

# SWITZERLAND

## PV TECHNOLOGY STATUS AND PROSPECTS

STEFAN NOWAK, NET NOWAK ENERGY & TECHNOLOGY LTD.

AND STEFAN OBERHOLZER, SWISS FEDERAL OFFICE OF ENERGY (SFOE)



Fig. 1 - Cabane Tracuit. Off-grid alpine hut at 3 256 m. 11 kW PV-façade together with 1 500 Ah battery storage (Photo: Studer Innotec SA).

### GENERAL FRAMEWORK AND IMPLEMENTATION

There is a general consensus in Switzerland that solar photovoltaics will play an important role in the long term future Swiss electricity supply. According to the official scenarios, 10 – 12 TWh should come from photovoltaics by 2050. Compared to the annual national electricity consumption of close to 60 TWh in 2013, this would represent close to 20 % of this value. The Swiss solar industry claims such contributions to be achievable much sooner than 2050.

In 2013, on the levels of Swiss policy and administration, work continued extensively regarding the preparation of the various measures in conjunction with Switzerland's phase-out of nuclear energy decided in 2011 in the framework of the new energy strategy 2050. These measures will have impacts on all levels from research to implementation and use, as well as regarding legislative and normative issues. Before coming into force, there will likely be a public vote on the new energy strategy, expected in 2016.

While the final form of the new energy strategy 2050 and its set of policy measures continue to be defined and shaped, a number of decisions have already been made by the national parliament in view of this strategy. These concern, for instance, an action plan for an increased energy research activity throughout all relevant energy technologies. In 2013, seven national energy research competence centres have been called for, six of which have been decided and established by the end of the year. The goal of these centres is to build up new permanent research capacities and institutional networks in the different technology areas. Alongside this structural measure, important additional financial means have been decided to support research activities in the different areas on the project level. Moreover,

the financial means for pilot and demonstration projects have been further increased, aiming at speeding up the technology transfer from research into industrial processes, products and applications.

On the implementation level, support continues to be provided by a quickly evolving regulatory framework. In 2013, important decisions have been made by the national parliament in view of moderately accelerating the deployment of photovoltaic power systems in the short term, namely up to 2016. These measures are also meant to relieve a long waiting list in the feed-in-tariff scheme and should increase the overall efficiency of the support schemes. By the end of 2013, more than 20 000 systems were on this waiting list. The changes will come into force in early 2014. Besides the feed-in-tariff scheme used since 2009 with decreasing tariffs and increasing shares attributed to photovoltaics, systems between 2 and 10 kW will in the future benefit from a onetime investment subsidy and will not be supported in the feed-in-tariff scheme any longer. Systems between 10 and 30 kW may choose between the investment subsidy and the feed-in-tariff whereas systems below 2 kW will have no support at all at the federal level. Systems of 30 kW and more will continue to benefit from the feed-in-tariff as before. As an additional new element, self-consumption of the electricity produced will be allowed and accounted for.

The development of the photovoltaic sector in Switzerland builds on a strong research and technology base, a diversified industrial activity and, more recently, an acceleration of the market deployment efforts. A comprehensive research programme covers R&D in solar cells, modules and system aspects. The Swiss energy research strategy



Fig. 2 - Farmhouse in Sempach, Switzerland. 171 kW roof-integrated PV system (Photo: Schürch-Egli AG).



Fig. 4 - Migros Logistics Centre, Neuendorf, Switzerland. 5.2 MW on-roof PV system (Photo: Tritec AG).



Fig. 3 - Office building from Flumroc Ltd. PV-façade and on-roof system, 128 kW in total (Photo: Viridén + Partner AG).

is defined by an energy RTD master plan updated every four years. 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) ([www.energy-research.ch](http://www.energy-research.ch)).

Concerning market implementation, the photovoltaic sector in Switzerland further developed in the year 2013, whereas the industrial activities suffered from the capacity and competition issues affecting the global PV industry. Nevertheless, activities in the Swiss PV supply industry remain high with an increasing emphasis on technology development and innovation. R&D activities in the public sector confirm this increasing trend. On the technology front, the key competence centres continued their efforts in their respective domains (solar cells, modules and systems) while increasing their cooperation with industry and on the international level.

The support of the national PV RTD programme can be expected to continue with a focus on innovative research activities, rapid technology transfer, industrial developments, new products for niche markets and ongoing international involvement. Due to the strong Swiss currency, global competition for the heavily export oriented

industry remains an issue. Nevertheless, the efforts to bring Swiss technology to the market place continue. Efforts in the technology development will concentrate on short to medium term market oriented approaches and continuous quality assurance.

The strategy to promote international co-operation on all levels continued, related to activities in the 7<sup>th</sup> Framework Programme of the European Union, the European PV Technology Platform, the IEA PVPS programme and in technology co-operation projects.

