SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS
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Fig. 1 - Extension of the solar power system on the football stadium Wankdorf in Bern to 1,35 MWp (PV design, engineering and installation: energiebüro®, Ingenieurbüro Hostettler, Minder Energy Consulting, TRITEC; photo: TRITEC).

GENERAL FRAMEWORK

Throughout 2007, the framework for photovoltaic technology development in the public sector did not experience any particular changes: Research and development activities persisted on the level of previous years whereas support for new pilot and demonstration systems continued to be very limited. The latter continues to pose a barrier to the rapid transfer of results from R&D into industrial solutions and products. On the other hand and driven by the rapid growth of the worldwide photovoltaic market, industry development continued to be strong with new entrants and production facilities announced.

Energy policy matters remained constantly high on the political agenda with various important decisions at government and parliament level all throughout the year 2007. Early in the year, the federal council announced the main energy policy goals along four main priorities, namely in-creased energy efficiency, increased use of renewable energies, new large scale power plants and a specific foreign policy for energy. In spring 2007, the parliament decided for the introduction of a CO_2 tax in the heat and power sector and concluded the debate for a new act on the liberalisation of the electricity market. In September, the Department of the Environment, Transport, Energy and Communications announced action plans for energy efficiency and renewable energy.

Of greatest relevance for photovoltaics and other renewable energies is the new act concerning the liberalisation of the electricity market. After the rejection by public referendum of the first attempt on this subject in 2002, a new law has now been adopted. Within this law, a goal of additional 5 400 GWh from “new” renewable energies by 2030 is formulated. The feed-in tariff model was decided as the main support scheme to be implemented. However, the law also includes green power marketing as a possible market model and the two promotion schemes may be changed during the lifetime of a power system. To support the deployment of renewable electricity through the feed-in tariff model, a levy of 0,6 cCHF per kWh of consumed electricity has been decided, yielding a total annual amount of about 320 MCHF. This amount is divided into maximum contributions from each of the renewable energy technologies.

Following the adoption of this law in March 2007 by the Swiss parliament, the rest of the year was devoted to elaborating the concrete terms and details. The act came into force on 1 January 2008 and actual payments in the feed-in tariff scheme will commence in 2009. This represents an important advance for the Swiss photovoltaic market deployment. It should allow the photovoltaic sector to follow a steady albeit quite limited growth over the years to come. Increased interest in renewable energy in general and photovoltaics in particular could be observed throughout the year 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, with 2007 as the last year of 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). During 2007, the next 4 year energy RTD master plan, covering the period 2008 – 2011 was adopted. It confirms the important position of photovoltaic RTD in the Swiss energy RTD landscape.

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 were limited during 2007. 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 has so far mainly been driven by voluntary green power marketing programmes of utilities. This will now change to the feed-in tariff scheme as explained above. Finally, the programme places emphasis on information and communication in order to raise the awareness for opportunities involving photovoltaics.

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 2007, the first term of the interdepartmental platform for the promotion of renewable energy in international

Fig. 2 - Minergie-P-eco office building Marché International in Kempttthal with 45 kWp solar power system (architect: Beat Kämpfen, PV design and engineering: Suntechnics, photo: Suntechnics).

Fig. 3 - Zero energy multifamily buildings Eulachhof in Winterthur with 176 kWp solar power system (PV design and engineering: Amstein & Walthert, TRITEC, photo: TRITEC).

co-operation – REPIC – was successfully concluded (www.repic.ch). This platform supported different photovoltaic projects of Swiss entities in developing countries. The four participating government agencies decided to extend the REPIC platform for a second term and to introduce energy efficiency as an equal topic to be promoted in the future.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

The Swiss Photovoltaic RTD Programme is based on a 4 year RTD master plan, covering the period 2004 – 2007. In the last year of this period, overall 55 projects, supported by various national and regional government agencies, the research community and the private sector were 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 2007, emphasis on transfer from R&D to industrial processes and products continued. Work on thin film silicon at the University of Neuchâtel concentrated on the efficiency and reproducibility of micromorphous solar cells as well as the rapid large area deposition of its individual layers of amorphous and microcrystalline silicon, including work on transparent conductive oxides (TCO) and intermediate reflector layers. In the area of thin film silicon, strong co-operation with the companies VHF-Technologies and oerlikon solar continued. During 2007, the equipment manufacturer oerlikon solar extended its activities as a leading supplier of manufacturing systems of thin film silicon solar cells on glass and was able to acquire a number of important large orders. 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 aluminium. During 2007, the spin-off company FLISOM, active in this solar cell technology, continued its efforts towards an industrial product.
For dye-sensitised solar cells, work continued on new dyes and electrolytes as well as high temperature stability of the devices. Exploratory work was undertaken on new solar cell concepts (organic solar cells) at the Swiss Federal Laboratories for Materials Testing and Research EMPA.

