ROM containing training material on PV building integration (Fig. 8) is intended as an introduction to architects on this theme. Following completion of the project, the IEA PVPS ExCo began its deliberations on building integration of photovoltaics in the new Task 10. It is expected to formalize this project in the course of 2003.

With the support of the State Secretariat for Economic Affaires (seco), Entec is responsible for the Swiss contribution to Task 9 on **photovoltaics development cooperation** [38], which is part of the *platform for development cooperation in photovoltaics*. Switzerland is responsible for coordinating the work of this project with bilateral and multilateral organisations. An initial report on selected financing mechanisms for solar home systems in the developing countries [110] was completed in time for the autumn meeting of Task 9. The meeting, which was held in St. Gall, also served as a venue for the second national workshop on photovoltaics in development cooperation. This provided an opportunity for an intensive exchange of information between Swiss experts and those of the international expert group. A range of further reports are to be completed in the near future in Task 9. The Swiss contribution to IEA PVPS Task 9 is to be expanded by various other activities under the PV EZA *platform for development cooperation in photovoltaics* with the objective of bolstering the induction of Swiss know-how and products into international projects. The facilities of multinational organisations – particularly the *GEF* (Global Environmental Facility) – are also to be further exploited. A corresponding pilot project is now underway with the support of the SAEFL.

Alpha Real is representing Switzerland in TC 82 of IEC and is heading the working group to prepare and issue proposals for **international standards** [70]. Alpha Real is participating in the work of ***PV GAP* (PV Global Approval Program)**, a worldwide programme on quality assurance and certification of photovoltaics systems. Certain aspects of these endeavours, including training, will be treated in the EU Altener project **quality is the key to the market** [73].

The new EU **PV-EC-NET** [39] project links the national PV programme coordination centers of 14 countries in a network (www.pv-ec.net). The project aims to intensify the exchange of information on PV programmes, compare programme experience and coordinate European research. Efforts to make European research more coherent are essential owing to the high degree of fragmentation in this area. The project should be seen as an exploratory initiative aimed at the European Research Area ERA.

3. National cooperation

At national level, the diversity of cooperative effort was upheld over the report period within the projects and professional events. Cooperation with private companies was intensified, whereby the interest in photovoltaics remained unbroken despite the sluggishness of the Swiss market. The national photovoltaics symposium in Lugano in May 2002 was a major success. A record 200 persons participated in the Symposium, providing a useful opportunity to promote national photovoltaics endeavours and cooperation, and the mutual exchange of information in Switzerland [111].

At programme level, cooperation was maintained with numerous federal agencies, cantons and the electricity industry. In this connection, the constant interchange with OFES, CTI, the Top Nano 21 program, SAEFL, SDC and seco, and also with SESA, PSEL and the Mont Soleil Association, is worthy of special mention. The many contacts made in this way helped to provide a broader base for programme activities – an increasingly important aspect.

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 on new and existing projects continued during 2002. This involved 14 projects under the EU's *DG Research* and 5 projects under *DG Transport & Energy*. Further projects are in progress in the EU *IST* and *Altener* programmes. Regrettably, ratification of the bilateral agreements with the EU suffered a setback, so that the hoped-for enhancement of the standing of Swiss participants in EU projects under the 5th Framework Research Programme did not materialize. This will now need to be renegotiated under the 6th Framework Program. Continued support for these projects was provided in the interim by the Swiss Federal Office for Education and Science (OFES). An intensive exchange nevertheless continues with the responsible authorities in Brussels. Furthermore, Switzerland is again participating in the management of the various programmes. Concerning development cooperation, contacts were maintained with international organisations (World Bank, GEF, IFC, UNDP, GTZ, KfW, etc.). Thanks to the multiplicity of interchanges, and despite the retardation in the Swiss market, Swiss photovoltaics has remained very prominent in the international arena.

5. Pilot and demonstration projects

Introduction

As in the previous year, a total of 45 photovoltaics P+D projects were in progress in 2002. As usual, several projects in the PV P+D programme were being more closely evaluated at the beginning of 2003. The P+D activities comprised pilot plants, studies and tools, component development and measurement campaigns. Interest centered on full-scale pilot projects for testing new components in P+D installations, and this continued to be a clear priority in the current year. **Building integration of photovoltaics** continues to be strongly represented. The remaining projects concerned PV noise barriers, stand-alone installations, measurements on various installations, quality assurance and PV planning tools.

This year, integrated installations designed to architectural standards were well received. These included the Midfield Dock at Zurich Airport [58] (title photo), Sunny Woods in Zurich [48] (Fig. 9) and Parking de l'étoile in Geneva [63] (Fig. 10), all of which were accorded the **Swiss Solar Price 2002**. Top performer was the Sunny Woods [48] 6 unit apartment house, which was accorded the **European Solar Price 2002** in the 'solar buildings' category.

Fig. 9: *Sunny Woods roof integrated photovoltaics installation*
(Photo: Architekturbüro Beat Kämpfen)

Fig. 10: *Parking de l'étoile roof integration in Geneva (Photo: Sunwatt Bio Energie SA)*

P+D projects

New P+D projects

In 2002, 10 new projects were begun in the PV P+D program. The majority of these involve photovoltaics installations in the built environment, among which the Freestyle® PV roof in Lutry [50] (Fig. 11) achieved a high degree of integration of the thin film silicon solar cells. The increasing number of projects focusing on thin film technology can be seen as an indication of the steadily growing interest in this technology on the part of the building integration sector. Results expected in the near future from the 18 test installations with thin film cell modules in the 'DünnFilmTest' [68] project (Fig. 12) in Zurich, will certainly be received with great interest.

Fig. 11: *Mounting of the PV roof integrated Freestyle® installation with amorphous triple cells in Lutry (Photo: Solstis)*

Fig. 12: *18 test installations with thin film cells in juxtaposition (Photo: NET AG)*

The projects begun in 2002 were as follows:

Installations

↓# Migros PV ThinFilm test in Zurich (18 test installations with PV modules with thin film cells in juxtaposition. Management: Energiebüro) [68], Fig. 12

↓# Photovoltaic obelisk (pilot realisation of architecturally designed information columns with integrated autonomous PV installations for supplying energy to public installations. Management: Enecolo AG) [59]

↓# Corviglia cablecar photovoltaic installation and St. Moritz Piz Nair installation (implementation of a 17.8 kWp installation along the Corviglia cablecar and a 13.5 kWp facade integrated installation in the mountain station, together with the Piz Nair mountain restaurant at 3050 m altitude. Management: SunTechnicsFabrisolar AG) [60]

↓# Roof integration of the Freestyle® integration system in Lutry (large-area photovoltaic roof integration with amorphous triple cell modules, new development, building integration. Management: Solstis Sàrl) [50], Fig. 11

↓# 70 kWp roof installation at the Palexpo in Geneva (grid coupled photovoltaic roof installation at a well-frequented location combined with two charging stations for electromobiles. Management: SSES Société Suisse pour l'Energie Solaire) [62]

- ↓ Photovoltaic shading installation with CIS modules (pilot implementation of multifunctional translucent modules with CIS cells for combined shading of an atrium and electricity production. Management: Enecolo AG) [61]

- ↓ Hünenberg 27 kWp AluStand installation (demonstration plant using the flat roof version of the AluTec module support system (AluStand). Management: Urs Bühler Energy Systems and Engineering) [74]

- ↓ RESURGENCE – Renewable Energy Systems for Urban Regeneration in Cities of Europe (realisation of a total of 1.3 MWp PV installations in city areas in the 5 countries Great Britain, the Netherlands, Denmark, Germany and Switzerland. Management of the Swiss part: Enecolo AG) [64]

Component development

- ↓ Alpur photovoltaic roof installation (photovoltaics roof with thermal insulation; building integration. Management: ZAGSOLAR) [44]

Measurement campaigns

- ↓ Monitoraggio dell'impianto PV da 100 kWp AET III (detailed measurement campaign on the modified 100 kWp PV installation alongside the SFR Bellinzona-Locarno route. Management: LEEE-TISO) [69]

Current P+D projects

As in 2001, several projects were accorded solar prizes in the current year.

The Sunny Woods 6 unit apartment house [48] (Fig. 9) won the European Solar Prize 2002 both in the 'solar buildings' and 'best integrated installation' categories, thereby receiving double honours for exemplary and integrated design in the architectural *and* energy fields.

The Midfield Dock integrated photovoltaic installation at Zurich Airport [58] (title photo) was awarded the Swiss Solar Prize 2002 in the 'best integrated installation' category. By virtue of its multifunctional PV shading design and full integration in the building, the installation measured up to exacting architectural standards.

The Parking de l'étoile in Geneva (Photocampa project) [63] (Fig. 10) was the third among the current P+D projects to receive one of the coveted Swiss Solar Prizes in 2002. The PV roof in Geneva was awarded a solar prize in the 'best photovoltaic installation' category.

The Mobicat solar catamaran [56] (Fig. 13), a passenger ship seating 150 persons, can look back on a very successful season in 2002. Over the last two years, it has sailed 4 000 km and transported some 10 000 passengers. The ship, hitherto mainly operated on a charter basis, has proved very popular among visitors. As a novum, a regular public transport service is to be introduced by the Bielersee-Schifffahrts-Gesellschaft (BSG) in the 2003 season.

The 10 kWp Solgreen installation in Chur not only combined photovoltaics and green roofs in an exemplary fashion but also achieved the exceptionally high yield of 1222 kWh/kWp. It is anticipated from the measurements that commercial module performance will lie in the *upper half* of the tolerance band! [51], Fig. 14.

The 12.75 kWp PV roof integrated installation in the historic village center of Wettingen [49], Fig. 15, also had a very successful year. The Wettingen installation with full-area roof integration and crystalline solar cells achieved the high energy yield of 980 kWh/kWp.

Various installations with modules based on thin film cells achieved above-average yields. The high yield of 1055 kWh/kWp produced by the 16.8 kWp installation with CIS modules in St. Moritz [57], Fig. 16, was not unexpected. It was, however, surprising that the Newtech [67] project in Burgdorf, Fig. 17,

comprising modules with the same CIS technology, achieved a yield of 1091 kWh/kWp over the same period. Furthermore, the installation with amorphous silicon triple cells in the same project achieved the exceptional value of 1033 kWh/kWp.

The overall picture is therefore very positive, with a substantial number of current P+D projects proving to be extremely successful. The next step must now be to introduce these technologies to current practice on as wide a scale as possible.

Fig. 13: *Mobicat solar catamaran (Photo: NET AG)*

Fig. 14: *10 kWp Solgreen roof integrated installation in Chur (Photo: NET AG)*

Fig. 15: *12.75 kWp roof integration Wettingen (Photo: NET AG)*

Fig. 16: *16.8 kWp installation with CIS cells St. Moritz (Photo: LEEE-TISO)*

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: EIAJ, Le Locle) [80]

↓# 10 kWp 'SolGreen' installation integrated in a green roof (newly developed support structure for green roofs, flat-roof integration. Management: ars solaris hächler) [51], Fig. 14

↓# 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) [55], Fig. 18

↓# 3 kWp PV Eurodach amorph (thermally insulated PV metal jointed roof with amorphous triple cells, building integration. Management: PAMAG Engineering) [45], Fig. 19

↓# 75 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) [54], Fig. 20

↓# 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) [47]

↓# Electrically driven passenger ship with 20 kWp PV system (catamaran seating 150 persons with an autonomous 20 kWp installation for supplying the drive motor. Management: Minder Energy Consulting) [56], Fig. 13

↓# 283 kWp photovoltaic installations Midfield Dock at Zurich Airport, including a 55 kWp PV demonstration plant (multifunctional photovoltaics building integration with shading facility, with particular demands on the mechanical stability of modules. Management: ARGE Zayetta) [58], title photo

↓# 16.8 kWp photovoltaic installation St. Moritz with CIS modules (exploratory use of modules with CIS technology in an installation of this size, extensive measurement campaign. Management of installation part: Rätia Energie AG; management of measurement part: SUPSI-DCT, LEEE-TISO) [57], Fig. 16

↓# 16 kWp roof integration Sunny Woods (roof integrated PV pilot installation with amorphous triple cells in a passively heated apartment building. Management: Architekturbüro Kämpfen, Naef Energietechnik) [48], Fig. 9

↓# 25 kWp Solgreen Kraftwerk 1 green roof installation, Zurich (exploratory use of a newly developed support module for green roofs. Management: Enecolo AG) [52], Fig. 21

↓# Newtech, comparison of three 1 kWp installations (direct comparison of three installations with different thin film cells – a-Si-tandem cells, a-Si-triple cells, CIS cells. Management: University of Applied Science Burgdorf) [67], Fig. 17

↓# 12.75 kWp PV roof integration Wettingen (harmonious PV roof integration in the historic village center of Wettingen, where the attempt was made to achieve an inexpensive solution using standard components. Management: Eigentümergemeinschaft P.P. Stöckli / H.-D. Koeppel and Energiebüro) [49], Fig. 15

