International Energy Agency

Co-operative Programme on Photovoltaic Power Systems

Task 1
EXCHANGE AND DISSEMINATION OF INFORMATION ON PV POWER SYSTEMS

National Survey Report on PV Power Applications in Switzerland 2003

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For the
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i Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the organisation for Economic Co-operation and Development (OECD), which carries out a comprehensive programme of energy co-operation among its 23 member countries. The European Commission also participates in the work of the Agency.

The IEA Photovoltaic Power Systems Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The twenty participating countries are Australia (AUS), Austria (AUT), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Israel (ISR), Italy (ITA), Japan (JPN), Korea (KOR), Mexico (MEX), The Netherlands (NLD), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), The United Kingdom (GBR) and The United States of America (USA). The European Commission is also a member.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (tasks) is the responsibility of Operating Agents. Nine tasks have been established, and currently six are active. Information about these tasks can be found on the public website www.iea-pvps.org. The new task concerning urban-scale deployment of PV systems is now underway.

The objective of Task 1 is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of photovoltaic power systems.

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ii Introduction

This National Survey Report gives a brief overview of what has been achieved in the photovoltaic (PV) power area in Switzerland in the year 2003. It is only a summary of the most important developments and applications of photovoltaic power systems and does not pretend to be complete in any way. A more comprehensive view of PV research and pilot / demonstration plant is available from the Swiss national photovoltaics website (www.photovoltaic.ch).

iii Definitions, symbols and abbreviations

For the purposes of the National Survey Reports, the following definitions apply:

PV power system market: The market for all nationally installed (terrestrial) PV applications with a PV power capacity of 40 W or more.

Installed PV power: Power delivered by a PV module or a PV array under standard test conditions (STC) – irradiance of 1 000 W/m^2, cell junction temperature of 25^{o}C, AM 1,5 solar spectrum – (also see 'Rated power').

Rated power: Amount of power produced by a PV module or array under STC, written as W.

PV system: Set of interconnected elements such as PV modules, inverters that convert d.c. current of the modules into a.c. current, storage batteries and all installation and control components with a PV power capacity of 40 W or more.

Module manufacturer: An organisation carrying out the encapsulation in the process of the production of PV modules.

Off-grid domestic PV power system: System installed in households and villages that are not connected to the utility grid. Usually a means to store electricity is used (most commonly lead-acid batteries). Also referred to as 'stand-alone PV power system'.

Off-grid non-domestic PV power system: System used for a variety of applications such as water pumping, remote communications, telecommunication relays, safety and protection devices, etc. that are not connected to the utility grid. Usually a means to store electricity is used. Also referred to as 'stand-alone PV power system'.

Grid-connected distributed PV power system: System installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic PV systems and other grid-connected PV systems on commercial buildings, motorway sound barriers. etc. These may be used for support of the utility distribution grid.

Grid-connected centralized PV power system: Power production system performing the function of a centralized power station.

Turnkey price: Price of an installed PV system excluding VAT/TVA/sales taxes, operation and maintenance costs but including installation costs. For an off-grid PV system, the prices associated with storage battery maintenance/replacement are excluded. If additional costs are incurred for reasons not directly related to the PV system, these should be excluded. (E.g. If extra costs are incurred fitting PV modules to a factory roof because special precautions are required to avoid disrupting

production, these extra costs should not be included. Equally the additional transport costs of installing a telecommunication systems in a remote area are excluded).

Field Test Programme: A programme to test the performance of PV systems/components in real conditions.

Demonstration Programme: A programme to demonstrate the operation of PV systems and their application to potential users/owners.

Market deployment initiative: Initiatives to encourage the market deployment of PV through the use of market instruments such as green pricing, rate based incentives etc. These may be implemented by government, the finance industry, utilities etc.

NC: National Currency

Final annual yield: Total PV energy delivered to the load during the year per kW of power installed.

Performance ratio: Ratio of the final annual (monthly, daily) yield to the reference annual (monthly, daily) yield, where the reference annual (monthly, daily) yield is the theoretical annual (monthly, daily) available energy per kW of installed PV power.

1 Executive summary

While the world-wide photovoltaics market continued to boom in 2003 – thanks to large-scale promotion and attractive remuneration for solar power - the Swiss photovoltaics market had to cope with unfavourable conditions as far as promotion was concerned. Thanks to on-going efforts in the solar stock-exchange area, though, at least the status quo could be held. Progress was still being made, however, both in the research and pilot and demonstration (P+D) areas. A central topic in 2003 was the discussion on whether the Federal Office of Energy's SwissEnergy Programme was to be discontinued. This led to a considerable amount of uncertainty in the PV market. Cut-backs in funding will affect the P+D area in particular. Also, considerable differences in PV promotion are to be noted in various Swiss regions. In spite of these difficulties, the number of projects and funding could be held constant as a result of support by European projects, the Federal Office for Education and Science and the Swiss Commission on Technology and Innovation. The exchange of information remained an important topic: In October 2003 the German-language version of www.photovoltaic.ch, the Swiss photovoltaics website, was completed and Swiss photovoltaics was represented at the third World Conference on Photovoltaics in Osaka where Swiss contributions won two prizes.

