SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS
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Fig. 1 - 280 kWp flat roof system at Geneva airport with AluStand® mounting system (PV design: Enecolo, photo Urs Bühler).

GENERAL FRAMEWORK

Following the budget reductions of the *SwissEnergy* Programme (www.swiss-energy.ch) decided during 2003, the consequences of these reductions persisted in 2005. In particular, no new pilot and demonstration systems could be supported by the federal government. This represents a severe cut along the chain from technology development towards the market and thus affects rapid transfer of results from R&D into industrial solutions and products. Electric utility organisations and governments of cantons can provide support for pilot and demonstration systems but photovoltaics are generally not a first priority.

Different matters related to energy policy are presently on the political agenda. In part, 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 Carbon Law which has been in force for a number of years. As an alternative to the CO_2 tax, voluntary measures can be proposed. During 2005, the Climate Cent Foundation was established as a voluntary measure of the Swiss industry (http://www.stiftung-klimarappen.ch), in accordance with the Carbon Law. For the mobility sector, instead of introducing a CO_2 tax, a climate-cent of 1,5 cents CHF per litre is charged by the private oil association on imported petrol and diesel. This will generate around 100 million Swiss Francs annually which will go towards closing the gap in CO_2 emissions reductions. These reductions of 1 800 000 t in 2012 are planned to be achieved through CO_2 emission reduction projects both in Switzerland (200 000 t) and abroad (1 600 000 t). For the heat sector, the political debate about the introduction of the CO_2 tax is ongoing.

The second issue on the policy level, of greater relevance for photovoltaics, 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. During 2005, the National Council (large chamber of the federal parliament) has favoured the introduction of a feed-in tariff system for "new" renewables and a bidding model for hydro. The Council of States (small chamber of the federal parliament) will have this debate in the course of 2006. Final decisions on this subject are expected by the end of 2006 on the parliamentary level, upon which a public referendum may be possible during 2007. 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). By the end of 2005, work had started for the next 4 year energy RTD master plan, covering the period 2008 - 2011.

Fig. 2 - 110 kWp roof integration on a farmhouse with Solrif® frames (PV design: Solstis, photo NET).

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 stimulation. As indicated above, activities in pilot and demonstration projects had to be further reduced in 2005. 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. Thorough component - in particular for photovoltaic modules and inverters - and system analysis aims at increasing efficiency, reliability and performance. Accompanying measures to raise the quality and reliability of photovoltaic power systems include 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 places emphasis on information and communication in order to raise the awareness for opportunities involving photovoltaics. Direct promotion of the market through incentive 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 energy efficiency and/or renewable energies. Photovoltaics is generally not a priority and support through direct subsidy schemes is presently limited to a few cantons.

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 2005, the new interdepartmental platform for the promotion of renewable energy in international co-operation - REPIC - was continued (www.repic.ch) and supported photovoltaic projects of Swiss entities in developing countries.

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, 65 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 2005, emphasis on transfer from R&D to industrial processes and products continued. Work on thin film silicon at the University of Neuchâtel concentrated on micromorphous solar cells and the rapid large area deposition of its individual layers of amorphous and microcrystalline silicon. In this area, strong co-operation with the companies VHF-Technologies and Unaxis Solar continued. VHF-Technologies has increased the annual capacity of their pilot manufacturing plant of amorphous silicon solar cells on plastic substrates to 100 kWp. During 2005, the equipment manufacturer Unaxis confirmed the strategic priority of the solar photovoltaic business area and increased its development efforts as a leading supplier of manufacturing systems of thin film silicon solar cells on glass. With regard to CIGS solar cells, the Federal Institute of Technology in Zurich focused the work on high efficiency flexible CIGS cells on plastic and - as a new substrate - aluminium. During 2005, the spin-off company FLISOM was founded in view of transferring the promising R&D results into industrial products. For dye-sensitised solar cells, work continued on new dyes and high temperature stability of the devices. Flexible solar cells were also a subject for this technology.

Fig. 3 - 12 kWp facade system on the highly energy efficient commercial building Wattwerk (PV design: Holinger Solar, photo NET).

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 standardisation, continue to be of high priority. The centres of competence at the Technical Universities of Burgdorf and Lugano carefully evaluate products such as PV modules, inverters and new systems. 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.

The visionary project of a non-stop flight around the world in a solar powered airplane SolarImpulse (www.solar-impulse.com) by Bertrand Piccard was defined in its technical concept. With its wingspan of 80 m, a weight of about 2 tons, and about 40 kWp of photovoltaic power, this exceptional airplane should rise to an altitude of 12 000 m during day time and slowly descend during the night. 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 16 projects running in the 5th and 6th framework RTD programmes of the European Union during 2005.

Participation in new Integrated Projects has been successful in 2005. 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. For this purpose, a national IEA PVPS pool has been founded in 2005 which receives support from electric utilities of the city of Zurich, the Canton of Basel and the Mont-Soleil Association; further partners are under negotiation. The support to Swiss IEA PVPS activities could thus be broadened, in particular for activities in Tasks 2 and 10.
On the programme level, international co-operation is also taking place through the PV-ERA-NET project (www.pv-era.net) and the newly established European Photovoltaic Technology Platform (www.eupvplatform.org).