↓# Photocampa: multifunctional PV shading installation (Parking de l'étoile Fig. 10, école de cirque, école de Lullier, Midfield Dock Zurich Airport. Management: Windwatt SA) [63],

Fig. 17: *3x1 kWp test installation Newtech Burgdorf (Photo: NET AG)*

Fig. 18: *Autonomous installation Alp Amburnex (shelter) (Photo: Service Industriels Lausanne)*

Fig. 19: *3 kWp PV Eurodach amorph Flums (Photo: NET AG)*

Fig. 20: *75 kWp noise barrier installation A1 Safenwil (Photo: BFE)*

Fig. 21: *Solgreen Kraftwerk 1 Zurich (Photo: NET AG)*

Component development

↓ Inexpensive monitoring of photovoltaic installations (development of a simple and inexpensive solar installation monitoring unit with wireless data transmission. Management: NewLink Anderegg) [43], Fig. 22

Measurement campaigns

↓ Measurement campaign 100 kWp installation A 13 (management: TNC Consulting AG) [65]

↓ 47.5 kWp installation IBM (self-cleaning surface coating of modules, flat-roof installation. Management: awtec AG, Zurich) [66], Fig. 23

Fig. 22: *SMS Box Newlink*
(Photo: NewLink)

Fig. 23: *Flat roof installation IBM Zurich*
(Photo: NET AG)

Studies – tools – various projects

↓ Standardisation work on PV systems (management: Alpha Real) [70]

↓ Integration of combined PV and thermal collectors in building systems (management: S. Kropf, ETHZ Zurich) [71]

↓ REMAC Renewable Energy Market Accelerator (measures to accelerate the market for renewable electricity. Management – Swiss contribution: NET AG) [72]

↓ Quality is the Key to PV Market – accreditation / certification (preparation of quality assurance programmes for photovoltaics. Also see programme and standards [70]. Management: Alpha Real) [73]

↓ Electro college of further education PV programme 2002 (management: TNC Consulting) [A]

↓ Swiss Photovoltaics Statistics 2001 (management: Energiebüro) [B]

↓ Solar electricity from utilities (Management: Linder Kommunikation AG) [C]

The following P+D projects were completed in 2002:

Installations

↓# 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) [46]

↓# Three 10 kWp photovoltaics noise barrier installations along the expressway (combined photovoltaics and noise protection system, 3 prototype installations. Management: TNC Consulting) [53]

↓# Zholar solar boat for hire on Lake Zurich (6-seater electric catamaran with an integrated autonomous 730 Wp photovoltaics installation for supplying electricity to the drive motor. Management: SSES Zurich Regional Group) [75]

↓# Héliotram, 800 kWp PV installations in Lausanne and Geneva with DC direct injection into the tram grid (management: Sunwatt Bio Energie SA) [76]

Component development

↓# SOLight modular support structure (lightweight support structure for flat-roof installations. Management: Energiebüro) [40]

↓# Optimisation of Solgreen system (optimisation of system in respect of costs, easy mounting and material; building integration. Management: Enecolo AG) [41]

↓# Sunplicity solar roof slates (development of a PV roof slate with special attention paid to high robustness, ageing resistance and simple mounting and cabling; building integration. Management: Alpha Real AG) [42]

Measurement campaigns

↓# Visualisation and evaluation of PV installation on the Rothorn Mountain (management: Chur University of Applied Science) [77]

↓# 1 Megawatt NOK solar chain (normalised data 1997-2001. Management: Axpo) [78]

Studies – tools – various projects

PV City Guide: international final report. A national publication in three languages is in preparation (realisation of PV installations in the urban environment. Management Swiss contribution: NET AG) [79]

6. Assessment of 2002 and perspectives for 2003

The international photovoltaics market is now booming thanks to extensive promotion programmes and incentives for photovoltaic grid supply in certain countries, with growth rates of between 30 and 40%. In contrast, the Swiss photovoltaics market could not boast such favorable conditions in 2002, although the figures for the previous year could be upheld thanks to the solar stock exchanges. Relatively speaking, the IEA PVPS market data for individual countries show that while Switzerland is falling behind developments in the largest of today's markets – particularly in Germany and Japan – her position is nevertheless enviable in comparison to many other countries.

Despite the dull home market, the noticeable growth in international markets is spurring industry to take a closer look at photovoltaics. Photovoltaics is now seen as a legitimate entrepreneurial option that may provide worthwhile growth and opportunities for diversification at a future time. It is encouraging that industry's investment in photovoltaics research and development is markedly expanding (the example of Unaxis is mentioned here). This development demonstrates the importance of the firm profiles adopted by the public sector and industry, in conjunction with the distribution of responsibilities among them, with research results being increasingly implemented in industrial activities and products. Switzerland's recognised high level of know-how must be exploited to further the export of products and services.

Thanks to broadly-based promotion of the photovoltaics program, the number of projects and the level of public funding could be maintained despite the tight financial situation. The financial support provided by the Federal Office for Education and Science (OFES) to EU projects, and by the Commission for Technology and Innovation (CTI), are worthy of acknowledgement. Successful interaction between all the players, both nationally and internationally, provides the essential basis, and this aspect will continue to receive concerted attention.

Like importance is attached to the continued exchange of information and the addressing of new target groups. In this vein, the photovoltaics website www.photovoltaic.ch is to be extended. The principal events in 2003 will be the 18th Symposium for Photovoltaic Solar Energy in Staffelstein (12-14 March 2003), the 3rd World Photovoltaics Conference in Osaka (12-16 May 2003), and the IEA PVPS Conference in Osaka (19-20 May 2003).

Directed and coordinated endeavours will continue through 2003 to implement the fruits of Switzerland's research efforts, and to promote current programmes with the support of all those engaged in the field. The response to the initial call for tenders under the EU's 6th Framework Research Programme will be an important benchmark.

7. List of Research projects

(AR) Annual Report 2002 available
(FR) Final Report available

ENET: ENET Order number

A copy of the Annual Report can be downloaded at: http://www.photovoltaic.ch

A copy of the Final Report can be ordered through ENET and downloaded at: http://www.photovoltaic.ch

Further information can be downloaded at the noted Internet addresses below

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8. List of P+D projects

(AR) Annual Report 2002 available
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11. Abbreviations (and Internet websites)

General terms

PV EZA	Swiss Platfrom Photovoltaics – development cooperation	http://www.photovoltaic.ch

Funding institutions

PSEL	Fund for Projects and Studies of the Swiss Electric Utilities	http://www.psel.ch

National institutions

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
CTI	The Innovation Promotion Agency	http://www.admin.ch/bbt/d/index.htm
CUEPE	Le Centre universitaire d'étude des problèmes de l'énergie	http://www.unige.ch/cuepe
EIAJ	Ecole d'Ingénieurs de l'Arc jurassien	http://www.eiaj.ch
EMPA	Swiss Federal Laboratories for Materials Testing and Research	http://www.empa.ch
ENET	Net for information & technologies transfer in the field of energy	http://www.energieforschung.ch
EPFL	Swiss Federal Institute of Technology 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
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
LEEE - TISO	Laboratory of Energy, Ecology and Economy - Ticino	http://www.leee.dct.supsi.ch
LESO	Laboratoire d'Energie Solaire EPFL	http://www.lesomail.epfl.com
OFES	Swiss Federal Office for Education and Science	http://www.admin.ch/bbw

OPET	Swiss Federal Office for Professional Education and Technology	http://www.admin.ch/bbt
PSI	Paul Scherer 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
SESA	Swiss Electricity Supply Association	http://www.strom.ch
SFOE	Swiss Federal Office of Energy	http://www.admin.ch/bfe
SI Lausanne	Services Industriels Lausanne	http://www.lausanne.ch/energie
SUPSI	Scuola universitaria professionale della Svizzera Italiana	http://www.leee.dct.supsi.ch
	University of Applied Sciences Burgdorf	http://www.hta-bu.bfh.ch
	University of Applied Sciences Chur	http://www.fh-htwchur.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/
ESTI	European Solar Test Installation	http://ies.jrc.cec.eu.int/FieldAct/RE
IST	Information society technologies	http://www.cordis.lu/ist/
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
UNDP	United Nations Development Programme	http://www.undp.org

Private institutions and companies

NOK	Nordostschweizerische Kraftwerke	http://www.nok.ch
	Unaxis	http://www.unaxis.ch

12. Further Internet websites

	Swiss Photovoltaic Website	http://www.photovoltaic.ch
	Programme SwissEnergy	http://www.energie-schweiz.ch
	Swiss Energy Research	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/
SFOS	Swiss 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
SOLAR	Schweizerischer Fachverband für Solarenergie	http://www.solarpro.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 2002

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

This 3-year project is concerned with the further development of the micromorph tandem solar cell technology, with the aim to obtain industrially relevant manufacturing processes. During the last year of this project, 2002, the following **main results** were achieved:

- The research on high-rate deposition of microcrystalline silicon by VHF (Very High Frequency)-GD (Glow Discharge) at high working pressures (3 mbar) led to improved rates of up to 25 Å/sec. These rates could be obtained at moderate gas flows (100 sccm total flux). Raman spectroscopy showed a high degree of crystallinity for these films.
- An NREL-confirmed stabilized cell efficiency of 9.5 % was obtained, for an amorphous single-junction p-i-n solar cell deposited on in-house ZnO layers, fabricated by LP-CVD (low Pressure Chemical Vapour Deposition). This cell has been first light-soaked for 700 h under 0.75 sun intensities.
- Micromorph tandem cells (p-i-n/p-i-n) with a stabilized efficiency of 10.8 % (V_{oc} = 1.40 V, FF=66.6%, J_{sc} = 11.55 mA/cm^2) could be obtained.
- Micromorph tandem cells with an incorporated intermediate TCO layer (p-i-n/TCO/p-i-n) were manufactured; they reveal a high stability under light-exposure: almost no change in the efficiency (η = 10.7 %) could be observed after 1300 h of light-soaking. The bottom cell of this tandem has a thickness of only 1.8 µm.
- Mini-modules fabricated by a 8x8 cm^2 size reactor have been fabricated using LP-CVD ZnO as front TCO (transparent conductive oxyde), with the help of our self-developed laser-scribing equipment. In the case of amorphous single-junction p-i-n modules a stabilized aperture efficiency of 8.5 % could be achieved. In the case of micromorph p-i-n/p-i-n tandem modules a stabilized aperture efficiency of 9.8 % has been obtained.
- Our study of n-i-p a-Si:H solar cell was focussed on substrate (PET) and back-reflector texturing: the short-circuit current density J_{sc} thereby reached 14.4 mA/cm^2 with a textured PET substrate and 15.3 mA/cm^2 on textured Ag deposited on a glass substrate.
- Microcrystalline silicon n-i-p solar cells with high performance were obtained (9.2% conversion efficiency)
- Micromorph n-i-p/n-i-p tandem solar cells were deposited and 10.5% initial conversion efficiency were obtained.

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Annual Report 2002

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 transparent conductive oxide (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 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 focuses on the choice of the most appropriate 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 were deposited with uniformity better than 10% (30x30 cm^2) at deposition rates between 3 and 4 Å/s.

First half of the second year of this project, was devoted to the deposition system debugging, to the optimisation of doped layers and further exploration of the deposition parameter space for fast deposition of µc-Si:H layers. Deposition of device-grade µc-Si:H material with acceptable uniformity over 30x30 cm^2 at rate up to 10 Å/s has been achieved using VHF PE-CVD at 135 MHz. During the second half of 2002 we started the µc-Si:H cell optimisation. As the the µc-Si:H cell process in the large area deposition system is debugged, efficiency (now around 3%) is expected to reach the milestone of 5% at the end of 2002.

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Annual Report 2002

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

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Project- / Contract -Number	KTI 5994.2
Duration of the Project (from – to)	August 2002 - August 2003

ABSTRACT

The aim of the project is to develop a large area, single chamber, high thoughput coating system for mass production of silicon thin film solar cells, based on plasma enhanced chemical vapour deposition (PECVD).

In a single chamber reactor, a critical issue is the boron contamination of the intrinsic layer after deposition of the boron-doped p-layer. Several novel techniques were found to avoid the contamination, two of which are the subject of patent applications, and the method used will depend on industrial preference. Another key point was to increase the deposition rate. It was found that higher rates are accompanied by an increase in film porosity, which appears to be linked to excessive degradation of the cell efficiency. However, one should be able to compensate this effect with a combination of different technical methods (higher substrate temperature, higher excitation frequency, and dilution). The solar cells obtained meet the specifications of the original project, but further refinement of the process parameters will be carried out to reach the revised goals that were introduced due to interaction with a potential customer during execution of the project. A full size reactor (1.375 m^2 glass area) mass production system has been completed and qualification tests are underway.

