SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS

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Fig. 1 - Swissolar Prize Winner 2017: The most powerful PV façade in Switzerland on the F. Hoffmann-La Roche AG's parking garage in Kaiseraugst, Switzerland. This façade system has a total installed capacity of 633 kWp and an estimated production of 473 000 kWh per year (Photo: © BE Netz AG, Ebikon).

GENERAL FRAMEWORK AND IMPLEMENTATION

2017 has been a decisive year for the Swiss energy policy providing for the long-term strategy and general framework for the coming decades. Prepared by the Federal Council, discussed by the two political chambers (National Council and Council of States) over the previous years, a public vote (referendum) on a fully revised energy act was taken in May 2017 as a first measure of the implementation of the "Energy Strategy 2050" (www.energystrategy2050.ch). The key elements of the new Energy Act are a reduction of the total energy consumption by a strong increase in energy efficiency and the promotion of renewable energy. The construction of new nuclear power stations will be prohibited.

The "Energy Strategy 2050" includes photovoltaic power systems as a key pillar of the long-term strategy for the future Swiss electricity supply. In all scenarios, the role of photovoltaics is acknowledged and expected to contribute in the order of at least 10 – 12 TWh to the national electricity supply by 2050 (60 TWh for 2016). The recent deployment trends (1,80 TWh end of 2017) are presently above the long-term scenarios.

During the year 2017, three elements characterized the national regulatory framework for photovoltaic power systems: a onetime investment subsidy for systems up to 30 kW, a feed-in-tariff scheme for systems above 10 kW and, applicable since 2014, measures for self-consumption. As the financial means for the different support schemes have their origin in a fixed levy on the electricity bill, there continues to be a cap on the total amounts available, resulting in a long waiting list for the feed-in-tariff for photovoltaic power systems. Therefore, self-consumption and new business models implemented by utilities and other commercial operators contribute increasingly to the market deployment.

With the entry in force of the new Energy Act by 1st of January 2018, the support schemes for PV systems has changed: the onetime investment subsidy is extended to all sizes of PV systems whereas as the feed-in tariff scheme (feed-in remuneration at cost (KEV)) is gradually replaced by a feed-in remuneration closer to the market requirements. For systems below a capacity of 100 kW, only the onetime investment subsidy will be available. Although the original feed-in tariff support scheme (KEV) can be applied for PV systems up to 2022, due to the long retroactive waiting list, no newly built systems are expected to benefit from the original system.

As a new element, different endconsumers have the possibility to connect together and to act as a collective towards the local energy supplier. This new measure allows for more flexibility for self-consumption and fosters the integration of PV in the local electricity grid.

Among the early actions of the new energy strategy, an action plan for an increased energy research throughout all relevant energy technologies has been launched in 2013. In 2017, the eight national competence centres for energy research (SCCERs) defined under this action plan have started into their second term for the period 2017 – 2020. The goal of these SCCERs is to build up new permanent research and innovation capacities, as well as institutional networks in the different technology areas. In addition to the SCCERs, CSEM (Centre Suisse d'électronique et microtechnique) runs a PV Technology Centre in Neuchâtel with the mission to support technology transfer and industrial development in the area of photovoltaics.

Two complementary national research programmes – NRP 70 "energy turnaround" (www.nfp70.ch) and NRP 71 "Managing Energy Consumption" (www.nfp71.ch) – continued their projects in 2017.

Alongside these structural measures, important additional financial means have been foreseen to support research activities in the different areas on the project level. Moreover, the financial means of the Swiss Federal Office of Energy (SFOE) for pilot and demonstration projects remain at a high level, aiming at speeding up the technology transfer from research into industrial processes, products and applications.

The development of the photovoltaic sector in Switzerland builds on a strong research and technology base, a diversified industrial activity and a continuous development of the market deployment efforts. A comprehensive research programme covers R&D in solar cells, modules and system aspects. The Swiss energy research strategy is defined by an energy RTD master plan updated every four years with a new period covering the years 2017 – 2020. The master plan developed by the Federal Commission for Energy Research (CORE) in cooperation with the SFOE is based on strategic policy goals (energy & environment, science & education, industry & society) (www.energy-research.ch).

NATIONAL PROGRAMME

Switzerland has a dedicated national photovoltaic RTD programme which involves a broad range of stakeholders in a strongly coordinated approach. The SFOE research programme Photovoltaics 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 accompanying measures for market stimulation. The programme is organised along the entire value chain and addresses the critical gaps from research over 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.

