SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS
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Fig. 1 - Solar Impulse, flying around the world in a solar powered airplane (photo Oxyde.ch - Saprisiti / ©EPFL Solar Impulse).

GENERAL FRAMEWORK

Following the political debate regarding the future of the *SwissEnergy* Programme (www.swiss-energy.ch) during 2003, the consequences of the budget reductions for this programme became reality in the course of 2004. In particular, the federal government support for pilot and demonstration systems had to be strongly reduced for all energy technologies, leaving only marginal means for new projects in this area. This represents a severe cut along the chain from technology towards the market and thus affects rapid transfer of results from R&D into industrial solutions and products. Discussions are ongoing with different parties on how to continue this important activity.

Further matters related to energy policy are presently on the political agenda. On the one hand, this concerns the introduction of a CO_2 tax on fossil fuels. The legal basis for the introduction of such a tax is defined by the CO_2 law which has been in force for a number of years. Different variants of this tax are presently in discussion with an alternative proposal for the introduction of a climate-cent on the use of fossil fuels. In particular, the proposed variants represent differences whether their impact will mainly concern CO_2 emission reductions realised on a national or on an international level through the use of the Kyoto instruments and emissions trading. The second issue on the policy level is a new proposal for a liberalisation of the electricity market. After the rejection by public referendum of the first attempt on this subject in 2002, a new law has been proposed. Within this proposal, a goal of additional 5 400 GWh from renewable energies by 2030 is formulated. Here, the political debate concerns the instruments to be used to achieve this goal, namely a bidding model or feed-in tariffs. The Swiss Parliament will deal with this subject in the course of 2005.

Finally, the framework for the energy research remains otherwise unchanged: The energy research strategy is defined by a 4 year energy RTD master plan for the period 2004 - 2007. The master plan developed by the Federal Commission for Energy Research (CORE), in cooperation with the Swiss Federal Office of Energy (SFOE), is based on strategic policy goals (energy & environment, science & education, industry & society).

NATIONAL PROGRAMME

Switzerland has a dedicated national photovoltaic RTD programme which involves a broad range of stakeholders in a strongly coordinated approach (www.photovoltaic.ch). This national photovoltaic programme focuses on R&D,D in a system and market oriented approach, from basic research, over applied research, product development, pilot and demonstration projects all the way to market stimu-lation. As indicated above, activities in pilot and demonstration projects had to be reduced in 2004. On the technical level, thin film solar cells and building integration are the foremost topics of priority. The programme is organised along the entire value chain and addresses the critical gaps from technology to the market place.

Fig. 2 - 15,4 kWp flat roof PV system using the Sarnasol product (photo Sarnafil).

Accompanying measures to raise the quality and reliability of photovoltaic power systems include thorough component analysis, work on standards and design tools. On the market side, deployment is promoted by a customer-oriented approach in the campaign "solar electricity from the utility." Finally, the programme puts emphasis on information and communication in order to raise the awareness for opportunities involving photovoltaics. Direct promotion of the market through incen-tive schemes is within the responsibility of the cantons on a voluntary basis. This has led to regional differences whereby the governments of the cantons define their priorities between promotion of en-ergy efficiency and/or renewable energies. Support for photovoltaics through direct subsidy schemes is limited to a few cantons presently.

Through the bias of Task 9 of the IEA PVPS Programme, the subject of technology co-operation with developing countries continues to be expanded. During 2004, a new interdepartmental platform for the promotion of renewable energy in international co-operation - REPIC - was launched and became operational (www.repic.ch) with first projects supported.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

The Swiss Photovoltaic RTD Programme is based on a 4 year RTD master plan, presently covering the period 2004 - 2007. Overall, 75 projects, supported by various national and regional government agencies, the research community and the private sector are conducted in the different areas of the photovoltaic energy system. Market orientation, cost reduction, industrial viability and transfer as well as increased efficiency and reliability are the main objectives of the technical R&D.