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Annual Report 2002

Aufrauhen von Polymer Substraten

(gezieltes Aufrauhen von Plastikfolien für ein effizientes Light-Trapping in amorphen Solarzellen)

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Duration of the Project (from – to)	01.08.2001 – 30.09.2002

ABSTRACT

The objective of the project is the increase of light-trapping scenarios for a-Si:H solar cells deposited on polymer foils. The concept consists in defined random roughening of the substrate prior to the deposition of all involved layers. The way of roughening is focussed on in-situ RIE (Reactive Ion etching) using SF_6 / O_2 . mixtures. The application of such substrates is projected to increase the cell efficiencies of absolute 1 %

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Annual Report 2002

Optical nano gratings for nano crystalline silicon solar cell

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Duration of the Project (from – to)	01.03.2002 – 31.08.2002

ABSTRACT

Goal of the present feasibility study is to investigate the possibility of increasing the quality/price ratio of thin film silicon solar cells, by the use of low-cost plastic substrates (e.g. PET) in connection with light trapping techniques. Basically, this feasibility study was concerned both with amorphous silicon (a-Si) as well as with micro/nano-crystalline silicon (nc-Si) solar cells. However, our industrial partner, VHF-Technologies S.A., le Locle, indicated to us that, at the present stage of their commercial development, amorphous silicon (a-Si) solar cells constitute a clear priority for them. Consequently, the main part of the work done in this feasibility study is centred on a-Si solar cells. Light-trapping, in general, allows one to enhance the short-circuit current, and increase, thus, the efficiency of a solar cell. To obtain efficient light trapping, 2 different types of nano-structured surfaces were used in this project : irregular randomly textured surfaces and regular, periodic gratings. In the first case, the work described here is so far purely empirical. In the second case, theoretical work, based on numerical calculations was also carried out. During the project, a whole variety of randomly-textured nano-structures was examined in detail. The so far best structures led to a relative increase in short-circuit current of 16% (from 11.8 mA/cm^2 to 13.7mA/cm^2) for a-Si solar cells and of 16% (from 21.2 mA/cm^2 to 24.7mA/cm^2) for nc-Si solar cells. As for regular, periodic nano-gratings, the numerical calculations done here predict a relative increase in short-circuit current (and, consequently, in efficiency) up to 30% and of up to 50% for nc-Si solar cells. So far however, nano-gratings with the required optimum dimensions could not be fabricated; with the nano-gratings fabricated so far, we could only obtain on increase of 10% for a-Si solar cells, whereas nc-Si solar cells were not yet tested.

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Annual Report 2002

Thermophotovoltaik

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

*Das Projekt wurde 2002 vom PSI (SiGe-Photozellen) und ab Juli 2002 vom KTI (Thermophotovoltaik – Systemtechnologie Projekt HEAT) finanziert.

ABSTRACT

Thermophotovoltaics (TPV) is a technique to convert heat into electricity by the use of photocells. A radiation emitter is heated by a combustion flame and illuminates a photocell module. The technological difficulty is matching the emission spectrum to the spectral sensitivity of the photocells. We developed a selective Yb_2O_3 emitter, which is suitable to illuminated Si solar cells. By using relatively inexpensive Si solar cells the application of TPV in residential heating systems is possible. In an electrically self-powered heater the electricity needed for running a circulation water pump, an air fan and the electronics is provided by the TPV system. With a small TPV demonstration system we could achieve a system efficiency of 2.4 %, a record for a Si photocell based TPV system. A larger TPV demonstration system was tested successfully and can be integrated into a prototype heating system.
For a better matching of the photocell bandgap to the radiation emitter SiGe nanostructures were investigated, which might be integrated into the base of a Si photocell to increase the infrared sensitivity. The absorption coefficient in strained SiGe quantum wells was measured and compared to that of pure Si. Ge quantum dots were grown onto a Si surface to study, if Ge dot stacks are also suitable to enhance the infrared efficiency of photocells.

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Annual Report 2002

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

Addition of sodium in $Cu(In,Ga)Se_2$ (called CIGS) layers is important for high efficiency solar cells. Microstructural and electronic properties of CIGS are influenced because of Na in CIGS. Therefore, a good control of Na concentration is necessary. We have developed a method for a controlled incorporation of Na in CIGS using evaporation of the NaF precursor material.

Structural properties of CIGS layers depend on the growth procedure, substrate temperature and Na content. Sodium present during growth of CIGS has been found to reduce the grain size and to increase the variations of the Ga and In concentrations in the finished absorber film. Na incorporation method is modified to maintain the large grain size while effectively doping the CIGS layers. Solar cells were developed on sodium barrier coated glass substrates. Efficiency of solar cells grown at low deposition temperature of 450 °C increased from 10.4% to 14.4% with this approach (applied for a patent).

Another topic of investigation was the development of solar cells with alternative buffer layers grown with physical vapor deposition (PVD) methods. Effect of air exposure of CIGS prior to the deposition of CdS was investigated. Efficiency of solar cells with chemical bath deposited (CBD) CdS is 13-14% while PVD-CdS cells have efficiency of 10-11% in those specific experiments. The efficiency of solar cells with electron beam evaporated ZnS and ZnSe has increased to 8.5% but the values are lower than chemical bath deposited buffer layers.

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Annual Report 2002

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

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Project- / Contract Number	TOPNANO21: 4875.1
Duration of the Project (from – to)	July 2001 to July 2003

ABSTRACT

A novel technology utilizing nano-sized precursors for the production of low cost, high efficiency and stable thin film solar cells of Cu(In,Ga)Se_2 (called CIGS) is being developed. The unique functionality and properties of the nano-sized particles facilitate the growth of 1-2 microns thick CIGS layers of large grain size. Different nano-sized precursors are synthesized and evaluated to obtain thin layers of compact grains and good opto-electronic properties. Solar cells with efficiency of 4% have been developed on glass substrates. The advantage of this method is low cost processing and better utilization of the resource materials.

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Annual Report 2002

Dye - sensitised Nanocrystalline Solar Cells

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Project- / Contract Number	EPFL / EPFL-V
Duration of the Project (from – to)	January – December 2002

ABSTRACT

It is recognised at this time that sensitised photoelectrochemical devices offer the only technically and economically credible alternative concept to the conventional solid-state junction photovoltaic devices for solar energy applications. 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. A major limitation on efficiency is the recombination of photogenerated charge carriers within the device. In the dye-sensitised system this loss mechanism is minimised since the processes of optical absorption and charge separation take place on distinct phases within these photovoltaic cells. In consequence oppositely charged species are restricted to separate phases. 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 electrolyte phase is replaced by an organic charge transport medium. Significant progress has been made during the past year, particularly with the heterojunction device.

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Annual Report 2002

Highly Efficient Nanocrystalline Solar Cells for Indoor Applications

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Project- / Contract Number	5815.1 / 5480.3
Duration of the Project (from – to)	36 months; 2001 - 2004

ABSTRACT

The goals of this project are the up-scaling to commercial dimensions and the technology transfer to the partner industry of the necessary nanoparticle-based technologies required for the production of dye solar cells. As stated in a separate report, recombination losses are inhibited by the specific characteristics of this type of solar cell, rendering it more suitable for operation indoors and under reduced light levels. Cell fabrication requires the preparation of nanoparticulate semiconductor powders, and methods of preparing mesoporous layers from these materials on transparent conducting oxide coated glass substrates. The layers are then sensitized to visible light by chemisorbed electroactive dyes. This photoanode is associated with a redox electrolyte and cathode to form an electrochemical photovoltaic cell. The cells will be optimised for indoor applications. This project is critical to the start-up company Greatcell Solar, as it will receive key information and technology required for its intended product.

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Annual Report 2002

Outdoor measurements of new-technology solar cells

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

ABSTRACT

The project deals with the validation of dye-sensitized nanocrystalline solar cells as devices for outdoor use and test procedures in a natural environment. Such measurements are essential to determine the energy conversion yields of these new photovoltaic devices under realistic conditions. The project has started in the spring of 1999 with preparative work at EPFL. A test structure for the solar cells was constructed and 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 conventional solid state devices where one third of the efficiency is lost over the same temperature range. Compatibility of cell sealants and structural materials was investigated under outdoor service conditions. Cells were constructed showing stable indoor operation under UV light and/or temperature stress. The effect of the air mass number on the photovoltaic conversion efficiency was investigated: the conversion efficiency decreases gradually with increasing air mass number. A series of cells have been installed in the test structure at Mont Soleil for outdoor aging tests.

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Annual Report 2002

NANOMAX - dye-sensitised nanocrystalline solar cells having maximum performance

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Project- / Contract Number	NNE5-2001-00192 / BBW 01.0268-1/2
Duration of the Project (from – to)	36 months, 2001 - 2004

ABSTRACT

Nano-crystalline dye sensitised solar cells (DSC) and modules are a field of rapid evolution in research and development. World-wide, about 60 groups are engaged in a growing effort, especially in Japan. As well as an innovative concept, these cells use materials not previously investigated for PV applications

Most work in recent years on dye sensitised solar cells has focussed on the optimisation of cells with a standard photoelectrode design, i.e. a single sensitising dye adsorbed on nano-crystalline titanium dioxide. Although great progress has been made in terms of stability, in large part due to work on electrolyte composition and sealing, progress in efficiency has proven difficult.

In this project, directed by ECN, the Netherlands Energy Research Centre and sponsored by the Commission of the European Communities, there is a break with this practice. New concepts, both for cell design and in materials, are necessary to boost the efficiency from the present 8 - 10% to ~15% in the near future to compete directly on efficiency grounds with silicon solid-state devices. In NANOMAX, cells with various new photoelectrode concepts and materials will be manufactured and studied. In particular, cells with thinner or multiple-layer structures will be produced. Nano-crystalline oxides with reduced electron recombination properties will be prepared and surface selective as well as near-infrared (NIR) enhanced sensitising dyes will be applied.

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Annual Report 2002

Photochemische, Photoelektrochemische und Photovoltaische Umwandlung und Speicherung von Sonnenenergie

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

ABSTRACT

AgCl layers which are deposited electrochemically onto glass, together with Ag^+, can work as a photo catalyser for the oxidation of water in oxygen. Thereby, silver clusters are formed on the AgCl layer which can be oxidised quantitatively to Ag^+ by using a polarising voltage. These silver clusters are also responsible for the self sensitisation which allows the system to absorb light in the visible spectrum. In order to increase the absorbance of the AgCl photoanode and hence the produced amount of O_2, first experiments were carried out with AgBr sensitised AgCl electrodes. This solution is interesting and should be further explored. Photocathodes were made of platinated silicon solar cells and platinated p-$GaInP_2$. With both semiconductors it was possible to split water into hydrogen and oxygen

Light absorption in zeolyte mini-crystals filled with dyes is used to develop a new generation of thin film solar cells. Interesting results were produced with these photonic antennas: Light absorption occurs in molecules with strongly fluorescent dyes covering the entire visible spectrum which are introduced in linear channels of tiny and porous zeolyte crystals. When light shines on the fluorescent dye, the molecules absorb light quanta. These “packets of energy” allow electrons to reach an activated state. When the dye molecules are properly ordered in the mini crystals they are densely packed and orientated. This in turn allows the packets of energy to be transported without radiation. The trick is to close the channels with a second kind of fluorescent molecule like a cork. The different molecules are well adapted to each other. This “cork” molecule can absorb the packets of energy to activate electrons but this energy cannot be fed back into the crystal channel. The energy is then transferred to the surface of the crystal where it can be accepted by a neighbouring semiconductor substrate. The latter works as a conventional thin film solar cell.

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Annual Report 2002

Photoactive Composite Module

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Project- / Contract Number	KTI 5581.1 FHS
Duration of the Project (from – to)	1.4.02 – 31.3.03

ABSTRACT

The purpose of this project is the integration of thin-film silicon solar cells on industrial facade elements. The combination of an Alucobond facade element of Alusuisse with flexible solar cells of VHF-Technologies is a completely novel possibility of integrating solar cells on facade elements. Both, Alucobond facade materials and VHF-Technologies' solar cells are produced in a roll-to-roll fabrication process, therefore a simultaneous and direct lamination of solar cells (off the roll) at the moment when the Alucobond is manufactured is feasible. Such a continuos roll-to-roll fabrication method is particularly cost competitive when compared with the standard fabrication of single modules based on crystalline technology, where individual cells have to be selected, assembled, interconnected and finally have to be carefully sandwiched between two tempered glass plates.

The goal of this project is to demonstrate the technical and industrial feasibility of this new photovoltaic facade element by the fabrication and testing of prototype modules. Simultaneously, the economical viability of the concept shall be assessed.