Installed PV power

Total installed PV power in Switzerland rose once more and reached a total of 21 MW of which 18 MW is delivered by grid-connected installations. The increase in total installed capacity was 1.5 MW, whereby 1.3 MW was on-grid. This, when compared with the 2002 figure of 2 MW, illustrates the Swiss PV market's difficulties, as mentioned above. Whilst the number of new installations with power-ratings over 250 Watt (75) was about the same as in 2002, the increase in installed power was much lower than in previous years. Around 170 very small installations (less than 250 W) went on-grid. As far as the off-grid, stand-alone market is concerned, it is estimated that a total of around 3 MW of PV power is now installed in Switzerland, this being an increase of 0.2 MW compared with 2002.

Costs & prices

Turn-key prices for PV Installations have continued to drop as world-wide production and market volumes increase. The average price of installed power for grid-connected, single-family home plant fell once more to an average of around CHF 9.25 per watt (2002: CHF 11.00). Larger installations with installed powers of over 10 kW, fell too from CHF 9.20 in 2002 to an average of around CHF 8.40 per watt in 2003.

PV industry

As far as solar cell production in Switzerland is concerned, emphasis in the area of micromorph silicon and other thin-film cells was placed on moving from laboratory-scale production technology to industrial scale manufacture. Co-operation continued between a major Swiss manufacturer of equipment used in the production of LCD

computer displays and the Institute for Microelectronics in Neuchatel with the purpose of adapting and further developing thin-film coating technology for use in the production of solar cells. Also, first product lines featuring portable, flexible cell-based products for outdoor use were made commercially available and first applications of new thin-film modules combined with traditional flexible roofing membranes are being tested within the framework of the Swiss P+D programme. Other industrial activities feature projects on the recycling of silicon production wastes and the combining of new thin-film PV technology with various building materials.

Budgets for PV Promotion

Up till now, promotional funding for PV installations by the Swiss Confederation occurred within the framework of pilot and demonstration (P+D) projects, whereby the promotion of PV technology is given priority. A total of around CHF **xxxx** million was made available for P+D projects. In the R&D and technology area, Federal funding amounted to around CHF **xxxx** million. At the local and regional level, subsidies for PV are only available in certain areas.

2 The implementation of PV systems

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries.

2.1 Applications for photovoltaics

In Switzerland, the majority of PV Installations are grid-connected plant, built mostly on the roofs of buildings. Larger installations (> 50 kW) are usually flat-roof mounted on commercial buildings, offices etc. Several combined PV / noise barrier installations along motorways and railway track form an exception to this rule. The smaller grid-connected PV installations (typically around 3 kW) can normally be found on the roofs of single-family homes. Traditionally, off-grid installations are relatively small (< 1 kW), with Systems combining PV with diesel generators or small hydro installations form the exception to this rule and are used for the operation of farm buildings in remote alpine areas.

In 2003, work on the dissemination of PV Technology was characterised by its orientation towards the demonstration of PV applications and PV marketing. Know-how-transfer and up-scaling of new technologies remained the most important activities in the thin-film cell production area. As in 2002, around 85 projects were being worked on in 2003 by Swiss technical institutions, industry and professionals, 32 of the projects were active P+D projects. In 2003, 16 P+D projects were completed and 13 new ones started.

Several Swiss technical institutions are active in the monitoring and quality assurance areas for both PV components and system technology. Quality assurance and energy yields of various types of PV modules and inverters and the long-term behaviour of grid-

connected PV plant are being looked within the framework of pilot and demonstration projects.

2.2 Total photovoltaic power installed

Our assessment is based on the following data:

- On-grid PV: Swiss Federal Office of Energy / Swiss Association of Electricity Enterprises, PV Statistics 2003
- Off-grid PV: SOLAR (Swiss Professional Association for Solar Energy) annual survey of PV sales for 2003.

Table 1 Cumulative installed PV power in 4 sub-markets.