For solar cells, the main focus remains on thin film solar cells with projects in a wide variety of materials (amorphous and microcrystalline silicon, compound semiconductors, dye-sensitised cells). During 2004, emphasis on flexible solar cells has increased. For flexible CIGS solar cells, a new world record efficiency of 14,1% was achieved during 2004 at the Swiss Federal Institute of Technology in Zurich. Transfer to industry of these RTD activities has continuously increased over the past years. The spin-off company VHF-Technologies has increased the annual capacity of their pilot manufacturing plant of amorphous silicon solar cells on plastic substrates to 40 kWp. Another technology transfer is occurring with the equipment manufacturer Unaxis. Building on the strong synergies with this company's exper-tise for production equipment of flat panel displays, Unaxis is setting up a new business unit, Unaxis solar. This new venture of Unaxis with the Institute of Microtechnology at the University of Neuchâtel intends to develop a leading position in the industrial production equipment of thin film "micromorphous" silicon solar cells.

A strong emphasis continues to be given to the application of building integration, both for new solutions involving thin film solar cells as well as for new mounting systems and structures for sloped roofs and facades.

With the ongoing market development, quality assurance of products and systems, as well as stan-dardisation, continue to be of high

priority. Three centres of competence have been established which evaluate products such as PV modules, inverters and components for building integration. Long term experience with the operation of photovoltaic power systems is carefully tracked for a number of grid-connected systems, ranging between 10 and more than 20 years of operation. Continuous development of system solutions has resulted in a number of industrial products which are increasingly being exported.

An exceptional and visionary project has been initiated by Bertrand Piccard, the first man together with Brian Jones, to circle the earth non-stop in a balloon in 1999. This new project with the name Solar Impulse (www.solar-impulse.com) has the goal of a non-stop flight around the world in a solar powered airplane (Fig. 1). Exceptional efforts in photovoltaic cell and system technology, energy management and design will be required to achieve this ambitious goal. The project has the scientific support of the Swiss Federal Institute of Technology in Lausanne, the University of Neuchâtel and other organisations in Switzerland and abroad.

International co-operation continues to form a strong pillar of the R&D activities with about 20 projects running in the 5th and 6th framework RTD programmes of the European Union during 2004. International projects are also carried out as part of programmes such as the European Space Agency. The co-operation within the IEA PVPS programme has remained a further strategic activity for which target-group specific dissemination is crucial.

IMPLEMENTATION

Market implementation of PV systems continues to be driven by the campaign for "solar electricity from the utility" and similar approaches related to green power marketing. Since the introduction of the *naturemade*® labels for renewable electricity, utilities have started introducing different product brands, some with a mix of different renewable energy sources and others with technology specific products, e.g. the product *"Premium Solar"* by the utiltiy of the city of Zurich. Increasingly, solar electricity is thus part of mixed green power products, according to naturemade star® labelled brands. Typically, around 5 % of the customers are willing to pay the comparatively high prices for solar electricity, in the best cases. Thus, it requires a strong and consistent marketing approach. However, with mixed products, more customers can be attracted. Market implementation is further supported by regional initiatives, for example in the cantons of Basel and Geneva.

INDUSTRY STATUS

Some years ago, Swiss industrial PV products covered mainly system components such as inverters, both for grid-connected and stand-alone applications, components for electrical connection, mounting systems for building integration and custom designed PV modules. Over the past years, industrial activities in the area of solar cells, solar modules and manufacturing equipment for both of these areas have considerably increased.