In the first part of the project, the following results were obtainded:

- a process for fabrication of large area modules with a high yield was established at VHF-Technologies
- a stable aperture area efficiency of 3% was obtained with this process
- a survey of various lamination technologies was conducted
- this study resulted in a preference towards a conservative EVA/ETFE short term encapsulation solution
- various PV facade element prototypes were fabricated to be submitted to lifetime testing
- a large area module of 2000mm x 1000mm was fabricated on an Alucobond sheet, delivering 34 $Watt_{peak}$

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Annual Report 2002

HIPERB High Performance photovoltaics in buildings

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Project- / Contract -Number	EC: NNE5-1999-0233 (ERK6-1999-00009; BBW 99.0039)
Duration of the Project (from – to)	(1. April 2000); 1. Oktober 2001 to 31. September 2003

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 aesthetical 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.

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Annual Report 2002

AFRODITE Advanced Façade and Roof Elements Key to Large Scale Building Integration of Photovoltaic Energy

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Project- / Contract -Number	NNE5-2000-00178 / ENK5-CT-2000-00345
Duration of the Project (from – to)	(1. April 2001); 1. Oktober 2001 to 1. April 2004

ABSTRACT

The objective of this work is to improve the acceptability of building integrated renewable energy conversion by developing high performance photovoltaic building elements with a high visual appeal. After an exercise of translating the visual appeal into technical specifications, a number of novelties are introduced both on the level of the crystalline silicon solar cell structure, the required production equipment and for the module manufacturing. Supporting the development of the new products with both reliability testing and an extended outdoor performance evaluation, a number of highly efficient demonstrator building elements have been manufactured.

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Annual Report 2002

ADVANTAGE Advances next generation rear contact module technology for building

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Project- / Contract Number	EKN5 - 2000 - 00340
Duration of the Project (from – to)	2000 - 2003

ABSTRACT

In the EU project ADVANTAGE, work is being carried out on the development of rear contact solar cells and their integration in glass modules. The electrical contact of the rear contact solar cells with the glass surface occurs through a strip conductor which is burned into the glass at very high temperatures. Screen printing is used to bring the conducting paste containing a large fraction of silver onto the glass substrate. The pattern of the strip conductors depends on the accessibility for contact of the solar cells and the chosen contact place. An important prerequisite for manufacturing is to be able to sold onto the conductor strips. The glass modules are fabricated of two glass surfaces which are kept separate by a distance frame and sealed on the outer frame. This system allows to mount rear contact or other solar cells in a vacuum environment. Since some time, Kurth Glas & Spiegel is working on the processing of glass for solar applications, electrical contacts of glass surfaces and the manufacturing of glass modules.

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Annual Report 2002

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 31st of December 2002

ABSTRACT

In 2002, DEMOSITE continued to promote and stimulate the development of Building Integrated Photovoltaic, even though the allocated budget had to cover 12 months instead of the 3 months previously planned:

- Several group visits were organised on the site location in Lausanne,
- A particular attention was dedicated to the development of the Website.
- The set of posters on Demosite were presented at the Swiss National Photovoltaics day in Tessin
- The Final Report was produced

DEMOSITE was also presented (oral presentation) at the European conference "PV in Europe", organised in October in Rome. 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.

This year, being the first operation year after the official closing of the Task 7, no new pavilion has been built.

As planned, the reduced operation team concentrated on the dissemination activities linked to Demosite: visits, website, reports and conferences.

The future of the site should be decided next year, considering a potential use within the upcoming Task 10, a limited period of reduced activity or a complete dismantling.

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Annual Report 2002

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 is now in its third year. Main activity in 2002 were the publication of the two Enerbuild newsletters and the project leaflets and the preparation of status reports including recommendations for future strategies to each of the six thematic areas. These reports aim at outlining the future R&D-priorities in order to increase the market share of renewable energy utilisation and the reduction of nonrenewable fuel consumption. In the reporting year there were three Steering Committee meetings in Brussels and a project workshop with about 40 participants in Lyon together with the EPIC 2002 AIVC conference. Integrated in this successful workshop with, the launching of the collaboration with NAS-partners was another major event. An individual report to each of the six thematic areas is prepared and afterwards collected in one report.

Beside Energy there are other related aspects discussed such as living and comfort, architectural and industrial issues and social aspects covered. A key statement such a context is that energy saving methods and the utilisation of solar energy must consider also the requirements for comfort, aesthetics, safety, economics and quality.

For the PV part, the strategy report contains among other the following conclusions:

Most of the PV market in Europe will be building integrated. Therefore building integration has to be an integral part of the EU-PV – program. R&D shall be continued in both technical approaches such as mono- and polycrystalline solar cells and thin film technology. The existing standards have to be adapted to include PV as construction element and building product and to consider wide spread use including safety and quality aspects. New marketing stimulation and guidance measures shall be developed and implemented in all EU-countries. An education program as part of the large deployment is recommended in order to reduce costs for the installations and to keep a high quality and performance. This has to include all levels of involvements from the system design over the installer up to the operator.

Enerbuild will conclude its activities by end of March 2003. Several options of future networking in the energy supply for buildings is under consideration.

Further information is available on www.enerbuild.net.

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Annual Report 2002

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 8th test-cycle of the modules and has begun a new (9th) test using 14 new types of module chosen and bought anonymously from those available on the Swiss market (3 sc-Si; 9 mc-Si; 2 a-Si). The initial power degradation of the c-Si modules was equal to -5% in the worst case.

The data analysis of the 7th and 8th cycles allowed a further improvement of matrix method for the energy yield prediction. The power matrixes P(G, Ta) have been improved and the method mean error reduced to 1.1%. The results are at the engineer's disposal, and they will be soon available on the web as simple Excel sheets.

On May 2002, the 10 kW TISO PV plant reached its 20th year of operation. For the occasion, the LEEE-TISO organized, in Trevano, the Swiss National Photovoltaic Symposium. A detailed analysis of the 10 kW TISO plant is supplied in the annual report of the European SOLAREC project “Mean Time Before Failure”.

The LEEE-TISO contributed to the drawing up of the cantonal decree for installation grants for photovoltaic plants. This initiative will allow the realization of about 50 PV systems. The LEEE-TISO is also responsible for the quality control of the installed plants. The subsidies program started in autumn 2002.

Four new small PV plants have been installed at the LEEE centre. They have been realized using the modules of previous test cycles, and the inverters bought for the postgraduate PV courses.

One year after the audit for the ISO 17025 accreditation, the LEEE-TISO successfully passed the annual quality control. The reliability of the LEEE-TISO sun simulator has been confirmed by the execution of repeatability measurements and round robin tests with other institutes. The LEEE-TISO has also been chosen, with other 9 laboratories, for an international inter-comparison measurement (2002-2005).

In 2002, the LEEE-TISO performed about 100 third party indoor I-V measurements, one on-site PV plant I-V measurement, and two PV systems infra-red analysis.

A six-month extension of the project has been requested in order to reach all the stated goals.

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Annual Report 2002

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

In May 1982, the first European grid-connected PV plant came into operation. The objective of this array was to provide a technologically advanced facility of medium size giving practical information for the planning of future photovoltaic plants.
In April 2000, in proximity to the 20-year design life of the plant, a collaboration between the LEEE-TISO and the ESTI Laboratory (JRC Ispra) started to determine the Mean Time Before Failure (MTBF) of the system and to investigate the physical degradation mechanism in action and to correlate field reliability with accelerated lifetime tests (IEC/CEI 61215).
Results show that, although it is not looking good from a visual aspect, the system is working in a very satisfactory manner.
Concerning IR analysis, hot-spots have been detected on 24% of modules. Hot-spots represent the principal cause of power degradation.
Outdoor strings measurements have been performed and the obtained data have been compared with the one of the same measurements executed in 1983. It has been a general comparison, as the plant configuration and the electrical wiring were changed in 1992 (inverter substitution). Results indicated no relevant strings performance losses.
Since June 2000, individual string energy production has been continuously monitored and recorded, allowing analysis and comparison of string behaviour. These data also show the seasonal variation of plant energy production, which is strongly influenced by ambient temperature.
Regarding the determination of the Mean Time Before Failure of the plant, it is reasonable to assume, on the basis of results obtained from accelerated lifetime tests, that the modules could continue to provide useful electrical power for another 10-15 years.

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Annual Report 2002

PV-Pro-Test-Datenbank - Energieertrag Output of PV-Modules

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Duration of the Project (from – to)	1/2002-12/2003

ABSTRACT

A new method has been proposed to calculate the yearly output of photovoltaic modules at selected sites with site-specific meteorological data [1]. It is based on efficiency models taking into account that the efficiency is dependent on module temperature, solar irradiance (part load behaviour) and relative air mass ("spectral quality of sun light"). To develop the models, current/voltage (I/V) characteristics of the modules are taken outdoors at PSI's test facility [2] under varying module temperatures, irradiances and air masses. Using these characteristics, semi-empirical efficiency models are developed, allowing a relatively simple calculation of the module (cell) efficiency under all relevant operating conditions. Models were elaborated not only for modules produced by Sharp, Siemens, Kyocera, Astro-Power, Uni-Solar and BP Solar, but also for prototype modules and cells from ZSW, Stuttgart, University of Neuenburg, EPFL and Solartec, Czech Republic. Using measured meteorological data (e.g. 5-min mean values) from sun-belt sites, alpine and midland sites, the monthly and yearly output of the modules and cells can be calculated precisely. These outputs are indispensable for calculating the electricity generation cost of the different modules and thus allowing for an economic selection of modules for given sites. They are also of vital importance for correct PV-plant sizing. The advantage of the method proposed is that no suppliers' data are required.

All detailed data of several thousands I/V characteristics of the modules and cells in question, in particular efficiency, module (cell) temperature, ambient temperature, irradiance, air mass, short circuit current, open circuit voltage as well as current, voltage and power output under optimum operating conditions, are stored in an access data base. These data are highly valuable for more detailed evaluation, not only to model the open circuit voltage and short circuit current as a function of cell temperature and irradiance, but also to investigate the influence of air mass on the efficiency.

The present report is restricted to tests and modelling with a CIS module of Siemens (ST40), an mc-Si module of Astro Power (AP1206), a triple junction module of Uni-Solar (US-30),an mc-Si module of BP Solar (BP585) and a CIGS prototype module from ZSW, Stuttgart. Output calculations for these modules were performed for a sunny site in Jordan (Al Qawairah) for which reliable measured meteodata are available [3]. The yearly output for these modules in South orientation and at an inclination angle of 30° was found to be: 230, 238, 149, 289 and 182 kWh/m^2 and 2298, 2264, 2376, 2272 and 2212 kWh/kWp respectively. For sun-tracked modules the yearly output was: 314, 328, 198, 396 and 257 kWh/m^2 and 3136, 3111, 3162, 3131 and 3125 kWh/kWp, respectively.

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Annual Report 2002

Energy Rating of Solar Modules Workshop March 22, 2002 in Zürich

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Duration of the Project (from – to)	1st Jan 2002 – April 2002

ABSTRACT

As there are commercial investors in photovoltaic, they need a better declaration of the most costly component of a PV installation: the solar modules. Today, we just know about the peak Power at STC. The actual purchase of modules is comparing the price vs. power output at STC. But it should compare price vs. the energy production. With the actual data, it's not possible. That's the reason why a workshop was held in March 2002 in Zurich to get an overview of existing methods of energy rating. There were three comparable methods found, that need to be tested to see which one gives the best information.

The workshop has been a good success, more than 30 people attended the workshop. As a result of the workshop a continuing project has been defined and is starting end of 2002.

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Annual Report 2002

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 2002

- Update of HTA Burgdorf's monitoring visualisation software, including a new option (export of monitoring data in the format of IEA PVPS Task II, possible also for old monitoring data).
- Detailed analysis of ageing behaviour of 2 older c-Si PV plants in co-operation with Enecolo AG, Mönchaltorf.
- Second cleaning of the PV Generator of PV plant HTA Burgdorf after 4 years since last cleaning and measurement of PV generator performance before and after cleaning.
- Revision of the old monitoring system of PV plant Schlossmatt 8 and of the PV test centre of HTA Burgdorf.
- Different improvements at the monitoring system of PV plant Mont Soleil.

Most important results in 2002

- Inverter reliability increased this year, because there was only one defect observed at a 7 year old inverter (SolarmaxS) until october 2002.
- At PV plant HTA Burgdorf: Cleaning after 4 years resulted in a power increase of about 9%. Irreversible loss of about 3% of STC power registered during 8 years of operation.
- During the last years, energy production of most PV plants in Burgdorf slightly decreased, because of inverter defects, permanent pollution of the PV generators and ageing of individual modules.
- Measuring of a 12 year old roof-integrated PV-plant with severe panel delaminations showed a power-reduction of 44% referred to rated power.
- Analysis of a 5 year old flat mounted PV generator (tilt angle = 5°) of a grid connected PV plant in Zürich. The power reduction caused by pollution was up to 8%.
- Long term monitoring data of 7 different PV plants with more than 30 monitoring years converted to IEA PVPS format for inclusion in IEA PVPS Task II database.