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 25 years of operation. Continuous development of system solutions has resulted in a number of industrial products which are increasingly being exported.

Along with the examples of the solar powered airplane project SolarImpulse (www.solar-impulse.com) by Bertrand Piccard and the solar powered boat project PlanetSolar (www.planetsolar.org), both of which plan to travel around the world by air and respectively on water in the coming years, the solar powered car project Solartaxi (www.solartaxi.com) started its actual trip in 2007. By the end of 2007, it had reached the Asia Pacific area and was in Bali during the UNFCCC Climate Change Conference.

International co-operation continues to form a strong pillar of the R&D activities with 11 projects running in the 6th and 7th framework RTD programmes of the European Union during 2007, of which 3 are integrated projets. Swiss research groups are participating in the integrated projects FULLSPECTRUM, PV-ATHLET and PERFORMANCE. International projects are also carried out as part of programmes such as the European Space Agency: The project envisolar aimed at the increased use of satellite based solar radiation information in solar energy industries and for monitoring purposes. The co-operation within the IEA PVPS programme has remained a further strategic activity. Founded in 2005, a national IEA PVPS pool receiving support from the electric utilities of the city of Zurich, the Cantons of Basel as well as Geneva, the Mont-Soleil Association and SWISSOLAR contributed to the Swiss expert participation in IEA PVPS. The support to Swiss IEA PVPS activities could thus be broadened, in particular for activities in Tasks 2 and 10.

Fig. 4 - Industrial production equipment for thin film (amorphous and micromorphous) silicon solar cells from oerlikon solar (photo: oerlikon solar).

On the programme level, international co-operation is also taking place through the PV-ERA-NET project (www.pv-era.net) and the European Photovoltaic Technology Platform (www.eupvplatform.org).

IMPLEMENTATION

Up to 2006, market implementation of PV systems was mainly driven by green power marketing schemes of utilities. 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. 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. Small scale private, domestic and non-domestic systems form a complementary part of the Swiss photovoltaic market which is served by local businesses.

In expectation of the introduction of the feed-in tariff scheme, interest for photovoltaic projects strongly increased throughout 2007. As the new promotion scheme allows projects back to 2006 to be promoted under the feed-in tariff scheme, many new projects were initiated during 2007. In particular, farmers with their large roof buildings have become very interested in realising photovoltaic projects.

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 190 MW/year. The Studer Company produces stand-alone inverters and is also very successful in exporting. ASP solar is the third company active in the inverter area.
On the PV industry supply side, an increasing number of companies are serving the worldwide photovoltaic market, e.g. wiresawing machines for silicon ingots from Applied Materials Switzerland (formerly HCT) as well as from Meyer & Burger; stringing, tabbing and soldering machines for solar cells from KOMAX or measuring equipment for PV module manufacturers from Belval. Swisswafer is extending its production capacity for silicon ingots and wafers. Solar plugging systems are offered by Multicontact as well as Huber & Suhner. The Alustand® and SOLRIF® mounting systems for building integrated applications have been very successful on the market.

Sarnafil, now a part of the SIKA Company, has developed a flexible, watertight flat roof PV system based on thin film silicon solar cells and 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 (oerlikon solar) and products based on thin-film technology (Flexcell® from VHF-Technologies, FLISOM). In 2007, oerlikon solar received a number of large orders for industrial production equipment of amorphous silicon solar cells and newly introduced the production equipment for micromorphous solar cells. Using oerlikon solar's technology, the project of a 30 MW production line by the Pramac Company, to be implemented in the southern part of Switzerland near Locarno, was announced. During 2007, VHF-Technologies announced the plan for a 25 MW production line for thin film silicon solar cells on flexible substrates. Furthermore, Swiss Solar Systems (3S) is building some of the world's largest

TABLE 1: SWISS PHOTOVOLTAIC ENERGY STATISTICS FROM 1989 - 2006 (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
2005	200	1 900	23,8	17 800	850
2006	250	2 150	26,1	21 000	845

(grid-connected systems)