Sub-market/ application	31 Dec. 1992 kW	31 Dec. 1993 kW	31 Dec. 1994 kW	31 Dec. 1995 kW	31 Dec. 1996 kW	31 Dec. 1997 kW	31 Dec. 1998 kW	31 Dec. 1999 kW	31 Dec. 2000 kW	31 Dec. 2001 kW	31 Dec. 2002 kW	31 Dec. 2003 kW
off-grid domestic	1 540	1 675	1 780	1 940	2 030	2 140	2 210	2 300*	2 390*	2 480*	2 570*	2 740*
off-grid non-domestic	70	100	112	143	162	184	190	200*	210*	220*	230*	260*
Grid-connected distributed	2 200	2 900	3 600	4 050	4 850	5’950	7 630	9 420	11 220	13 340	15 140	16 440
Grid-connected centralised	900	1 100	1 200	1 ’350	1 350	1 450	1 470	1 480	1 480	1 560	1 560	1 560
TOTAL	4 710	5 775	6 692	7 483	8 392	9 ’724	11 500	13 400	15 300	17 600	19 500	21 000

* Author’s estimates. Exact figures for the proportion of off-grid power for domestic and non-domestic applications are not available.

Compared with 2002, cumulative installed power increased by almost 8%

Figures for on-grid centralised plant cover larger installations that are operated on the production side (often by utilities or public authorities) and are not integrated into buildings (i.e. free-standing plant and installations on noise-barrier structures.

On-grid distributed covers building-integrated plant on houses, offices, factories etc. (usually privately owned) They are often used for in-house generation (e.g. single family homes) or supply energy for “solar stock-exchanges”. The latter installations are mostly in the range of 50 kW to 150 kW.

2.3 Major projects, demonstration and field test programmes

In 2003, a total of 48 PV pilot and demonstration (P+D) projects were active of which 13 were newly started. The one-to-one testing of new technologies and components in pilot installations continues to play an important role in Switzerland's P+D activities. PV integration in the built-up environment remained an important area of P+D activities with increasing interest being placed in combining PV technology with traditional building materials..

Both the testing of new components and the demonstration of PV for the general public were represented in the P+D projects started in 2003. Many projects are concerned with the integration of PV systems in buildings and the built-up area. In the following examples of new P+D projects are given.

In the components area, a mounting system that enables thin-film modules to be used in building facades is being tested at the University of Applied Sciences in Lucerne, which has load-testing and wind-simulation facilities at its disposal.

Combining traditional flat-roof waterproofing membranes and flexible amorphous thin-film solar cells, a 15.4 kW flat-roof installation in southern Switzerland is to provide data on the thermal behaviour of the amorphous silicon modules and to compare yields with traditional back-ventilated panels mounted on the roof of the nearby University of Applied Sciences.

Initial planning of a further thin-film installation on the roof of a listed building used by the Federal Institute of Technology in Zurich was started in 2003. The 16.3 kW PV plant will be installed in the course of renovation work to be carried out in 2005. Solar power production will be monitored and displayed in the building's cafeteria.

Multifunctional PV roofing modules are being investigated by a P+D project in central Switzerland. On the roof of a high-bay warehouse, elements are being used that combine thermal insulation and frameless solar modules. The production of the 62 kW installation is to be displayed at the entrance to this new logistics centre.

Tackling problems posed by light-weight buildings with flat-roof constructions that cannot bear the extra loading caused by the weight of traditional PV module mounting systems, a new project has been started to further develop and test a light-weight fixing structure that will meet wind-load requirements by using the weight of the gravel already used to protect such flat roofing.

New projects demonstrating the use of roof-integrated PV include a scout's clubhouse using large-scale PV slates (15 kW) and a 23.5 kW demonstration plant with a large public display of the power being produced at the Swiss border town of Kreuzlingen.

In the area of stand-alone systems, a P+D project has been started that is to investigate the use of a combined PV and fuel cell driven energy supply system for locations with no conventional electricity supply. In 2003, work on a test installation at the Swiss Federal

Office for Water and Geology's laboratory was started in preparation for field trials in remote areas.

Two new monitoring projects were started in 2003 in Soyhières – where the power production of an autonomous 3 kW PV installation is being measured and analysed and in Wittikofen near Berne, where the power produced by facade-mounted PV plant on a high-rise apartment building is being measured in order to investigate wind and back-ventilation effects on such tall installations.

In the motivation area, a study was started on how to improve the implementation of building-integrated PV systems by the reduction of hindrances, improvement of information and increasing the level of professional competence of planners, investors and property developers.

The integration of the new IEC standard 60364-7-712 for PV installations in Swiss national electrical installation standards is also the subject of work started in 2003.

Of the on-going P+D projects, work continued in 2003 on several projects that deal with test installations concerning roof and facade integration. In the following, a selection of findings is presented.

First provisional results from an 18-field installation with 6 different types of thin-film cells - each in three standard modes of mounting – have revealed that at least some types of thin-film cells can be used for direct integration without back ventilation or even for combination with insulation elements.

A new form of roof integration called "Freestyle" using amorphous triple-cells combined with thermal insulation in Lutry near Lausanne fits in well with the building's architecture.

The multifunctional use of PV modules as sun shading and for power generation in Chur using special, semi-transparent modules with CIS cells has seen success as far as both its shading and power production capabilities are concerned..