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Annual Report 2002

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. The project has reached its mid-term objective in December 2002 and all the participants have presented the state of their technology and the objectives which could be obtained in the future.

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.

The project could have been entitled “Are there alternatives to Lead-Acid batteries for renewable energy storage” : today lead-acid batteries are used in almost all the autonomous applications of solar energy. Only some professional systems working in northern countries at low temperature use Ni-Cd batteries.

From the table comparing all the technologies, we see that only one challenger is able to compete in terms of pricing. Compressed air systems can store energy at a lower cost than lead-acid batteries with numerous advantages:

- They use existing components (air bottles, valves, ...) available everywhere and few new components have to be designed.
- Their environmental impact is very low : no heavy metal, no chemicals, very long life systems.
- High efficient mechanical power available for rural applications like food processing, cooling, ...

The other technologies described offer all some specific interest:

- Li batteries for their energy density and life-time for portable applications.
- Ni-MH also interesting for portable needs at a lower cost than Li.
- Super caps and flywheels are efficient for very short term energy needs.
- Redox systems might become cost effective for large needs.

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Annual Report 2002

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

SODA is an EU project within the IST (Information Society Technology) of the 5th RTD framework programme of the European Commission. The goal of this project is to provide worldwide solar data in an easier way. This is being achieved by using the internet.

During the third project year, a prototype of the new internet service (www.soda-is.com) was developed. It consists of a wide range of resources which are provided by different servers throughout Europe. The customer communicates with the central server only. This central server collects the necessary data even if these are distributed in a network of computers. METEOTEST has programmed 20 resources and provides these through its own server to the new internet service.

The resources available show many aspects of irradiation meteorology and climatology for a variety of applications. SODA is not just a (simplified) Online-METEONORM but it consists of a connection of data models and data bases used in METEONORM and the European Solar Radiation Atlas (ESRA). The prototype also contains up-to date daily data (MARS database) which can be used to check the performance of solar installations. Moreover, simple models for the simulation of thermal and photovoltaic solar systems and brightness analyses are provided. The accessible data cover short-wavelength, UV- and long-wavelength radiation as well as temperature values.

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

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Project- / Contract -Number	ENK5-2000-00332
Duration of the Project (from – to)	2001 - 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 2002

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 Sebastian Will 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 and manage 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 behaviour and 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 2002

Schweizer Beitrag IEA PVPS Task 1

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Project- / Contract Number	11427
Duration of the Project (from – to)	2002

ABSTRACT

The Swiss contribution to the PVPS Programme included:

- **National Survey Report**, a summary of developments in the market and political areas. The report's data is integrated into the IEA's **International Survey Report**
- Acquisition of Swiss contributions to **PV Power**, distribution of the magazine to approx. 250 Addresses in Switzerland
- Targeted search for **new contacts** in the PV area
- Contributions to national and international **workshops**
- **PR-work** in Switzerland. Reference to the programme's international publications

The results of these activities included

- **National Survey Report** (NSR) based on the statistics provided by the Swiss Association of Solar Professionals and the Swiss Association of Utilities (grid-coupled installations)
- Distribution of the **PV Power** Magazine in July and December, including an article on the new PV installation on the football stadium in Basel
- Utilities active in the Solar Power Exchanges area reacted positively to sample copies. An E-mail based **newsletter** has been suggested.
- Two **Task 1 meetings** in Bode, Norway and Basel, Switzerland. The latter presented the opportunity of presenting the City of Basel's promotion scheme and other Swiss activities.

Work still to be done includes:

- Definition and collection of commercial data (**Value of Business**). Task 1 Members still have to be convinced of the importance of business (and not just technical) data.

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IEA PVPS Programm, Task 2 (Schweizer Beitrag 2002)

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Project- / Contract -Number	14805 / 86295
Duration of the Project	1. January 2002 - 31. December 2002

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 2 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 PVPS Performance 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 published in May 2000.

The second phase of the Task work consists now mainly in the preparation and the dissemination of results to the target groups via the Task 2 homepage (http://www.task2.org/).

This annual report gives an overview of the Task 2 main activities for the year 2002. Which where:

- Two expert meetings
- Distribution of the IEA PVPS Performance Database
- Analysis of the data collected
- Maintenance of the Task 2 WWW-Homepage
- Definition and implementation of new activities
- Dissemination of results

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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IEA PVPS Task 3
Use of photovoltaic systems in stand-alone and island applications

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Project- / Contract -Number	35550 / 85956
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 draft of **"Management of the Quality of SAPV systems: recommended practices",** has been improved and should be finalized for the end of the task.

In Subtask 2, the following works continue:
- The paper **"Guidelines for selecting SAPV systems"** which allow prospective users of SAPV systems to find what system meet best their needs should be finished for spring 2003. A second publication **"Monitoring guidelines for SAPV systems**" has been be split in two papers, one on the system performance evaluation, one on technical recommendations for the measurement and monitoring of systems and should be edited for the end of 2003.
- **"Testing of batteries to be used in SAPV systems"** should be available on the T3 web site at the end of 2002. This work summarizes a large study of 7 techniques to measure lead-acid batteries to be used in stand-alone PV systems. Many curves show the behavior of the usual battery technologies
- **"Use of appliances in SAPV systems: problems and solutions"** will also be on the T3 web site for the end of 2002. A French version will follow shortly. This work presents experience coming from real PV systems all around the world where load problems have been identified. It proposes solutions to solve typical problems and recommendations on how to avoid these problems from the design stage.
- The draft on **"Demand Side Management"** has been improved and should be ready for the end of 2003. It will gives recommendations on how to optimize the use of all the power sources (e.g. solar, diesel, wind) in order to reduce the cost of energy, improve the reliability of the energy supply and optimize the overall system performance.

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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 October 2002

ABSTRACT

With the participation of experts from 11 countries, first stage of the Task 5 activity was carried out from 1993 to 1998. The main objective was to develop and verify technical requirements, which may serve as the technical guidelines for grid interconnection of building integrated and other dispersed PV systems. The development of these technical guidelines intend to safe and reliable interconnection of PV systems to the utility grid at the lowest possible cost. PV systems to be considered were set as systems connected with a low-voltage grid, which are typically of a size less than 100 kilowatts. In order to achieve the objectives, three subtasks were established and collaboration work between participating experts were conducted.
1998 Task 5 finished first stage of work to identify grid interconnection issues of PV systems and to draft possible recommendation for improvement. In total five reports (two internal and three public) were published. Several issues still remained, like islanding issues, interconnection of many PV systems, financial aspects of grid interconnected PV systems and so on. These issues were studied in the follow-up Subtask 50: Study on highly concentrated penetration of grid interconnected PV systems. This extension of Task 5 was started January 1st 1999 and concluded December 31st 2001. The objective was 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.

The original defined objectives have all been met, leading to an extensive list of high quality results. These results have contributed to the technical understanding and development of grid interconnected building integrated and other dispersed PV systems. The effectiveness of the national participation was good. Task 5 participants represented actors from inverter manufacturers, network utilities, engineering companies and testing institutes. The participating experts learned from each others experiences and provided excellent national information, being reflected in a list of high quality deliverables. Clearly one of the highlight in the Subtask 50 work was the two-year measurement in the Netherlands to determine the probability of an islanding situation with a multiple PV system in a normal residential grid. Thanks to all the results, adequate detection methods for islanding were reported in a workshop, held in Arnhem, NL. These results are providing a better understanding of the probability of the islanding phenomena and will lead towards cost-effective and safe methods for the detection. Further deliverables of Subtask 50 will help to consider the impact of highly concentrated PV systems on electricity distribution systems and enable the widespread deployment of solar energy.

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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 October 2002

ABSTRACT

Task 7 started 1st January 1997 and ended officially 31st December 2001. Due to the final conference, which was held in connection with the 'PV in Europe'-conference in Rome and deliverables, which were in ballot or print process, the Task closed in October 2002.

The objective of Task 7 was to enhance the architectural quality, the technical quality and the economic viability of PV systems in the built environment. Besides, attention was paid to the assessment and removal of non-technical barriers to PV as an energy-significant option. Primary focus was 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). In order to achieve the overall objectives, participants have carried out the work in four Subtasks: architectural design, systems technologies, non-technical barriers and demonstration and dissemination.

The original defined objectives (per subtask and overall) have almost all been met, leading to an extensive list of high quality results. These results have contributed to the architectural and technical development of building integrated PV, as well as to the understanding of near term market opportunities for building integrated PV. However, a minor revised working plan and a revised deadline at the end of Task 7 were necessary to receive all deliverables. The effectiveness of the national participation was good. Task 7 participants represented all actors in the market, through which the introduction of PV could be influenced over the full scope of relevant topics. The participating experts learned form each others experiences, being reflected in an extensive list of high – quality deliverables. Following some of the highlights:

A public PV database www.pvdatabase.com presents in one section world-wide BIPV applications in different building areas. A second section presents an overview of available BIPV system technologies today. Further the Task 7 book 'Designing with Solar Power', targeting architects, engineers and the PV community with high-profile case studies and several general information on BIPV issues. In Subtask 3 one outstanding report is covering the PV potential in the IEA countries and another report marketing strategies. An important topic in Subtask 4 is the DEMOSITE in Lausanne, co-ordinated by EPFL-LESO.

The experts disseminated the gained international knowledge to other national parties. National workshops proved to be a valuable asset to commit the industry. Task 7 showed a good visibility to the PV community. The results are widely spread through national workshops, (inter)national conferences, a broad world-wide experts network and through www.task7.org. Task 7 has provided an unique opportunity to link together leading PV programmes in the US, Europe, Japan and other countries. This has lead to a unique co-operative for dissemination of experiences and information exchange.

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Swiss Platform PV Development Co-operation and Contribution to IEA PVPS Task 9

(Deployment of Photovoltaic Technologies: Co-operation with Developing Countries)

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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 - Deployment of Photovoltaic Technologies: Co-operation with Developing Countries. The objective of Task 9 is to further increase the overall rate of successful deployment of PV systems in developing countries. This is being 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.

In the course of the third project year, first recommended practice guides were published by Task 9.

Beyond the contribution to IEA PVPS 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

In the third project year, dissemination activities were ongoing with a number of workshops and conference contributions. Interest for the subject of renewable energy in technology co-operation activities as well as awareness of the relevant issues for successful projects and programmes were clearly increased. A concept was developed for the possible future Swiss activities in this area. A broader platform for the promotion of renewable energy in international co-operation is envisaged.

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PV-EC-NET - Thematic Network for Co-ordination of European and National RTD Programmes on Photovoltaic Solar Energy

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Project- / Contract -Number	NNE5-2001-00201, BBW 01.0190
Duration of the Project (from – to)	01.01.2002 - 30.06.2003

ABSTRACT

PV-EC-NET is bringing together most co-ordinating institutions of the national PV RTD programmes of the member and associated states of the European Union. The main goal of PV-EC-NET is to increase the efficiency and coherence of the PV RTD Programmes of the EU and the independent EU member- and associated states (hereafter indicated as 'EU and national PV RTD programmes'). PV-EC-NET is therefore collecting, analysing and disseminating the information about these EU and national PV RTD programmes. This should be achieved by establishing a Central European PV Information Centre, which will be given the task to co-ordinate the collection, processing and dissemination of this information, resulting in a commonly shared European PV roadmap.

With the goal to analyse and, where possible, improve, the efficiency of the EU and national PV RTD programmes, a benchmark of these programmes will be part of the activities of PV-EC-NET. This benchmark also aims to identify successful strategies and their key features. Furthermore a SWOT (Strengths, Weaknesses, Opportunities and Treats) analysis of the European PV situation is performed. Ultimately, the network aims to provide a common European PV RTD Roadmap, thereby benefiting the EC and national PV RTD programmes by strengthening the European PV RTD base and its impact on the European PV industry.

In order to increase the coherence of activities at as many levels as possible, the information is made available to all interested parties of the member- and associated states through several different means of communication, including at least a professional website, a periodical and workshops.

The most important deliverables of PV-EC-NET will thus be an Information Office and a commonly accepted European PV RTD roadmap. Further deliverables will be a commonly accessible website, containing all available information on EU and national PV RTD programmes and activities, a newsletter, containing the latest information on the EU and national programmes and an overview of the state of the art of PV in the EU and the different states and in the other PV strong regions like Japan, USA and Australia. Based on the acquired information and in close consultation with representatives of the EC, PV-EC-NET will furthermore propose a set of recommendations for the EC and the national governments.

Through the installation of a Common European PV Information Centre, PV-EC-NET provides a solid basis for continuation of information exchange, required for direct and future PV RTD Programme co-ordination.