The strategy to promote international co-operation on all levels continued, related to activities in the Horizon 2020 Programme of the European Union, the European PV Technology and Innovation Platform, the European SOLAR-ERA.NET Network, the IEA PVPS programme and in technology co-operation projects. The new SOLAR-ERA.NET (www.solar-era.net) Cofund Programme, coordinated by Switzerland, executed a new joint call, again covering both PV and concentrated solar power (CSP). Within the IEA PVPS Programme, Switzerland presently leads Task 9 Deploying PV Services for Regional Development and in 2017 the newly established Task 16 Solar Resource for High Penetration and Large Scale Applications (co-lead) (see this report p.15 and p.40).

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In 2017, more than 60 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 research efforts.

In the field of solar cell research, priorities lie on heterojunction structures and passivating contacts for high-efficiency crystalline silicon solar cells as well as on different thin-film solar cell technologies for building integration, in particular CIGS cells. Perovskite solar cells and tandem cells with these are increasingly being investigated. Further downstream, new approaches for building and grid integration are being developed and tested in pilot and demonstration projects.

Work at the Swiss Federal Institute of Technology (EPFL) and the CSEM PV Technology Centre in Neuchâtel have focussed on heterojunction and passivating contacts for high-efficiency crystalline silicon solar cells. As part of the activities related to passivating contacts, new process steps (e.g. thermal annealing and selective front side contacts) compatible with industry practice were successfully explored.

On the more fundamental R&D side, in a recent project on perovskite / silicon heterojunction tandem structures, 22,7 % monolithic tandem cells and 25,6 % 4-terminal tandem cells were achieved. Another highlight of the photovoltaic research at CSEM in Neuchâtel in collaboration with the NREL in the United States was the demonstration of a new one-sun record conversion for tandem solar cells of 32,8 % achieved with a gallium indium phosphide / crystalline silicon solar cell. The Neuchâtel PV group extended its cooperation with PV and other industries.

With regard to CIGS solar cells, the Swiss Federal Laboratories for Materials Testing and Research (Empa) have continued their work focussed on flexible CIGS cells on plastic and metal foils. As for silicon solar cell research, the efforts are directed both to increased efficiency as well as industrial implementation. The work aimed for development of novel strategies to reduce non radiative recombination mechanism in order to improve the photovoltaic parameters in CIGS solar cells towards 25 % power conversion efficiency. To do so, novel passivation strategies for bulk and especially interfaces have been explored. On the way towards industrial implementation of flexible CIGS solar cells, cooperation continued with the company Flisom which is commissioning a 15 MW pilot production plant.

For dye-sensitised solar cells, work continues at EPFL on new dyes and electrolytes as well as high temperature stability of the devices. Further rapid progress has been achieved at the Laboratory of Photonics and Interfaces at EPFL concerning perovskite-sensitized solar cells.

On the part of application oriented research, emphasis continues to be given to building integrated photovoltaics (BIPV), both for new solutions involving different solar cells as well as for new mounting systems and structures for sloped roofs and facades. Using new approaches and designs for surface appearance and coloured PV modules, a number of new pilot projects have made good progress in 2017. Using coloured, crystalline silicon-based modules, PV systems in heritage protected zones are starting to be realised (Fig. 2), thereby providing opportunities for applications in critical zones. As part of the analysis of such systems, the losses in energy yield using different technologies to create the colour appearance are being assessed.

Fig. 2 - A southwest view of the PV installation on a farm house in Ecuvillens, Fribourg, Switzerland. With their terracotta appearance, these innovative PV roof tiles provide a perfect integration into the townscape (photos: © CSEM & © ISSOL).

As a recent topic rapidly gaining relevance in some countries and regions, grid integration has continued to generate interest and innovative projects have extensively analysed the implications of PV on the distribution grid. Through detailed modelling work, methods to considerably increase the share of PV in distribution grids have been identified. Based on these more theoretical studies, new pilot projects have started investigating different approaches and experiences with high penetration PV in various grid configurations. 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 Southern Switzerland (SUPSI) and Bern (www.pvtest.ch) carefully evaluate products such as PV modules, inverters and new systems. A number of further Universities of Applied Sciences (e.g. ZHAW Winterthur, Wädenswil, Rapperswil) have developed their PV system infrastructure and analysis. 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. During 2017, all Universities of Applied Sciences with PV related activities have met in a workshop to explore cooperation opportunities, in view of strengthening the applied research base from components to systems and applications.

INDUSTRY AND MARKET DEVELOPMENT

Swiss industrial PV products cover a large part of the PV value chain starting from materials, production equipment and small scale manufacturing of solar cells and modules, over diverse components and products all the way to system planning and implementation. A broad range of competitive technologies, products and services are offered to the growing PV market, both domestically and abroad.

The company Meyer Burger, one of the largest equipment suppliers for complete PV module manufacturing lines and advanced PV module technologies, continued its efforts in advanced solar cell technology (silicon heterojunction, smart wire, glass-glass modules). Other technology companies active in the supply of equipment for solar cell manufacturing include Indeotec and Evatec.