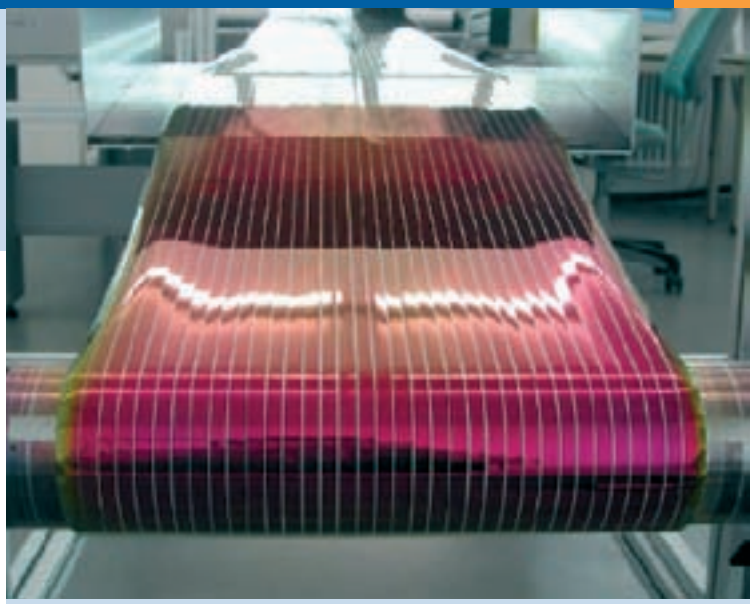

Fig. 3 - Roll-to-roll manufacturing of flexible amorphous silicon solar cells (photo VHF Technologies).

In the inverter area, some products have achieved a high export rate. The Sputnik company produces grid-connected inverters at a capacity of 90 MW/year and presently ranges as number 3 in the European market. The Studer company produces stand-alone inverters and is also very successful in exporting. On the PV industry supply side, different products count among the world leaders, e.g. for wire-sawing machines from HCT as well as from Meyer & Burger; and measuring equipment for PV module manufacturers from Belval. In addition to the solar plugging systems made by Multicontact, another company, Huber & Suhner, has entered into this market. The SOLRIF® mounting system for building integrated photovoltaics made by Schweizer Metallbau and Enecolo continues to be successful on the market. A new entrant is the Sarnafil company, which has developed a flexible, watertight flat roof PV system based on thin film silicon solar cells (Fig. 2).

More recently, industrial activities have started in the field of process equipment (Unaxis solar) and small scale products based on thin-film technology (Flexcell from VHF-Technologies, Fig. 3). Further-more, Swiss Sustainable Systems (3S) is building some of the world's largest PV module laminators.

Based on the long term experience and the large number of installed systems, considerable know-how is available amongst engineering companies for the design, construction and operation of a large variety of different applications, ranging from small scale, stand alone systems for non-domestic, professional applications and remote locations, over small domestic grid-connected systems to medium and large size grid-connected systems in various types of advanced building integration. The export volume of Swiss photovoltaic products has surpassed 50 MCHF in 2004 and thus represents about twice the size of the national market.

Besides an increased interest from the manufacturing industry, the finance sector continues to pro-mote financial services directed towards renewable energy. Increased investments have occurred in the renewable energy sector, including photovoltaics, and dedicated