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SOLight PV-Module Structure

New Light-Weight Flat Roof Photovoltaic Module Mounting System

Especially for Use on Roofs with Low Static Reserves

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Project- / Contract -Number	27703 / 69120
Duration of the Project (from – to)	January 1999 - April 2002

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 labour 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 times 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 UV-protection 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 were being tested for verification purposes.

The project has been successfully completed and a few promising designs have been evaluated as most promising. From these solutions, which are different deviates from a somewhat similar idea, 2 systems have been chosen to be further explored. For this, a pilot installation is planned for 2003, incorporating a significant number of SOLight structures with small alteration such as material, make or number of support structure to test the system for its usability in real outdoor condition, e.g. wind and snow load.

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SOLGREEN
PV - Anlagen auf Gründächern

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Project- / Contract -Number	37527 / 77266
Duration of the Project (from – to)	2000 - 2003

ABSTRACT

SOLGREEN is a new mounting structure for PV modules on green flat roofs. It helps to combine clean solar energy production with environmentally friendly roof surfaces.

The goal was to develop a lightweight system which uses the existing substrate on the roof to withstand the windforces. Thus the mounting structure of the modules is kept in place by the gravel and the substrate for the roof vegetation. The project team Enecolo AG, EPFL-LESO, Ernst Schweizer Metallbau AG and Solstis Sàrl has developed a new, material saving, esthetically pleasing and lightweight mounting structure. The result will be visible on the market with competitive products.

An important design aspect was the establishment of a reasonable distance between the roof surface and the lower edge of the modules. Thus, shading of the lower cells by the vegetation is avoided and the time between two maintenance cycles is increased. The proposed distance is in the range of 20 – 30 cm.

A higher structure causes increased costs because more material is used. The developed products had to be optimized in view of costs. Otherwise such systems would have the character of a niche product.

SOLGREEN is available for different inclination angles between 20° and 30° and for most of the available solar modules, either laminates or framed modules. Several pilot and demonstration systems have been installed up to now, with a power of more than 80 kW_p. The analysis results as well as the feedbacks from the involved persons are very positive. The combination of PV with roof vegetation works well. Monitoring of the installations in Zurich and Basel over a period of 5 years, including windforce measurements, shall prove the quality and proper function of the system and give hints for possible improvements.

Central point of interest is the durability and the solidity of the system, because it has to withstand heavy windforces over a period of 20 to 30 years at exposed places. Many efforts were made in this area. Another important aspect is the choice of seeds and soil substrate. Slow and low growing plants should be preferred, as well as the substrate shouldn't contain too many fertilizing components making plants growing too intensive.

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Annual Report 2002

Solar roof shingle Sunplicity ™

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Project- / Contract -Number	37528/77267
Duration of the Project (from – to)	1999-2002

ABSTRACT

SUNPLICITY is a new solar building element for tilted roofs. It has been designed, built and successfully tested in a combined effort in an industrial partnership between three Swiss and one US based company. Four test set- ups have been built and evaluated to optimise integration, design and electrical interconnection. The first one in Zürich was to proof feasibility, the second one in Rickenbach was to evaluate potential roofer's concern, the third one in Schwyz to optimise cabling and interconnecting issues and the fourth and final one at LEEE in Lugano to measure and evaluate expected temperature in comparison with rack mounted PV modules. The temperature histogram over a given period was used to extrapolate expected lifetime of the plastic material and potential energy losses to the particular integration. SUNPLICITY fits in every conventional roof built from fibre cement shingles, which are widely used in northern Europe.

Its dimensions are exactly identical to a 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 very straightforward: wherever the roofer wants solar shingles, he replaces conventional shingles with the new solar shingle Sunplicity. Even the electrical connections are in the same plane. A new interconnection design provides safe and reliable cabling of the PV array formed by the solar roof shingles.

Requirements on the roof may be higher, and the challenge to meet the low cost figures of conventional roofing material is much harder than in the facade. The facade is more forgiving in terms of waterproofing, water shedding, snow and wind loads, UV, heat etc. Nevertheless, when considering the option to contribute not only to a merging niche market, but to contribute to a new energy supply paradigm based on renewables, the roof will ultimately play a more important role. Several studies indicate that the market for roofing systems in countries like Switzerland are in the range of 20sqm per capita. This represents a huge market, which certainly justifies the efforts the PV industry to develop innovative new products and systems for the roofs. The new design Sunplicity fulfills these criteria.

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Annual Report 2002

A Simple and Inexpensive Monitoring Unit for Solar Plants

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Project- / Contract Number	43851 / 83896
Duration of the Project (from – to)	Jan 2002 – Mar 2003

ABSTRACT

Today, photovoltaic plants must be supervised because they are mainly financed by their energy production. A monitoring unit for these plants should be easy to install and very economically in the long run.
The system developed in this project fulfils these requirements in a simple and effective way:

- The device communicates through GSM which keeps the installation costs at a minimum.
- Data or alarms are uniquely transmitted by SMS, thus removing the need of a costly line subscription by using a prepaid SIM-Card.
- For simple monitoring and alarm detection, only an energy meter with a impulse output is needed.
- GSM enables the transmitting of pager, fax or e-mail messages.

The operating costs of this unit are below one franc per month. This makes the unit also interesting for small PV plants.

The development and the field-test were completed this year. They showed that the developed system can efficiently supervise a PV plant.

We also did some examination and experimentation concerning different alarm criteria. By the combination of two simple alarm conditions almost every technical and operational malfunction can be efficiently detected. For normal supervising, there is no need for an addition light sensor.

In summary, the device proved to be reliable and simple to use. The experiences show that there is still room for some improvements especially for the user interface and for a reduction of the manufacturing costs.

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Annual Report 2002

Photovoltaic-Alpur-Roof

New roofing-system for photovoltaic modules

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Project- / Contract Number	45134 / 85214
Duration of the Project (from – to)	May 2002 – April 2004

ABSTRACT

The project photovoltaic-alpur-roof contains the development and tests of a new roofing-system for photovoltaic modules:

- First the insulation-elements are mounted on the wood-layer above the rafters. The insulation-elements contain already a roofing-membrane and the structure for the fixation of photovoltaic laminate.
- The elements are fixed to the rafters.
- Finally the photovoltaic modules are placed into the structures.

First prototype elements have been produced and mounted on the testing-roof at the Alporit company. They showed the functionality and the expense for the production and mounting. The results are promising. Several investigations of details and improvements leaded to the final test-elements which now will be checked at the Technical school of Engineering and Architecture in Lucerne

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Annual Report 2002

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.

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Annual Report 2002

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 230 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 2002

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; extended to December 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 and is described in [2].

The evaluation period has been extended until December 2002 in order to get some more data from two additional installations. One of these installations however, is not roof integrated as planned, but provides some additional data for comparison between complete roof integrated and detached installation of a similar system.

The evaluated systems operated as expected during the evaluation period.

Unfortunately, the provider of the satellite based yield prediction data has temporarily ceased its proper operations. The weather data has still been logged during the reporting period but the predicted values have not been delivered.

The comparison of the predicted values with the evaluation results will be reported in the final document of this project in early 2003.

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Annual Report 2002

Sunny Woods, Zürich Photovoltaik-Anlage in Blechdach integriert

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Project- / Contract Number	42203 / 82131	
Duration of the Project (from – to)	07/01 – 08/03	

ABSTRACT

The condominium "Sunny Woods" is located on a south-facing hill in a residential area of the city of Zurich. Mostly because of the new approach to design, taking into consideration architectural, ecological and energetical considerations into account, the building has already been widely published in different professional journals, but also in the general press. Until now, "Sunny Woods" has been visited by fare more than thousand architects and engineers from Switzerland and from whole Europe. Also the project has been presented in many lectures and on different symposiums.

Energetically, the project "Sunny Woods" is characterized by the following specifications:

- The insulation of the four-story wood building is outstanding. For example, the following u-values are achieved: façade 0.17W/m²K, roof 0.11W/m²K, windows 0.9Wm2K (glass 0.6 W/m2K, wood frames insulated partially with vacuum-insulation).
- The electrical power, which is produced by the pv-modules on the roof, should match the amount of power needed by the heat pump for heating and warm water.
- The roof of the building is covered with industrial aluminum sheet panels. The roof has a simple rectangular form and is slightly sloped to the south. It isn't shadowed by other buildings or trees. The roof is completely covered with 504 standard pv-modules of Unisolar-Beckert, which utilize amorphous, triple junction silicon solar cells with a rating of 32Wp.
- Each of the six photovoltaic-units with 84 modules and a Fronius pv-inverter is connected to the grid of the local power company. The maximum power provided by one pv-unit is 2'688Wp, so for the six apartments a total rating of 16'128Wp can be achieved.
- The installation of the pv-roof was very easy and could be completed in a very short period. The plugged electrical connections of the waterproofed junction boxes and the clipped mechanical connections of the panels to the roof saved a lot of time during the installation the roof.

The main goal of the P+D project is to control the efficiency of the complete chosen energy system. The energy diagram shows the result of the different numbers taken on site. One apartment is being measured in detail from July 2002 until June 2003. The numbers taken in the other apartments serve to control the results.

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Annual Report 2002

12.75 kWp Photovoltaik-Anlage Dachintegration Dorfkernzone Wettingen

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Project- / Contract Number	43850 / 83895
Duration of the Project (from – to)	Februar 2000 – 15. Dezember 2003

ABSTRACT

This report describes the first year of operation of the 12.75 kWp PV installation on the office building of Stöckli, Kienast & Koeppel. Being daily confronted with environmental and landscape issues because of their profession, the owners of the mentioned office decided to contribute to sustainable resource management themselves.
After having recognised that the southern part of the roof of the office building was predestined for a PV installation because of its orientation, steepness and unshaded surface, the planning work was started in early 2000. The building is located in the protected village-zone, which is why – also based on the architectural requirements of the owners – it was decided to replace the tiled roof with a fully integrated PV installation using SOLRIF-frames. This decision was achieved in cooperation with the local authorities of Wettingen and helped a smooth and fast sanction process.

So far no negative comments from neighbours were heard of; however a planned survey among neighbours and passers-by had to be postponed because of a very nearby construction site whose scaffold blocked the view from a close street onto the PV installation, thereby not allowing a representative poll.

Because of a good selection of electrical components as well as a professional installation, the favourable location helped for a very good production result for the first year of operation. The expected amount of approx. 10'500 kWh was outmatched by some 2'000 kWh, resulting in an annual output of 12'499 kWh, whereas the official electricity meter was only hooked up about two weeks after the commissioning. The ratio of surplus production was in the summer months smaller than in the other months, showing the limited ventilation capabilities of roof integrated PV installations.

An electronic information display panel will be installed within the next few weeks. Highlights of the coming year will be the mentioned poll as well as an open day event together with the 'Elektrizitätswerk Wettingen', the 'Aargausiche Elektrizitätswerke' as well as with 'Axpo'.

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Annual Report 2002

Toiture photovoltaïque Freestyle de 5,5 kWp à Lutry

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Project- / Contract Number	45795 / 85855
Duration of the Project (from – to)	July 2002 to March 2004

ABSTRACT

The roofing system Freestyle allows to cover a roof with a unglazed watertight photovoltaic system. This system features :

- aluminium profiles that fixed to the roof structure
- corrugated panels made of reinforced polyester, that plays the role of self-draining sub-roof
- half-finite PV laminated based on triple cell a-Si technology that are assembled on steel plates
- EPDM joints, inserted in the gullets of the aluminum profiles, are used for the fixation of the PV laminates on the aluminium profiles.

The pilot system of Lutry has a full size of 160 m2. The active solar area is 100m2 for an installed STC power of 5,5 kW. The color « dark grey » (RAL 7016) of the plates was chosen by the architect and is well matched to the color of the photovoltaic cells. This shows the capability of the system to offer a maximal satisfaction as far as esthetics are concerned.

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Annual Report 2002

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 of the 10 kWp SOLGREEN System in Choire (tilt angle, no shadowing by plants etc, snow gliding and wind cooling), an excellent performance ratio could be registered (May 2001-April 2002, >83%). The project was completed in May 2002. See final report, Jan. 2003.

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Annual Report 2002

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 Pilot and Demonstration plant ”Solgreen Kraftwerk 1” in Zürich, was built in June 2001 and realised the results 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 optimized 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 an external expert. First results were made under construction and operation of the new plant in 2001.

In 2002, the behaviour of different module support systems has been analysis by thermographic pictures. The modified support type introduces a slight cooling effect right above the aluminium profile placed in the middle of the modules. This detected variation of temperature should not give any relevant electrical variation.

As documentation of influences between the Solgreen system and the roof vegetation has shown, vegetation growths slowly and has therefore no disturbing effect to the modules. Several sample areas with different sorts of soil and seed should now give more information about intensive and extensive vegetation on roofs.

An important subject of observation is the metal parts of the construction with direct contact to the soil. Little corrosion was detected. Wind load measurements have indicated no critical load to the support system up to now.