In the alpine resort of St. Moritz, a further 9.7 kW PV installation on the lower Piz Nair cableway station in addition to the existing 17.8 kW and 13.5 kW PV installations in the area. Interesting results on albedo effects in Winter and Spring have been collected.

The 70 kW on-grid, roof-mounted installation the Palexpo Exhibition Centre in Geneva, provides an example of how PV can be discretely integrated. As for other newer PV installations too, this plant exhibits production figures of over 1 000 kWh per installed kWp

Among the P+D projects finished in 2003, several involved the integration of PV installations in new and existing buildings. Various aspects such as integration in building in areas with listed buildings, full integration as part of an architectural concept - as demonstrated by the prize-winning installation on the new Dock E at Zurich Airport - and the combination of PV mounting systems with extensive planting of flat roofs.

One of the projects completed in 2003 concerns the comparison of new thin-film cell technologies under everyday conditions. Measurements made have shown that the CIS-cells exhibited the highest yield and the amorphous silicon triple cells were among those installations at the test site with the highest yields. The efficiency of the amorphous-Si tandem cells was found to be low at low irradiance levels.

The project concerning the solar-powered, 150-passenger catamaran operating on the Lake of Bienne was also concluded in 2003. This ship has carried around 14,000 passengers and travelled nearly 6,000 kilometres since its inauguration in summer 2001 and has been very popular both with the general public and the media public.

As far as PV-associated equipment is concerned, the development of a simple, low-cost GSM-based monitoring and alarm system for the operational monitoring of PV installations was concluded in 2003.

Further projects concluded in 2003 included a measurement campaign on the noise-barrier PV installation along the A1 motorway in Safenwil, a multi-functional shading / PV installation in Geneva and the 16.8 kW CIS-installation at the St. Moritz ice rink.

Generally speaking, in the past few years several projects initialised under the Swiss R+D and P+D programmes have proved commercially interesting. A particularly good example is the Sputnik Engineering Company that worked closely together with the University of Applied Technology in Bienne to develop inverter technology. The company's SolarMax inverters are, today, well known across the whole European market. The yearly production has reached a level that can deal with around 40 MW of installed PV power – over twenty times as much as is installed in Switzerland itself per year.

Another example of a successful Swiss development is the SOLRIF roof-integration frame system that was developed by the Schweizer Metalbau and Enecolo companies. Since its introduction in the European market, the frame system has been used for installations with a total power of around 5 MW.

Summary of major projects, demonstration and field test programmes

The following table lists a selection (by no means complete) of interesting Swiss P+D projects:

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2003 /problems and lessons learned	Funding	Project management	Remarks
CPT Solar – Flat roof integration, TISO, Trevano, 2003	Test of roofing product featuring the combination of solar cells and waterproofing membranes	Test of flexible triple-junction amorphous thin-film cells bonded to plastic foil. Assessment of thermal effects	Waterproofing membranes mounted in August 2003	Private, SFOE	SUPSI, DACD, LEEE-TISO, Cannobio	3 small open-rack installations with a-Si and c-Si for comparison
Corviglia and Piz Nair alpine PV, St. Moritz, 2003	Monitoring of the performance of PV plant mounted on aerial cableway stations	Monitoring the performance of PV installations mounted on the facades of the stations and along the track of the Corviglia funicular	The expected increased power production due to albedo effects was confirmed	Private, SFOE	Sun Technics, Küsnacht	Plant on the lower station of the Piz Nair cableway inaugurated in July 2003
62 kW PV installation Triengen, 2003	Combined Power Guard insulation/PV roofing sytem on a high-bay warehouse	Test of solar roofing elements consisting of 5 cm insulation with 2 bonded laminated PV panels	Planning accomplished, roofing to be mounted December 2003	Private, SFOE	Zagsolar, Kriens, Trisa Electro AG, Triengen	Production display to be mounted on nearby transformer station.
Freestyle, roof cladding system in Lausanne, 2002	Triple a-Si cells laminated onto steel sheeting	Testing of an unglazed, watertight PV roofing system, architectural integration	Plant was put into definte service in May 2003.	Private, SFOE	Solsitis, Lausanne	Performance is to be monitored until may 2004