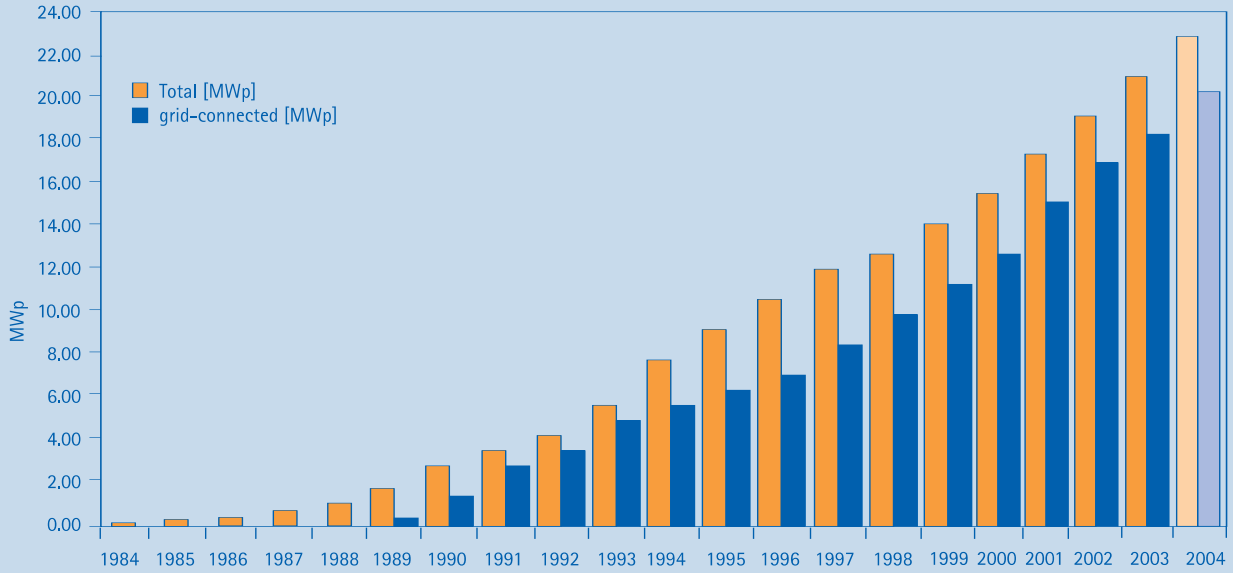

Fig. 4 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2004 (total and grid-connected, estimated values for 2004).

funds are operated by important finance organisations. This trend is manifested by the regular investment analysis reports published by the Bank Sarasin.

MARKET DEVELOPMENT

The market development has been mainly driven by the federal campaign "solar electricity from the utility" or similar schemes, supported by promotional programmes and actions in some cantons. The annual market volume for grid-connected systems is estimated to about 2,0 MWp, similar to previous years. The total installed capacity has thus risen to about 23 MWp (Figure 4), corresponding to about 3,3 Wp/capita. The PV energy statistics have been established by tracking the energy produced by grid-connected PV systems and their statistical distribution since 1992 (Table 1). The record summer of 2003 resulted in an increased energy production of about 10 % with a specific energy production reaching 875 kWh/kWp and a total energy production of 15 GWh.

FUTURE OUTLOOK

Regarding photovoltaic technology in Switzerland, the broad support of the national PV programme can be expected to continue with an ever-increased focus on industrial developments, new products for niche markets and ongoing international involvement. For solar cells and modules, the effort to bring Swiss technology to the market place will continue. Efforts in the technology development will concentrate on market oriented approaches and continuous quality assurance. The strategy to promote international co-operation on all levels will continue, related to activities in the 6th framework programme of the European Union, the IEA PVPS programme and increasingly in technology co-operation projects. Increased co-operation with other European PV RTD Programmes will be established in the framework of the PV-ERA-NET project. The initiative of the European Photovoltaic technology Platform will be closely followed.

In the near term, PV market implementation will continue to depend on the initiatives of regional authorities and even more on those from the private sector, namely the utilities. A market volume of about 2,0 MWp/year can be expected under these circumstances. For the mid-term, market imple-mentation will further strongly depend on the outcomes of the political debate concerning the new electricity law during 2005.

TABLE 1: SWISS PHOTOVOLTAIC ENERGY STATISTICS FROM 1989 - 2003 (GRID-CONNECTED SYSTEMS)

Year	Number of New Systems	Total Number of Systems	Installed Capacity [MWp DC]	Energy Production [MWh]	Specific Energy-Production [kWh / kWp]
1989	60	60	0,3		
1990	110	170	0,8	400	
1991	210	380	1,8	1 100	
1992	110	490	3,1	1 800	800
1993	110	600	4,0	3 000	810
1994	80	680	4,8	3 500	800
1995	60	740	5,4	4 000	815
1996	80	820	6,2	4 700	825
1997	130	950	7,4	6 000	880
1998	150	1 100	9,2	7 100	860
1999	125	1 225	11,0	7 700	770
2000	100	1 325	13,0	10 000	810
2001	125	1 450	15,0	11 000	800
2002	75	1 525	17,0	12 000	810
2003	75	1 600	17,9	15 100	875

(grid-connected systems)