With a strong research base in various PV technologies, an ongoing diversified industrial base along the entire value chain, an increasing market deployment activity and an overall favourable policy framework, the signs continue to be positive for an increased role of PV from research over industry all the way to the market.

## NATIONAL PROGRAMME

Switzerland has a dedicated national photovoltaic RTD programme which involves a broad range of stakeholders in a strongly coordinated approach ([www.photovoltaiic.ch](http://www.photovoltaiic.ch)). This national photovoltaic programme focuses on R&D in a system and market oriented approach, from basic research, over applied research, process and product development, pilot and demonstration projects all the way to accompanying measures for market stimulation. On the technical level, thin film, tandem and heterojunction solar cells, their variations and building integration continue to be the topics of highest priority. The programme is organised along the entire value chain and addresses the critical gaps from technology to the market place. Thorough component and system analysis, as well as testing, aim at increasing efficiency and performance. Accompanying measures to raise the quality and reliability of photovoltaic power systems include work on standards and design tools.

## RESEARCH, DEVELOPMENT AND DEMONSTRATION

In 2013, more than 75 projects, supported by various national and regional government agencies, the European Commission and the private sector, were conducted in the different areas of the photovoltaic energy system. Innovative solutions, cost reduction, increased efficiency and reliability, industrial viability and transfer as well as adequate market orientation are the main objectives of the technical R&D.



Fig. 5 - Ski station, Laax, Switzerland. 21 kW PV-façade with CIS modules (Photo: Solarmarkt GmbH).

For solar cells, the main focus remains on thin film solar cells with projects in a wide variety of materials (crystalline silicon, amorphous and microcrystalline silicon, compound semiconductors, dye-sensitised and organic solar cells). Work on thin film silicon at the Swiss Federal Institute of Technology (EPFL) in Neuchâtel is being concentrated on micromorphous solar cells with a particular emphasis on silicon oxide intermediate reflector layers. Significant progress is also being achieved in the area of high-efficiency heterojunction silicon solar cells, reaching efficiencies above the 22 % mark. Industry co-operation has been extended with various companies. In 2013, with important support by the Swiss Confederation, CSEM (Centre Suisse d'électronique et microtechnique) has established a new photovoltaic technology centre in Neuchâtel. The mission of this PV technology centre is to accelerate the transfer of innovative PV technologies to the industry by an increased collaboration and a dedicated infrastructure.

With regard to CIGS solar cells, the Swiss Federal Laboratories for Materials Testing and Research EMPA focuses the work on high efficiency flexible CIGS cells on plastic and metal foils. As a highlight, a new record efficiency of 20,4 % was announced in 2013 for CIGS solar cells on plastic substrates, thus representing a substantial increase of the last record of 18,7 % achieved the year before. This efficiency record is slightly higher than that for CIGS cells on glass and in the range of best multicrystalline silicon solar cells.

For dye-sensitised solar cells, work continues at EPFL on new dyes and electrolytes as well as high temperature stability of the devices. Important progress has been achieved at the Laboratory of Photonics and Interfaces at EPFL concerning perovskite-sensitized solar cells. Using sequential deposition for the formation of the perovskite pigment, solar cell efficiencies of more than 15 % were achieved in 2013 and have since reached values of 17 %. Perovskite-sensitized solar cells have thus demonstrated the steepest efficiency increase in recent years and attract a large interest by the global PV research community.

Organic solar cells are the research subject at the Swiss Federal Laboratories for Materials Testing and Research EMPA, the University of Applied Sciences in Winterthur (ZHAW) as well as at CSEM in the Basel region. In this technical area, CSEM coordinates the large European project Sunflower.

An increasing interest for photovoltaic technology can be observed at various research institutions as well as from industry. In line with the international trend to a broader scientific and technological base, increased activities take place in the fields of nanotechnology, chemistry and numerical modelling.

On the part of application oriented research, emphasis continues to be given to building integrated photovoltaics (BIPV), both for new solutions involving thin film solar cells as well as for new mounting systems and structures for sloped roofs and facades. A dedicated website deals with the topic of BIPV ([www.bipv.ch](http://www.bipv.ch)) and includes information about available products. Related to BIPV systems in the market support schemes, the requirements for the recognition as BIPV systems have been clarified. Various other PV applications on built infrastructure, e.g. ski lifts or snow avalanche protections, have recently been proposed and realised in pilot installations.

As a recent topic rapidly gaining relevance in some countries and regions, grid integration has continued to generate interest and recent projects have extensively analysed the implications of PV on the distribution grid. Methods to considerably increase the share of PV in distribution grids have been identified based on detailed modelling work. High levels of PV penetration in distribution grids are thus no longer considered as insurmountable barriers.