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2003/problems and lessons learned	Funding	Project management	Remarks
Newtech, Burgdorf University of applied science, 2000	Comparison of three 1 kW thin-film installations	Direct, long-term comparison of installations using a-tandem cells, a-triple cells and CIS cells	Best results delivered by the installations with CIS and triple cells. Tandem cells produce somewhat less	SFOE	ADEV Burgdorf / Fachhoch-schule, Burgdorf	All installations with above average or good yields. Project now closed
Thin-film test installation, Migros, Zürich, 2002	Comparison of 6 types of thin-film modules, each in 3 application modes	Direct, long-term comparison of various types of commercially available thin-film modules. Conventional sc-Si for comparison	Measurements show that some cells without back-ventilation or mounted on thermal insulation are not detrimentally affected by high temperatures	SFOE, EWZ, private (solar stock exchange project)	Energiebüro, Zürich	Mounting variants: flat, thermally insulated; flat, open back; inclined, open back.
“Sunny Woods” 16 kW installation	PV pilot installation on a ultra-low energy-consumption building using amorphous triple cells	Integration in an architectural concept, Verification that PV yield meets power demands of heat pumps	PV-production measured on a monthly basis. Production slightly less than defined	Private, SFOE	Beat Kämpfen, Architect, Zurich	Production in winter to be measured in detail
Ice rink, St. Moritz, 2000	16.8 kW pilot installation using CIS technology	Demonstration of CIS technology, detailed measurement campaign	High efficiency (PR=0.81) confirmed. 2 years of monitoring with no failures	SFOE, Rätia Energie	SUSPI, DCT, LEEE-TISO, Canobbio	More energy could have been produces if invertrs had not gone into overload

Project Date plant start up	Technical data/Economic data	Objectives	Main accomplishments until the end of 2003/problems and lessons learned	Funding	Project management	Remarks
Terminal E, Zurich Airport, 2001	5-part 290 kW plant, integrated into the terminal's roof	Demonstration of multi-functional building integration including shading for passenger lounges	Installation works without problems. Production well above expectations	SFOE, Unique Airport Zurich	ZAYETTA consortium, Zurich Airport	Part of European PHOTOCAMPA research project
BIPV Würth GmbH, Chur, 2002	3.9 kW shading/PV installation for the atrium of an office building	Demonstration of semi-transparent CIS panels as a shading element, measurement campaign	In operation since October 2002	Private, SFOE	Enecolo AG, Mönchaltorf	Building-integrated PV with striped CIS panels

2.4 R&D Highlights

In Switzerland, a wide variety of research and development projects deal with solar cells. Thanks to support from academic and governmental institutions as well as industry co-operation projects, both fundamental research as well as technology transfer aspects were covered in 2003.

In the field of thin-film and multi-layer cell concepts, work was continued on micromorph thin film cells, where industry co-operation continues to move laboratory-scale production technology to the industrial scale. Here, the Unaxis company is adapting its commercially available deposition equipment that is currently used in the production of LCD monitors to fit the needs of the production of thin-film solar panels.

Other areas of interest involve the optimisation of cell production such as deposition speed of the microcrystalline silicon, the improvement of light-capture and the increasing of conversion efficiencies. Together with the University of Applied Science in Le Locle, The VHF Technologies company is working on methods of roughening the surface of polymer substrates to improve light capture of the amorphous cells produced in their roll-to-roll process.

At the Institute for Microtechnology IMT in Neuchatel, work is being done within the framework of the EU's DOIT project that aims to produce a 30 x 30 cm micromorph panel with a stable efficiency of 11%. In particular, the IMT is looking at the VHF process necessary for the deposition of the silicon film.

The development of dye-sensitised nano-crystalline cells was continued within the framework of Top Nano 21 projects at the Swiss Institutes of Technology. In co-operation with industry, work was done on dye-sensitised cells for indoor use and on flexible dye-sensitised cells that use stainless-steel foils as their substrate.

Long-term work on CIGS and cadmium-telluride cells was carried further at the Federal Institute of Technology in Zurich, where research within the framework of several EU projects was carried out.

In the area of crystalline silicon, the HCT Shaping company took part in the EU's RE-SI-CLE project that is looking into ways of recycling the wastes produced in the semiconductor industry for re-use in the production process. At present around 34 % of the silicon used to produce multi-crystalline cells is lost as silicon powder in the wafer-sawing process.

Building integration is still the most important area of PV applications. While the actual integration of PV panels is a topic covered by many P+D projects, research and development is concentrated on the production of the panels themselves. Here, emphasis is placed on the development of composite PV modules that directly combine thin-film solar cells with facade and roofing elements. Several Swiss companies and institutions are active in this area.

The use of chemically-etched anti-reflex glass for increasing the efficiency of solar modules is being investigated and the development of CIGS-based "MegaSlate" panels was continued. Other development projects involved the production of back-contact crystalline cells and the development of panels with on-glass conductors. Once more, EU projects provided the framework for further projects involving the packaging of cells and their integration in the built environment.

In the systems technology area, the main emphasis remained on the quality assurance of components (modules, inverters), systems (engineering) and plant (long-term monitoring). The standardisation of both products and testing procedures also remained an important topic, since, for example, standards for mounting components in building integration do not yet exist.