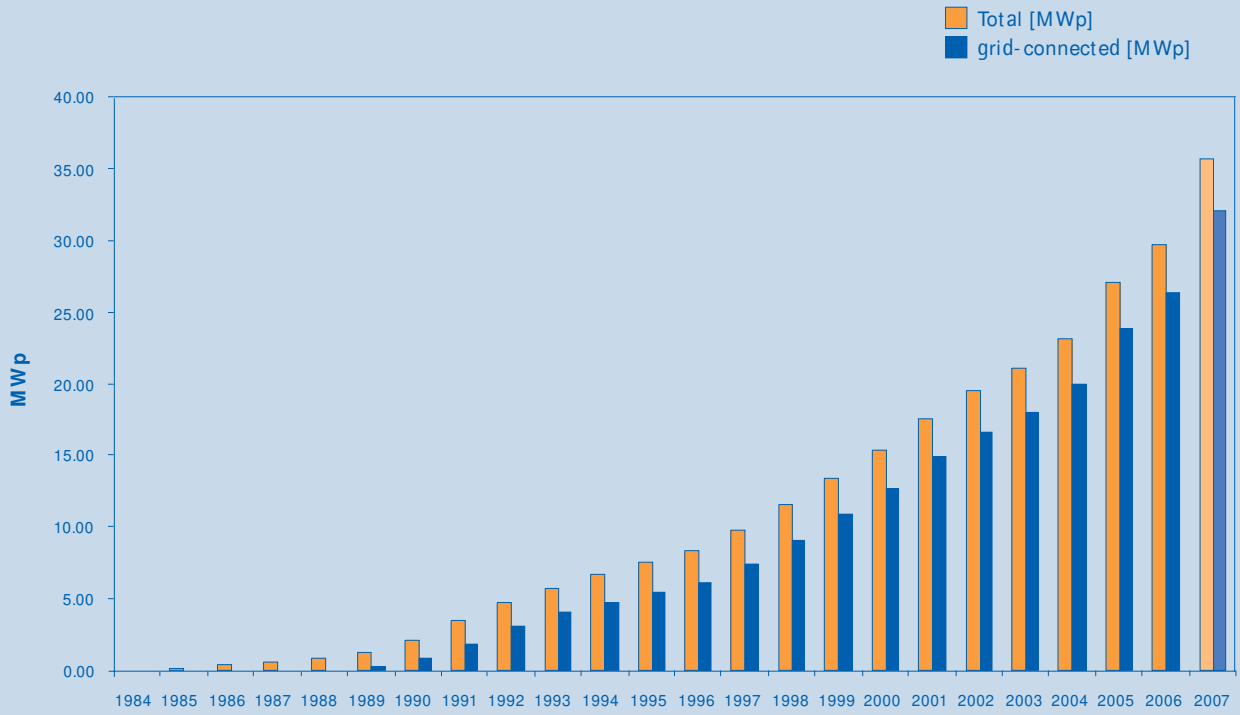

Fig. 5 - Evolution of the installed photovoltaic capacity in Switzerland between1984 and 2007 (total and grid-connected, estimated values for 2007).

PV module laminators. 3S has continued the strategic cooperation with the German company Schmid.

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 total export volume of Swiss photovoltaic products is estimated to more than 500 MCHF in 2007. 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, so far mainly driven by green power marketing schemes of utilities, supported by a few remaining promotional programmes and actions in some cantons, has experienced a stronger development in expectation of the feed-in tariff to be introduced soon. The annual market volume for grid-connected systems is estimated to a value around 6 MWp, which is about twice the market size of previous years. The total installed capacity has thus risen to about 36 MWp (Figure 5), corresponding to about 5 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 2006 is thus approaching 21 GWh.

FUTURE OUTLOOK

Regarding photovoltaic technology in Switzerland, the broad support of the national PV programme can be expected to continue with an ever-increasing focus on industrial developments, new products for niche markets and ongoing international involvement. For solar cells and modules, the efforts to bring Swiss technology to the market place is expected to materialise in further industrial activity. 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 7th 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 and joint projects will be established in the framework of the PV-ERA-NET project.

With the introduction of the feed-in tariff scheme in 2008, becoming operational in 2009, the next years will be most interesting concerning the domestic market development. On the supply side, new players can be expected, leading to increased competition. On the demand side, stronger marketing activities and end-user orientation will need to take place in order to reach and satisfy new customers. Due to the present limits built in the feed-in tariff scheme, some of the high expectations may not be fulfilled in the short term and the policy debate is expected to continue.