With the ongoing market development, quality assurance and reliability of products and systems, as well as standardisation, continue to be of high priority. The Swiss centres of competence at the Universities of Applied Sciences of Lugano and Burgdorf carefully evaluate products such as PV modules, inverters and new systems.



Fig. 6 – EPFL Campus, Lausanne, Switzerland. 2 MW on-roof PV systems featuring different kinds of technologies (Photo: Romande Energie).

The test infrastructure is continuously expanding and includes the accredited test centre for IEC module certification (Lugano, [http://www.supsi.ch/isaac/swiss\\_pv\\_module\\_test\\_centre.html](http://www.supsi.ch/isaac/swiss_pv_module_test_centre.html)) as well as the largest solar simulator for inverter testing up to 100 kW capacity (Burgdorf, [www.pytest.ch](http://www.pytest.ch)). 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 30 years of operation. Continuous development of system solutions has resulted in a number of industrial products well positioned in the export market.

Work continued on the second prototype of the solar powered airplane SolarImpulse ([www.solar-impulse.com](http://www.solar-impulse.com)) by Bertrand Piccard, André Borschberg and their team. Meanwhile, further flight experience was gained with the first prototype with a flight across the USA. The solar powered boat PlanetSolar ([www.planetsolar.org](http://www.planetsolar.org)), after its tour around the world by solar energy completed in 2012, accomplished the 2013 DeepWater expedition, a scientific mission across the Atlantic ocean contributing to the understanding of the gulf stream relevant for climate research.

International co-operation continues to form a strong pillar of the R&D activities with more than 20 projects running in the 7<sup>th</sup> framework RTD programmes of the European Union during 2013. The co-operation within the IEA PVPS programme has remained a further strategic activity.

Regarding international co-operation on the programme level, the new European SOLAR-ERA.NET project ([www.solar-era.net](http://www.solar-era.net)) coordinated by Switzerland launched its first joint call for projects covering both PV and concentrated solar power (CSP) which had a high resonance in the research community. The response to the call from Swiss R&D groups was good with four full proposals in total, two from PV and two from CSP. The collaboration with the European Photovoltaic Technology Platform ([www.eupvplatform.org](http://www.eupvplatform.org)) continued throughout the year, establishing a new strategy of this relevant European platform.

## INDUSTRY AND MARKET DEVELOPMENT

For a few years, Swiss industrial PV products cover the full value chain starting from materials, production equipment and small scale manufacturing of solar cells, over diverse components and products all the way to system planning and implementation. Due to the fierce competition and the ongoing consolidation in the global PV industry, important changes have taken place in the Swiss PV industry landscape as well. Due to the decreased investment in new production facilities world-wide and slower market growth in Europe, the export volume of Swiss photovoltaic products has somewhat reduced. Due to a strongly growing domestic PV market at the same time, the export share is presently estimated at 50 % of the total turnover.

On the PV industry supply side, different products count among the world leaders. The largest equipment supplier for complete PV module manufacturing lines and advanced PV module technologies continues to be Meyer Burger. Leading wire-sawing machines are also produced by Applied Materials (AMAT) Switzerland. Roth & Rau, largely acquired by Meyer Burger, has intensified its Swiss R&D activities into heterojunction silicon solar cells. Measuring equipment for PV module manufacturers is produced by Pasan (now a part of Meyer Burger Group). Komax, another important player in the module manufacturing chain, has decided to sell its solar business in 2013. Solar plugging systems are offered by Multicontact as well as Huber & Suhner.

Industrial activities evolve in the field of process equipment and products based on thin-film technology. TEL Solar (previously oerlikon solar), while continuing operations throughout 2013, has recently announced to withdraw from the PV module production business. In 2013 also, AMAT and TEL have announced their worldwide merger planned for 2014, leading to one of the most important global suppliers of the semiconductor industry.

Flisom, a company active in the CIGS technology, has announced the funding for a 15 MW pilot production in Switzerland. Flisom continues to work closely with the Swiss Federal Laboratories for