The long-term tests on the over 20-year old modules of the LEEE-TISO 10 kW installation were concluded in 2003, as was the project on the long-term behaviour of grid-connected PV plant, where 42 installations with a total of 55 inverters were monitored. The data of selected installations is to be published in the IEA PVPS Task 2 data base.

In the area of energy storage, work within the framework of the EU INVESTIRE project was concluded. Here, 20 companies and 15 research laboratories evaluated various methods of storing energy produced from renewable resources - in particular that produced by PV plant. The results showed that, economically, beating the lead battery will be difficult: only compressed air storage is an alternative here.

Work started, too, on the development of a rechargeable polymer solar battery that is to be combined with a novel polymer solar cell to provide power for mobile applications.

Other R&D work covered the development of aids for the design of PV installations and for associated topics, such as eco-balances and simulation systems. These included software for the monitoring of production using satellite data and the simulation of energy and material flows for groups of buildings in an urban context. In addition to these technical models, social aspects of PV power supply in off-grid communities were being modelled at the University of Zurich as part of the EU's MSG: Multi-User Solar Hybrid Grids project.

2.5 Budgets for market stimulation, demonstration / field test programmes and R&D

Table 2 Budgets (in Millions of CHF) for R&D, demonstration programmes and market incentives.

	R & D	Demo	Market	Total
National/federal	*10,3*	*1,0*	*0,5*	*11,8*
State/regional	4,0	0	4,0*	7.0
Total	***14,3***	***1.0***	***4.5***	***18.8***

* including grants / subsidies for private persons

The Swiss Federation runs a system of global grants to cantons, which has replaced direct federal funding to a certain extent. Not all Cantons have the appropriate legislature to augment and distribute these funds, and the situation concerning grants for RD&D and market incentives varies greatly. Some cantons set their emphasis on market measures (from market events over investment incentives through to direct subsidies), others on installing their own PV demonstration installations or on the support of local “solar stock-exchanges”.

The figure on the level of regional funding for market promotion quoted is the sum of those figures given for 2003 by 20 Swiss Cantons. The actual total may be somewhat higher, as not all figures are available.

The Canton of Geneva supports PV plant installed in connection with the local solar stock exchange with CHF 4 000 per kW. The canton has set itself a target of installing 5 MW of PV power by 2006.

The City and Canton of Basle’s incentive levy on electricity is continues to provide a very important impulse for PV in the area. The part of the income from this levy that is reserved for the promotion of PV power helped fund 456 kW of additional PV power in 2003, with over CHF 2.3 million.being paid out.

3 Industry and growth

There is no large scale industrial cell production in Switzerland. The Unaxis company, specialised in vacuum technology and the production of thin-film coatings (for LCD displays, for example), is, however, continuing to work together with the Institute for Micro-Technology in Neuchatel on adapting and further developing current industrial production equipment for the production of thin-film PV modules.

Other, "spin-off" companies are working on the commercialisation of the new thin-film technologies developed in Swiss technology institutes and universities of applied technology. The VHF Technologies SA company in Le Locle, for example, already produces amorphous cells on polyimide substrates in a continuous process.

3.1 Production of feedstocks and wafers

There is no production of feedstocks and wafers in Switzerland.

3.2 Production of photovoltaic cells and modules

The following table provides a quick overview of PV module production in Switzerland for 2003.

Table 4: Production and production capacity information for 2003 for each module manufacturer

Module manufacturer	**Technology** (sc-Si, mc-Si, a-Si, CdTe)	**Total Production** (MW) Cell	Module	**Maximum production capacity** (MW)
1 Star Unity (SunnyTile)	mc-Si	-	0.02	0.1
2 Solterra SA	sc-Si	-	*See note*	*N/A*
3 SES, Société d'Energie Solaire SA	sc-Si	-	*See note*	*N/A*
4 Swiss Sustainable Systems	sc-Si and mc-Si	-	0.1	0.2
Thin-film manufacturers				
1 VHF Technologies SA (Thin Film)	a-Si	*See note below*	0.002	0.01

Notes on manufacturers:

No.1: Star-Unity buys in mono-crystalline cells and integrates them into roof tiles with *standard dimensions.*

No.2: Solterra SA – a company also active in the thin-film coating business, produces various types of PV Panels as well as large-format roofing "tiles". Figures on production are not available.

No.3: SES, Société d'Energie Solaire SA, based in Geneva, produces and sells the "SUNSLATES", "SUNWALL" and "SUNSHADE" lines – standardised building elements for roofing and facades- as well as customer-specific modules. Figures on production are not available.

No.4: The 3S Swiss Sustainable Solutions company produces custom laminates up to sizes of 2 x 3.5 m using bought-in cells laminated onto glass. Also, approriate roof and façade-mounting systems are developed and sold. The production figures for 2003 have dropped due

to the shifting of production to the EU area. R&D activities include new encapsulation techniques and the development of thin-fim elements. These activities and the production of special modules remain in Switzerland. MegaSlate - a new roof integration system featuring CIS cells - is already in use and possibilities for external production are being looked at for the European and US markets.