IMPLEMENTATION

Market implementation of PV systems continues to be mainly 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 utility of the city of Zurich. Increasingly, solar electricity is thus part of mixed green power products, according to *naturemade star*® labelled brands. With a strong and consistent marketing approach, typically around 5 % of the customer base can be attracted to pay the comparatively high prices for solar electricity, in the best cases. 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.

Fig. 4 - Unaxis Solar KAI 1200 mass production system for thin film silicon solar modules (photo Unaxis).

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.

In the inverter area, some products have achieved a high export rate. The Sputnik Company produces grid-connected inverters at a capacity of 125 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 Alustand® and SOLRIF® mounting systems for building integrated applications have been very successful on the market. Sarnafil, which has developed a flexible, water-tight flat roof PV system based on thin film silicon solar cells, is taking part in a joint venture with the American company Solar Integrated Technologies (SIT).

As indicated above, industrial activities evolve in the field of process equipment (Unaxis Solar, Figure 4) and small scale products based on thin-film technology (Flexcell from VHF-Technologies, FLISOM). Furthermore, Swiss Solar Systems (3S) is building some of the world's largest PV module laminators. 3S has established a strategic cooperation with the German company Schmid and is the first Swiss manufacturer dedicated solely to photovoltaics which has gone public in 2005.

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 80 MCHF in 2005 and thus represents at least four times the size of the national market. Besides an increased interest from the manufacturing industry, the finance sector continues to promote financial services directed towards renewable energy. Increased investments have occurred in the renewable energy sector, including photovoltaics, and dedicated 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. For 2005, the annual market for grid-connected systems was of 4,3 MWp, substantially higher than in previous years. This rise is partly due to two large systems (850 kWp and 1 MWp) completed during the year by the electric utilities of Berne and Geneva. The

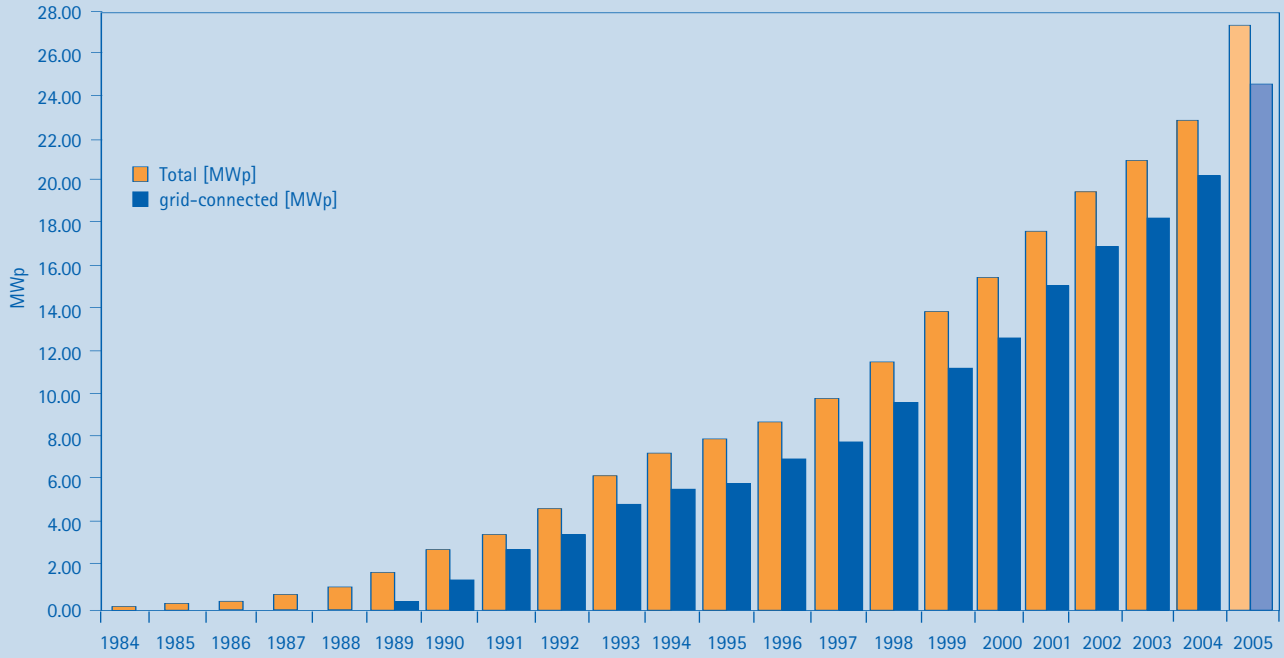

Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2005 (total and grid-connected, estimated values for 2005).

total installed capacity has thus risen to more than 27 MWp (Figure 5), corresponding to about 3,9 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 total energy production of grid-connected photovoltaic systems up to 2004 is thus approaching 16 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 European PV Technology Platform, the IEA PVPS programme and increasingly in technology co-operation projects. Stronger co-operation with other European PV RTD Programmes will be established in the framework of the PV-ERA-NET project.

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 to 3,0 MWp/year can be expected under these circumstances. Depending on the outcome of the political debate during 2006, on the new electricity law, concerning the future promotion of renewable electricity, the situation could change to a more favourable situation by 2008 at the earliest.

TABLE 1: SWISS PHOTOVOLTAIC ENERGY STATISTICS FROM 1989 - 2004 (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
2004	100	1 700	19,5	15 700	815

(grid-connected systems)