In 2003, the investigations will be focused on monitoring the vegetation sample areas, wind load measurements and the quality of the construction in order to get long-term experience.

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

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Annual Report 2002

Three pilot 10 kWp integrated PV sound barrier fileds

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Project- / Contract -Number	17225 / 59391
Duration of the Project (from – to)	1. January 1997 - 31. December 2002

ABSTRACT

After an international ideas competition by TNC Switzerland and Germany 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. The report show, that the performance of the system is reasonable, but the mechanical construction has to be improved . 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 finale report includes the evaluation and comparison of the monitored data of the last 24 months of operation.

This TNC project was co-financed by the Swiss Federal Office of Energy, the Swiss Federal Roads Authority and the electricity saving fund by the city of Zurich (ewz-Stromsparfonds).

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Annual Report 2002

PV / Noise Barrier Installation „Alpha A1“ in Safenwil

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Project- / Contract Number	37146 / 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 2002 were:

- Optimisation of production had absolute priority
- The data collection unit, which failed in December 2001 was back in full service as of February 2002
- PR: Poster-presentation at national PV conference in Neuchatel
- Website “www.alpha-a1.ch” on-air
- Publications in local newspapers and professional magazines
- “100,000 kWh”-party in July 2002
- Local digital display installed in summer 2002
- Alpha A1 won Swiss Solar Prize 2001
- Poster presentation at European PV conference in Munich
- After two years of operation, soiling of modules by motorway traffic noticeable
- Influence of weather on production clearly shown: in March and April above norm, in November and December below norm
- Comparison of energy production with the theoretical values calculated using irradiance data from own measurements and a local weather station
- Data collection: Problems with data collection unit / remote operation: reduced amount of data available, difficulties with supplier

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Annual Report 2002

Amburnex Solar Farm (3 kWp)

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

ABSTRACT

This year 2002 has been the very first one where the whole off-grid installation (photovoltaic panels – batteries – inverters – charger – diesel generator – control unit) was running without a single interruption. Hence the solar production of 700 kWh, which amount to nearly 40% of the total electricity consumption, has contributed in a sustainable way to the making of 8000 kg of cheese and the milking of 220 cows !
However, due to its low overall efficiency (30% of what was planned) this result is quite disappointing !
The reason for such a bad efficiency is the non ability of the batteries to give the requested peak-power in the early morning when all the machines are needed, all at the same time : hence the generator switches on and charges the batteries which, most of the time, are then nearly fully loaded when the sun arrives. For the next season, we intend on one side to ameliorate this situation and on the other side to use FAME (biodiesel) to run the generator.

Annual Report 2002

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 an array of 20 kWp of photovoltaic panels and stored in two lead-acid 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 about 10’000 passengers and achieved a total distance of more than 4000 km. Since July 2001 the main characteristics of the ship are being measured and recorded by means of an onboard data collection system. The measured data were analysed in order to obtain detailed information of the energy-related behaviour of the ship. In particular, the energy balance of the 2002 summer season was calculated.

The operation experience during the summer seasons 2001 and 2002 is generally positive and the project has attracted wide interest both by the public and the media.

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 - to demonstrate the feasibility of large solar-powered passenger ships and to present new solutions towards sustainable mobility on inland waterways - has been fully reached.

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Annual Report 2002

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

The monitoring of the 16.8 kWp grid-connected PV plant with CIS (Cupper Indium diselenide) modules, situated on the roof of the Ludains ice rink in St Moritz, is going on for the second year.

In more than one year of service (434 days), 4 breaks of the measurements system occurred; in total, 10-days data was lost (98% of reliability).

During the first year of monitoring (August 2001 – July 2002) the plant produced, without any days of blackout, 17715 kWh (1055 kWh/kW) with a daily peak of up to 87 kWh. Some strings, especially in winter, produce less due to partial shadows (about 3.3%) and inverter overload.

The high efficiency (PR=0.81) of this CIS plant seems, after more than one year monitoring, to be constant; for this reason the outdoor measurements of the I-V characteristics of the 42 strings have been postponed at the end of the project.

A comparison between the two data acquisition systems, one specially installed for the project and the other equipped with the inverters, revealed a non-linear relation. The ratio between the two recorded daily energy productions varied in function of the insolation. On the other hand, the difference between the two annual energy productions is equal to 3% only.

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Annual Report 2002

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

Dock Midfield, the new terminal building at the Zurich Airport, has been completed in November 2002. Since April 2002, the 290-kW-photovolatic plant on top of the building works perfectly. The produced electricity is manually reported, but from March 2003 on, it will be done by the building automation system.

The photovoltaic plant is integrated in the building's pergola roof. It has three functions. As an important element of the building's architectural design, it is one of the highlights of the building's appearance and forms the roof. The pergola, with its PV-elements, shades the facade of the attic level where the lounges are located. Of course, this building integrated PV plant will produce about 264 000 kWh of environmentally friendly electricity.

The installation is also part of the European research project PHOTOCAMPA: PV grid connected system in parking and roof, 5. EU-framework program. A part of the plant will be measured following the guidelines of ISPRA Research Center.

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Annual Report 2002

PV-Obelisk

Information system in the public sector

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Project- / Contract -Number	45574 / 85634
Duration of the Project (from – to)	1st June 2002 to 1st June 2003

ABSTRACT

A power supply with photovoltaic (PV) for non-building structures is known for parking ticket machines, emergency signals and others. Today few products are available but almost all lack an overall design and well thought concept incorporating PV and the application and the aesthetics. The innovative approach of this project (called PV-Obelisk) is the combination of PV in an aesthetic way with a multi-functional pillar made of natural stone. PV serves as power supply and as design element, thus it will be well visible. In the first evaluation concerning the market, it was shown that the PV-Obelisk has a big advantage over conventional structures in the public sector thanks to the autonomous power supply.

Currently the project team is in intensive discussions with several companies concerning the use of the PV-Obelisk for the test operation and the future interest in this product. First market surveys come up with an annual production of approximately 20 pieces. But the PV-Obelisk has to prove first its reliability and the advantages of the products during the test operation. In a next step the manufacturing cost must be reduced. At present they are too expensive but one has to account that they are mostly depending on the application. The application can be divided in two groups, passive systems (e.g. lighting, fountain, printed information) and active ones (e.g. booking, information exchange, Internet access). The applications can be easily extended and will be certainly have its use in the near future. We will face an increasing communication between non-building structures in the public sector, thus a good chance for a product like the PV-Obelisk.

It is important to work closely with the public sector from the beginning. The industry is asking for eye catcher to get a message easily over to the consumers, but these are often a 'thorn' in the eye of the public sector. An open and constructive co-operation has to be established. One has to consider the need of the urban planners and come up with overall solutions and not only with one specific product. This has been taken into account by the project team. The design allows also passive elements, like bench, pole for orientation or advertisement.

The PV-Obelisk gets many positive reactions and feedback from the public and private sector concerning its design and concept. The first prototyp has been built and started test operation November 16th in Zurich (Technopark). The start was timed with the event 'Designmeile' and the PV-Obelisk presented its use on three LCD panels mounted in the pillar material. The messages can be sent by connected PC or by SMS from any mobile phone. This function is crucial for such an application, as it offers location independence and contact at any time, thus emphasising the universality of the PV-Obelisk.

Thanks to a very engaged and effective co-operation of all project parties each individual work goes according to the time schedule and important results are collected. The project is planned to conclude beginning on June 2003.

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Annual Report 2002

PV St.Moritz Corvigliabahn Piz Nair

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Project- / Contract Number	45674 / 85734
Duration of the Project (from – to)	06. 2002 - 03.2004

ABSTRACT

Photovoltaicsystems on alpine sites above 2000m can produce, depending on the topological situation, significantly more power then anticipated. Reasons are the Albedoeffects (reflected light in addition to the direct sunlight) and portions of diffuse light. When sizing such installations this wishful increase input power has to be taken in account. In order not to lose valuable energy due to power limitations sufficient oversizing of the inverter is needed.

Both installations, Corviglia and Piz Nair (3500 m) can profit from Albedoeffects, especially in winter and early spring months. The maingoal of the two projects Corviglia (17.8 kWp) and Piz Nair (13.53 kWp) is to gain more information on the Albedoeffects under alpine conditions. The results will be of high value for the development of new projects. Both installations will become eyecatchers for tourists of the famous St.Moritz area. Especially the Piz Nair façade fascinates thanks to the perfect integration of PV into modern architecture.

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Annual Report 2002

Monitoring of the CIS BIPV plant Würth in Choire

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Project- / Contract -Number	47134 / 87254
Duration of the Project (from – to)	1st October 2002 to 31st September 2004

ABSTRACT

A new BIPV installation was concluded in October 2002 at the Würth Holding in Choire. The outstanding feature was the use of the synergies of new CIS BIPV modules. Those were special manufactured CIS modules, which had the task for producing energy and also to reduce the heat gain in the building by shading the skylights of the atrium. The goal was to get sufficient natural light and thus to safe the energy for artificial light during the daytime. Hence a combined concept was applied. On half of the skylights a fully automated roller blind was installed and on the other half the CIS specialised modules. For achieving the semi-transparency the layer of the CIS modules were removed in 1 cm strips, getting a 50% light gain. As each skylight has different measures different types of BIPV modules had to be manufactured. In total three dimensions but all with the identical operation voltage were manufactured and connected in parallel. This is resulting in a calculated PV peak power of 3.9 kW, which is being fed on a TopClass 4000/6 inverter and then to the building grid.

The project will monitor the performance of the modules and the PV plant over a period of 2 years. It is the goal to get many experiences and results with these special CIS modules. And also the influence of the BIPV plant in the building behaviour. This will be done in a two stage approach, part 1 is the monitoring and measuring of the electrical components (modules, net meter, pyranometer, etc.) and part 2 is focusing on the evaluation of the influence to the building. The monitoring concept (part 1) covers following inputs; DC energy impulse of one module, AC energy impulse of the net meter (thus the PV plant), outdoor temperature, module surface temperature, pyranometer horizontal and inclined, DC input voltage and current of the inverter and the AC output current. Part 2 has to be evaluated on energy data (cooling needs) from the total building and calculated for the atrium volume. Further we will survey the reaction of visitors of the BIPV installation concerning aesthetics, impression of the semi-transparency and the application (shading device).

It is expected to come up with the following results after the two year monitoring project:

- mechanical changes of the modules (degradation, browning, damages, etc.)
- energy values for one CIS module and of the PV installation depending on the temperature and irradiance
- influence of the BIPV installation as shading concept (sufficient daylight? reduction of the heat gain?)
- feedback from the visitors and users

The BIPV plant has been installed in mid of October and is running without problems since. The monitoring equipment features a datalogger with several inputs and a modem connection for downloading the data. All sensors and the datalogger have been installed mid of November. The first month was used to adjust the data and the sensors to secure a safe operation for the 2 years monitoring. The project was delayed due to the later installation. The monitoring started 1st of December and will give extensive data for the annual report after exactly one year operation.

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Annual Report 2002

Installation photovoltaïque à Palexpo

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Project- / Contract Number	45736 / 85795
Duration of the Project (from – to)	1.7.02 – 15.12.02

ABSTRACT

A 70 kW photovoltaic installation is currently approaching the end of construction on the roof of the new Palexpo hall. This installation is intended to feed charging terminals for electric vehicles.

The design of the charging terminals is currently under discussion, and these terminals could be included in a Geneva project for the promotion of electric two wheelers.

Explanatory panels could be placed at various strategic locations inside the halls.

SSES could take a stand in the entrance hall of the car show, a stand for which it is intended to organise a competition.

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Annual Report 2002

PHOTOCAMPA

PV GRID CONNENCTED SYSTEM IN PARKING AND ROOF

parking P+R de l'Etoile, aéroport de Zurich, école de cirque, école de Lullier

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Project- / Contract Number	99.0688 –1 –2 –3 –4 / NNE5-1999-00772	
Duration of the Project (from – to)	01.10.2000 – 31.12.2002	

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 2002

RESURGENCE - Renewable Energy Systems for Urban Regeneration in Cities of Europe

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Project- / Contract -Number	NNE5/00340/2001 / BBW 01.0370-1/-2/-3
Duration of the Project (from – to)	Jan. 2002 – Dec. 2005

ABSTRACT

It is proposed to demonstrate the installation of 1.3 MWp of photovoltaic in 5 countries as part of significant urban regeneration programmes. The four key project aims are photovoltaic system cost reduction, increased socio-economic acceptability and social sustainability, exploitation of liberalised electricity markets and finance innovation. The project targets the social housing / urban regeneration sector, other key objectives are to demonstrate innovative energy trading mechanisms, innovative PV system ownership models, and the exploitation of new capital investment mechanisms that exist for sustainable energy technologies.

Each country will demonstrate the use of PV as part of an integrated approach to urban regeneration. Partners have been drawn from all stakeholder sectors, including housing associations, housing networks, urban renewal companies, architects and engineers, building integration systems developers and installers, utilities and banks.