Thin-film manufacturers

No.1: VHF Technologies produces thin-film amorphous cells on plastic foil (polyimide) substrate. Initial applications are in small electronics applications and various products are commercially available, including a “Flexroll” charger for portable phones that can be rolled up. A pilot line for larger foil-modules is in operation, production figures are confidential. At the end of 2003, production facilities for 40 kW were under construction but not yet in service.

Module Prices during the period 1992 – 2002

We are unfortunately not able to quote complete figures for prices during this period. For Star Unity’s tiles a figure of CHF 20-30 / W is quoted. For the thin-film modules, no price information is available.

3.3 Manufacturers and suppliers of other components

Table 5 Price of inverters for grid-connected PV applications.

Various trends are to be found when viewing the situation in Switzerland concerning the manufacture of balance-of-system components. Whilst, as a result of the reduced impetus in the Swiss PV market, one of the pioneer Swiss companies in the inverter business no longer develops and produces inverters, another company is enjoying success on a Europe wide basis. Also, combined inverter / battery-chargers for stand-alone and back-up systems sold well.

In the area of supporting structures and combinations of PV panels / cells with structural elements and materials, several systems developed in Switzerland continued to be successfully marketed in 2003.

Another area in which Switzerland is active is the area of manufacturing equipment for the world-wide PV industry, such as wire-sawing machines, connector systems and measuring equipment.

One of these companies, HCT Shaping Systems, is involved in an EU-project called RE-SI-CLE, which is developing new processes for the extraction of raw silicon from silicon wastes, thus addressing an important problem in the resource-management of crystalline silicon.

3.4 System prices

Table 6: Prices of typical applications

Category/Size	Typical applications and brief details	Price per W in CHF
OFF-GRID Up to 1 kW	Roof-mounted, chalets, leisure activities, road building-sites (emergency telephones)	16.00
OFF-GRID >1 kW	Roof-mounted, holiday homes, remote homes	15.00
ON-GRID Specific case	3 kW roof-mounted system, single-family home	9.25
ON-GRID Up to 10 kW	Small modular plant (AC-Modules) roof-mounted, private owner	8.90
ON-GRID >10 kW	Commercial and P+D plant around 50 – 100 kW mostly flat-roof mounted, also on noise-abatement structures	7.83

Prices exclude sales tax. The figures are estimated on the basis of data provided by engineering offices and consultants involved in the building of PV installations.

Table 6a: National trends in system prices for on-grid standard installations (Prices in CHF / W for 10 - 20 kW flat roof and 3 to 4 kW residential systems)

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
10-20 kW	13.00	13.00	12.50	11.80	11.00	10.40	10.20	10.10	9.90	9.40	9.20	8.40
3-4 kW	13.40	13.30	13.20	12.80	12.60	12.30	12.30	11.90	12.50	12.20	11.00	9.25

3-4 kW residential systems

After a rise in prices in 2000, caused by tighter conditions on the market for buyers resulting from increased promotional measures in Switzerland's neighbouring countries, the average price for 3 – 4kW residential systems has still continued to drop in 2003 as production capacities word-wide were augmented.

Home System Kits

Small PV units are available in several varieties that can be easily set up by the “man on the street”. These units can be plugged into a normal power socket and require no installation work. The units with a ratings between 100 – 200 W comprise one or two standard PV modules, a built-in inverter with a connecting cable and a simple mounting system. Off-the-shelf end-consumer prices (incl. VAT) range from CHF 13.30 to 13.80 /W

3.5 Labour places

No exact figures are available for the number of persons employed in the PV area. The following figures are an estimate based on installed power, imports and budgets for research and development in 2003.

Category	R&D	Cell / Module Manufacturing	Planning / Installation	Manuf. facility suppliers	Total
Labour places	around 140	around 10	around 90	around 200	around 440

3.6 Business Value

The total end financial value of PV plant installed is estimated at around CHF 15 Million. This is estimated on the basis of PV power installed in 2003 and average turn-key prices.

As practically all cells and the greater part of PV modules in Switzerland are imported, the added value figure is probably more interesting: This amounts to around CHF 7 million.

4 Framework for deployment (Non-technical factors)

4.1 New initiatives

With the current national energy legislation, the responsibility for funding promotion activities in the PV area lies with the Swiss Cantons - and with private industry. Most activities therefore occur at a regional level and vary considerably from region to region. For 2003 no new promotional programmes for PV are to be noted at this level.

In the area of "green electricity" marketing, Swiss labelling institutions and utilities are active in the national and international areas. Certain producers of "green" electricity are attempting to sell their ecological added value - not to be confused with the actual electrical power – to utilities and consumers in the form of certificates for the production of a certain amount of "green" power. A major Swiss retail supermarket chain started to offer its customers the possibility of buying such certificates via the company's internet website.