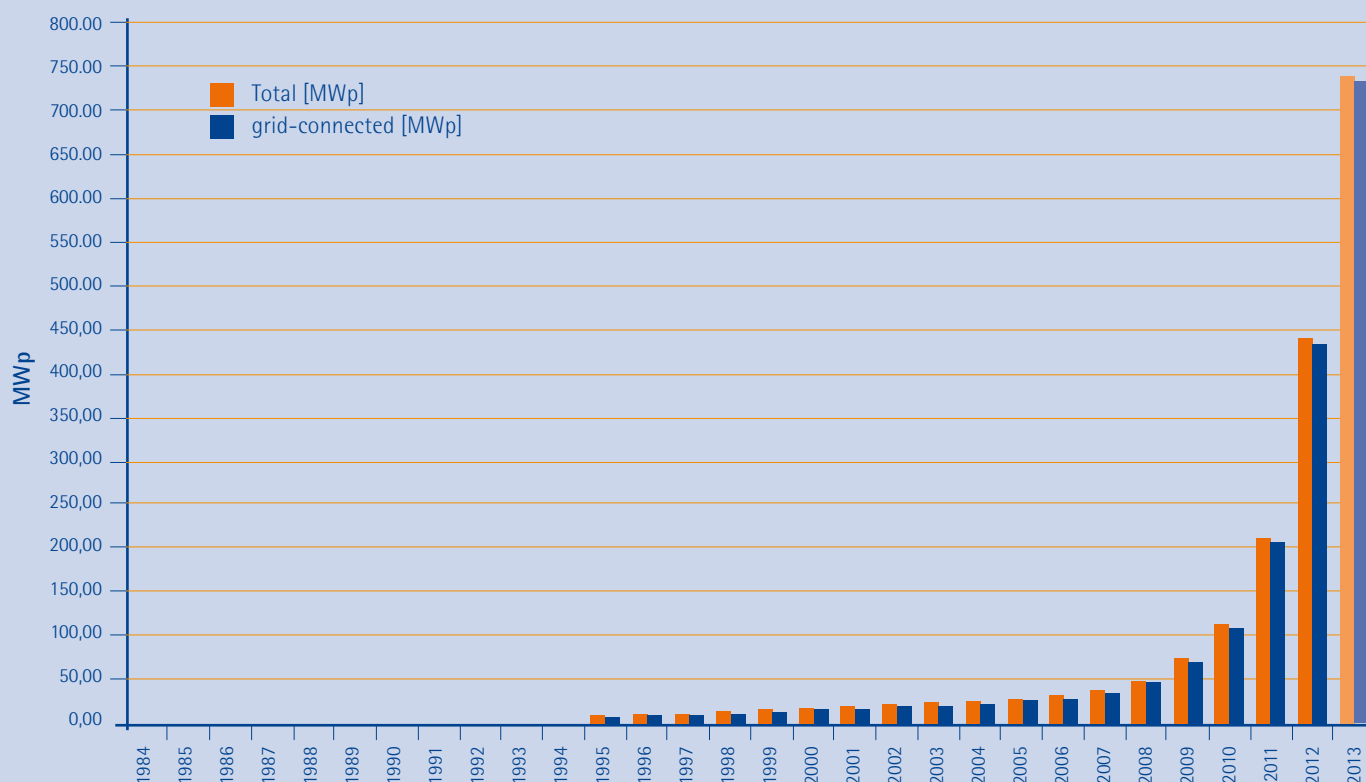


Fig. 7 - Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2013 (total and grid-connected, estimated values for 2013).

Materials Testing and Research EMPA. Further companies are active in the manufacturing of coloured PV modules (swissinsol) and dye-sensitized solar cells (glass to energy, Solaronix).

In the past, inverters have proved to be an export success. Due to the recent slower market development in Europe, this segment has also suffered. Sputnik Engineering produces grid-connected inverters with a capacity of up to 700 MW per year. Studer Innotec has had comparable success with their stand-alone inverters. ABB has entered the inverter market and closed its deal of acquiring the US manufacturer Power One during 2013, thereby becoming a leading inverter supplier.

With an increasing PV capacity being installed in Switzerland, a clear growth of the number of companies as well as that of existing businesses involved in planning and installing PV systems can be observed. 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. System sizes have increased over the past years with up to 5 MW systems being installed on building complexes. Formerly mostly driven by utilities own green power marketing schemes, there has been a strong development in the framework of the new feed-in tariff support scheme in recent years. This PV feed-in tariff distinguishes between three different categories of systems, namely ground based, building applied and building integrated systems (BIPV) for which the highest tariff can be obtained. The

applicable tariff also depends on the size of the PV system. In this way, a differentiated scheme is used which is based on regular market analysis to follow the dynamics of the market. Due to the limited financial volume available within the feed-in tariff for PV systems up to now, many systems could not benefit from the feed-in tariff and are on a waiting list (see also introduction). This has led to a variety of intermediate support schemes by regional governments and utilities, thereby diversifying the possible market support.

The combination of the various support schemes and the increased cost-competitiveness of PV systems have led to an annual market volume for grid-connected systems greater than 300 MWp, thus representing a roughly 40 % market growth compared to 2012. The total installed capacity has thus risen to about 740 MW (Figure 7) corresponding close to 100 W/capita. With this installed capacity, roughly 1 % of the annual national electricity consumption can now be covered by photovoltaics in Switzerland.