In 2002, Resurgence has started and first preparation works been done. As results there are several reports that can be downloaded in the website www.resurgence.info. The planned PV-projects are all on the way. All Swiss projects are preplanned and will see their realisation in the second quarter of 2003.

The goals for 2002 have been achieved with exception of joint tendering. Due to great differences in project status, but also tradition, company rules and know-how of project developer, joint tendering was possible only for a part of the modules. All other parts and installation will be tendered locally.

In 2003, most of the projects will be built in the several Resurgence-countries. First dissemination steps have already been made. They will consist of articles, local visits, workshop and our website.

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Annual Report 2002

100 kWp PV-Netzverbundanlage A13 Messkampagne, Periode 2002

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Project- / Contract -Number	32046 / 71920
Duration of the Project (from – to)	Jan. 2002 - Dec. 2002

Abstract

13 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 110'000 kWh 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 and 12th year (2000 and 2001) however, some minor but important components of the inverter unit failed. The components, which failed, were mainly electromechanical devices with moving parts and the faults were not always easy to find. In the years 2000 and 2001 a total of 286 operational days or 40% of the energy was lost due to non-operation of the inverter.

Some components of the inverter unit were replaced in November 2001. In May 2002 the Simoreg unit of the Inverter was replaced and the old unit was reconditioned and stored as a spare part for the future. In November 2002 the inverter failed again due to a faulty device in the new Simoreg unit.

In the year 2002 the plant produced 101'289 kWh or 963 kWh/kWp with a performance of 71 % and an availability of 94%.

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

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Annual Report 2002

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 2002:

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. At the end of the second year, there is now a large number of data available for different coating/glas combinations with either one or two years of exposition. Nevertheless, since it is the target to identify longterm effects, it is still to early to draw conclusions.

"Real term" investigations:
Two years of measurements have 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 2003.

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Annual Report 2002

Newtech – Vergleich 3 x 1kWp Dünnschichtzellenanlagen

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Project-Number	43849
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).
- The PV plant and the monitoring system operated successfully since 17.12.2001
- Newtech 1 with $CuInSe_2$-cells produced the highest energy yield (1091 kWh/kWp) of all PV plants in Burgdorf in the year 2002. The STC power of the modules is higher than the rated power indicated by the manufacturer.
- Newtech 2 with a-Si-Tandem-cells produced 964 kWh/kWp, which is the lowest yield of the three Newtech PV plants in the year 2002. When irradiation is low, the DC voltage of the modules decreases and therefore the inverter can't work at the MPP.
- Newtech 3 with a-Si-Triple-cells produced 1033 kWh/kWp. Performance Ratio PR of the plant is very high, when irradiation is low.

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Annual Report 2002

PV-ThinFilmTest

6 THIN-FILM TECHNOLOGIES IN 3 DIFFERENT BIPV MODES

COMPARED IN A REAL OUTDOOR PERFORMANCE TEST

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Project- / Contract -Number	45555 / 85617
Duration of the Project (from – to)	Sep 2002 – Dec 2004

ABSTRACT

In a worldwide probably unique large-scale thin-film test installation, 6 different thin-film PV technologies have been installed each in 3 different BIPV application modes on test installation in Switzerland. The total of more than 450 thin-film modules include a-Si and CIS technologies. Each module type has been installed in 3 modes: inclined (20°), flat with free back air flow, and flat with thermal back insulation.

Behavior and performance of all market available different thin-film BIPV systems are observed with an extensive monitoring program, including I_{DC}, U_{DC}, and P_{AC}, module and ambient temperature, and insolation. Additionally, 3 installed mono-crystalline PV arrays allow direct comparison of upcoming thin-film technologies to well known cell types. The performance test will lead to the most comprehensive overview of BIPV behavior of all thin-film technologies available on the market today.

The modules under test include 1-layer amorphous silicon technology (Kaneka K58), 2-layer amorphous silicon technology (ASIOPAK-30-SG, BP850, Dunasolar DS40), 3-layer amorphous silicon technology (UniSolar US-64), copper indium di-selenid technology (Shell Siemens Solar ST-40) and a well-known mono-crystalline silicon technology (Shell Siemens Solar SM 110) for comparison.

First results/trend of the monitoring program show the different dependency of array efficiencies on the solar insolation. It can also bee seen that the differences between thermal insulated modules and modules with free back air flow are significant. Whereas some module types are more efficient with free back air flow (behavior like ST40, BP850), three module type yields significantly more energy with thermal insulation (K68, DS40, US-64).

Please note that first results/trend has to be regarded with caution, in fact of the data set is not big enough yet (just data from November 2002) and the distribution of the insolation-intensity is not representatively for a normally year.

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Annual Report 2002

Monitoraggio dell'impianto PV da 100 kWp AET III a Riazzino

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Project- / Contract Number	43907 / 83947
Duration of the Project (from – to)	2002-2004

ABSTRACT

The 100 kW Mark II grid connected PV plant is located along the railway in Riazzino. It was constructed in 1992 by the TNC company on behalf of the Swiss Federal Office of Energy. In 2001 the plant had to be modernised. The old 100kW converter has been substituted the by three new converters, each 33kW, and part of the wiring has been redone. The renovated PV plant was put into service on November the 30th 2001. The AET has since then acquired this PV plant and it has therefore been renamed AET III.
The purpose of this project is to precisely monitoring for 3 years the behaviour of the plant following renovation, by continuous and periodic annual measurements. The data acquisition system has been adapted to the new configuration and it was put back into operation at the beginning of 2002.
The behaviour of the plant was analysed for the first months of operation: following renovation the plant is working properly. Its PR now reaches 70% and it is better with respect to that of previous years, when the plant had not been renovated yet. The converters are correctly dimensioned and they reach an efficiency of 95% corresponding to the value stated by the manufacturer. European weighted efficiency is 93%. The energy yield for the first months of operation seems to confirm the production estimations: during the first 11 months of the year 2002 the plant has produced 92.35 MWh**.**
Box 1 strings produce more than those in Box 6. Nevertheless, all the strings function properly.
A group of 26 modules has been measured at STC at the LEEE-TISO. Modules situated at the western end are dirtier than those at the eastern end due to their proximity to the railway station. After cleaning power @ STC rose on average by 5.5% and by 12% for the dirtiest modules. Water cleaning of the whole plant is justified since it would mean an increase in production of 5'000 kWh/a. Total estimated field power @STC with unclean modules is 87.3 kW whilst after cleaning it would rise to 92.0 kW. This value is still 11% lower than that declared by the manufacturer. Moreover, a thermographic analysis of the entire plant has been carried out: a few hot spots were found but many of them have a high temperature (÷ up to +25°C). The plant doesn't show any relevant or serious thermal problem. Only four modules with malfunctions were found.

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Annual Report 2002

IEC Normenarbeit für PV Systeme

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Project- / Contract -Number	
Duration of the Project (from – to)	2002-2003

ABSTRACT

Scope: To prepare international standards for systems of photovoltaic conversion of solar energy into electrical energy and for all the elements in the entire photovoltaic energy system. It is recognised that there will be common areas of interest between TC 82 and other technical committees such as TC 21, TC 22, TC 64, TC 88 and TC 105. Another aspect of TC 82 activity is its relationship with the European Union's PV Joint Research Centre (JRC) at Ispra from which invited experts participate in the working groups. A Category A liaison has also been established with the International Energy Agency (IEA) PVPS (photovoltaic power system) co-operation programme. Category A liaisons with PV testing laboratories is also being pursued.

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 it's 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 almost 30 years old, is producing a multiplicity of components and systems for terrestrial uses. It is very unfortunate, that there are still laking major IEC standards for PV component and systems. However, great success has been achieved during 2002 and several TC 82 drafts exist now for components and systems, both on a CD (Committee Draft) as well as on CDV (Committee Draft vor voting) stage.

For the Photovoltaic (PV) Industry and users, International Standards for PV products such as 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 the simple reasons: Standards are a key prerequisite for attaining quality.

Luckely, major progress has been achieved during 2002. On PV system level, several documents are now in the process for committee voting, with deadlines early next year. PV on building for grid connected systems has finaly passed the voting procedures, and the process of adopting to the Cenelec and finally Swiss standard is under fast track. It can be assumed that the new standard will be adopted by Cenelec during 2003, and previsions have been taken by TK82 to substitute the older provisional standard by a smooth transition to the new 60364-7-712.

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Annual Report 2002

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 - 31.12. 2003

ABSTRACT

The project's main target is to optimize 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 2002, a P+D plant including ventilated PV shingles was built in Steinhausen ZG. The co-generated thermal energy is used to supply an air/water heat pump which produces hot water. From April to October 2002, measurements on this installation were carried out.

During 2002, a dynamic model for the simulation of different installation types of ventilated PV shingles was developed and validated on the base of the measured data.

The next step is to optimize the energy management of the Steinhausen plant. In 2003, different possibilities of the accurate use of the produced thermal energy will be defined and quantified.

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Annual Report 2002

Solar *Electri* City Guide - Schweizer Solarstromführer für die Gemeinden

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Project- / Contract -Number	
Duration of the Project (from – to)	01.07.2002 - 30.06.2003

ABSTRACT

Introduction:
The Swiss Solar *Electri* City Guide is a follow-up activity of the European project "PV City Guide" supported by the Swiss Federal Office for Education and Science under contract no BBW 99.0569. The European project was finalised in spring 2002. The country-specific Swiss editions are supported within the frame of the SwissEnergy programme.

Purpose of the work:
The objective of this Solar *Electri*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. The focus is on municipalities and local implementation.

Approach:
The Swiss Solar *Electri*City Guide is being designed for practical use by the target groups in order to facilitate the implementation of future PV projects and policies. The international version of the Solar *Electri* City Guide in English is currently translated and adapted to the Swiss context in close relationship with experts and actors from different areas and sectors in order to consider local needs, actions and policies.

Results:
The project "PV City Guide" led to an attractive guide for the target audience. The international version in English as well as the results of the international workshop on Solar Photovoltaic Power in European Cities successfully held in Basel, Switzerland can be viewed on the project website http://pvcityguide.energyprojects.net. Some country-specific editions are already available. The Swiss editions in German, French and Italian are to be published during 2003.

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Annual Report 2002

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 was 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 was pursued through a co-ordinated series of activities, which also engaged senior decision makers from public administrations and the RE industry in exploring new market stimulation initiatives.

The project was carried out by a team of experts from CESI (Italy – co-ordinator) and its subcontractor Ecobilancio, 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 was therefore also 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.

As building blocks, the project team collected the most recent data on RE technologies, markets, and costs. The project also explored the implications of the major changes and restructuring that had been taking place in the RE industry and in energy markets during the past few years. These changes, together with the emerging activities and mechanisms from the Kyoto Protocol, are expected to have significant impacts on future growth of RE markets. The project reviewed the extent to which all these changes and mechanisms had been taken into account in the existing models for forecasting future RE markets. Gaps or uncertainties were identified, and recommendations made for how to address these aspects in the future.

Lastly, the project developed a road map, namely a list of priority policies, key intervention areas and actions needed to accelerate the market growth in order to attain the targets deemed as feasible over the next 20 years.

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Annual Report 2002

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)	2001 - 2003

ABSTRACT

The Project Quality is the key of the PV market and accredditation of PV training programs under the framework Altener are treated as a cluster project. 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.

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Annual Report 2002

PV on Vocational Colleges in Switzerland Data acquisition campaign

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Project- / Contract Number	10230 / 50191
Duration of the Project (from – to)	August 1992 - December 2002

ABSTRACT

Within the framework of the Swiss Photovoltaic Programme for Vocational Colleges, 21 of the 60 vocational school centers 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) a 50.2 kW (school of Lucerne). Approximately 40 % of all electricians being 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 programme has shifted and focuses on the development and application of educational tools in the area of Photovoltaics.

The ERFA group and the internet homepage have been continued. The data acquisition campaign, ongoing since 9 years, has been completed end of 2001.

The data being collected in this data acquisition campaign has also been used as part of the Swiss Cooperation in the IEA PVPS Task II. The data is incorporated in the international database.

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

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Annual Report 2002

Photovoltaic Energy Statistics of Switzerland 2001

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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 800 kWh/kWp, changing slightly from year to year due to changing irradiation and other effects. The systems overall reliability and operattional availability is with around 97 % still considered very good for technical systems.

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Annual Report 2002

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 SwissEnergy, aimed at providing customers of utilities with the service of solar electricity. The action is supported by SwissEnergy and the Swiss Electricity Supply Association (SESA) since 1996. 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 six years of operation, this action has achieved remarkable results: More than 130 utilities participate in the action as of end of 2002, more than half of the Swiss population now has access to this service, more than 5 MWp of photovoltaic power systems have been installed within this concept and more than 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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