4.2 Indirect policy issues

As legislature on the liberalisation of the electricity market was refused in public voting in 2002, the Federal government started to develop an alternative decree on the structure of the electricity industry in 2003. This decree is to regulate the generation, distribution and supply of electricity in Switzerland and combat the uncoordinated opening of the electricity market. Factors affecting niche markets such as regulations concerning the transport of "green" electricity to customers are also being addressed within the framework of this and other, existing, legislation.

Two advantages for PV power result from the revised Nuclear Energy Law: the remuneration for electricity generated from renewable resources (15 cents/kWh) is now to be paid by the overland grid companies and no longer by the local utilities. Also branding, i.e. the declaration of how the electricity is generated, is also called for by the new legislation.

4.3 Standards and codes

The integration of the new IEC PV standard 60364-7-712 in the Swiss national standards for electrical installations progressed well in 2003. Within the framework of the EU REMAC Renewable Energy Market Accelerator project, work on the development of guidelines for the enhancement of the European and global markets for renewable energy was continued. Another P+D project worked on quality standards for the PV market. Here, concepts for Training, Accreditation and Certification were worked on together with Institutes from all over Europe in a programme co-financed by the European Commission and the Swiss Government. Also, work continued in the IEC TC 82 working group on standards.

5 Framework for deployment (Non-technical factors)

In comparison other countries, the general conditions for the promotion of PV power systems in Switzerland remain poor. No broad national PV promotion programme exists at the moment and cut-backs in federal funding will affect the P+D area in particular. The promotion of the wide use of PV systems applications is therefore becoming more and more dependent on private initiative and marketing campaigns: basically, PV promotion is now a question of how well "green" electricity can be marketed. It is practically only the green power markets (solar stock exchanges) that allowed the Swiss PV market to remain stable in 2003.

In spite of these difficulties, it should be possible to hold the number of projects and funding constant thanks to support offered by European projects, the Federal Office for Education and Science and the Swiss Commission on Technology and Innovation.

After new electricity market legislation was turned down in 2002, no new programmes have been launched and possibilities for supporting the production of power from renewable resources stays at an all-time low. The possible introduction of levies on the CO2-production of non-renewable energy sources and an idea put forward by the oil industry for a "voluntary" levy on oil, diesel and petrol (the "Climate Cent") could help internalise some of the indirect costs of these energy carriers and provide the basis for promotion of energy efficiency and renewable forms of energy. These issues are to discussed in parliament in 2004.

Looking on the positive side of the PV situation in Switzerland, it is expected that industrial interest and investments in the area of the manufacture of thin-film solar cells and modules will continue to increase and thus allow R&D findings to be effectively transferred to industrial products and applications..

The general interest in PV as a key future technology is demonstrated at least once a year at the National PV Conference. This conference, where an audience of several hundred persons regularly takes the opportunity to keep in contact with the newest developments in the PV area, is an important aid in the promotion of PV Systems in Switzerland. The Spring 2004, conference in Zurich has building integration as its main theme.

In the area of public-oriented PV power plant, it is now mostly private persons and companies who are building PV plant that provide a certain amount of publicity for photovoltaics. A certain amount of effort is being made by power utilities, who, sometimes as a result of lobbying by environmental organisations, support the installation of PV plant in their supply areas.

Construction of the new national football stadium in Berne-Wankdorf is to commence in 2004. The stadium will boast the largest building-integrated PV installation in Switzerland. The installation will cover around 5,000 m2 of the stadium's roof. With around 600 kW rated peak output, the PV plant will deliver power for a local "solar stock exchange". If the sale of "green" power proves successful, it is planned to install additional PV panels on a further 3,000 m2 of the stadium's roof.

Annex A Method and accuracy of data

The Data on PV Installations and plant presented in this report have been collected from federal institutions, manufacturers and their professional associations, engineering and consultancy offices and private and institutional initiators of building projects. Much data is taken from the draft annual reports of the Swiss Federal Office of Energy.

The Figures presented in this national report come from various sources and exhibit various degrees of accuracy. Key figures such as installed power are correct to about +/- 5%. Data concerning national R+D funding are exact. The figure for regional funding of market-oriented activities and subsidies is the sum on data from somewhat more than four fifths of Swiss Cantons. With the shift of responsibility for promotional funding towards the Cantons and even individual municipalities the collection of data has become more difficult. The accuracy of our data in this category is therefore questionable and should be taken as a rough guide with an accuracy of +/- 20%.

Price and market figures are based on information provided by manufacturers, and we can therefore not quote any percentages on the accuracy of these data.

As for our own estimates, we have quoted any base data sources and stated any assumptions made directly in the text of the report.