Flisom, a company active in CIGS thin film technology on flexible substrates, has progressed with the implementation of a 15 MW pilot production of flexible CIGS modules in Switzerland. For this purpose, Flisom continues to work closely with Empa. After a short time of start-up of individual tools and setting of process parameters cells with efficiencies around 14 % have been achieved and process optimization on the large area started. A first product received the IEC certification early in the project and modules of 3 m length are undergoing IEC certification. In 2017 shipment of first product started in small numbers.

Small production facilities for PV modules are operated by Megasol, Meyer Burger and Sunage. Different companies are active in the manufacturing of coloured PV modules by various techniques, e.g. Swissinso, Solaxess and Üserhuus, as well as for dye-sensitized solar cells, e.g. H.Glass (formerly glass-2-energy) and Solaronix. Measuring equipment for PV module manufacturers is produced by Pasan (a part of Meyer Burger Group). Solar cabling and plugging systems are offered by Huber & Suhner, Leoni Studer and Stäubli Electrical Connectors (formerly Multi-Contact). A number of companies work on mounting systems such as Designergy, dhp technology, Montavent or Schweizer Metallbau.

Based on the US company Power One, ABB is now a leading worldwide inverter supplier. ABB is further active in the technologies for PV grid integration. Studer Innotec continues as a leading producer of stand-alone and grid-tied inverters, increasingly combined with storage units for self-consumption.

Fig. 3 - PV System at Philip Morris in Onnens, Switzerland. The entire system (mounted on several roofs) is presently the largest PV installation in Switzerland; with a capacity of 8,3 MWp, it produces approximately 8 GWh of solar power per year (Photo: © aventron AG).

Alongside 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 to multi-megawatt installations on building complexes (e.g. 8,3 MW at Philipp Morris premises in Onnens, Fig. 3).

The annual market volume for grid-connected systems is estimated at 260 MWp for 2017, about the same as for 2016. The total installed capacity by the end of 2017 has risen to above 1,9 GW (Fig. 4) approaching about 240 W/capita. With this installed capacity, close to 3 % of the annual national electricity consumption can now be covered by photovoltaics in Switzerland, which ranks PV number two in renewable electricity sources in Switzerland after hydropower.

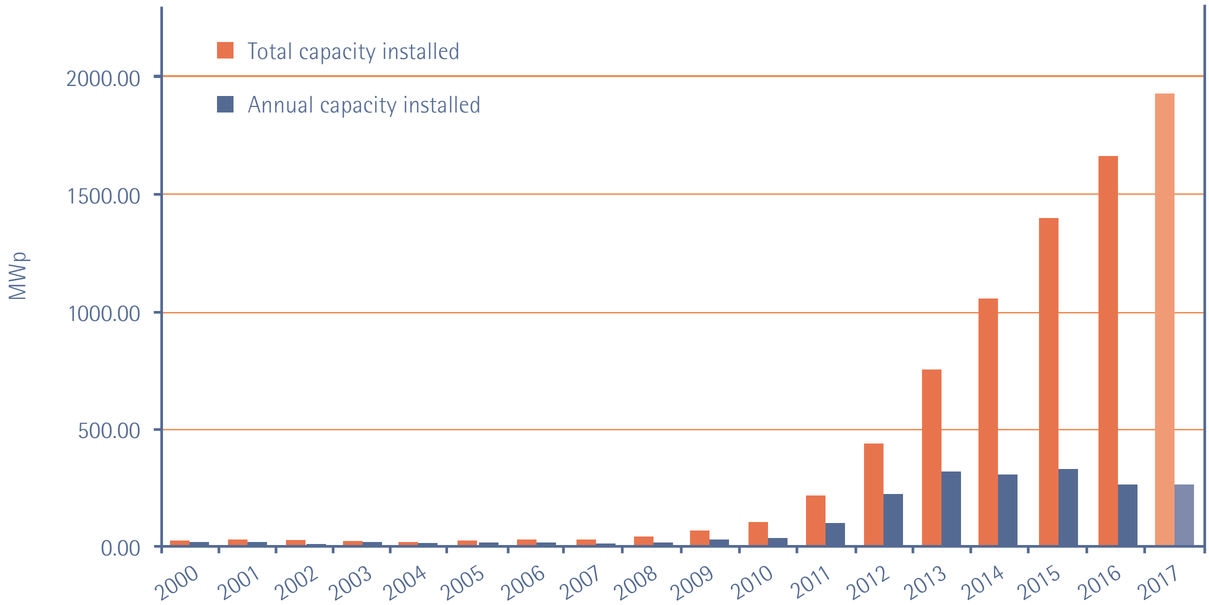

Fig. 4 – Evolution of the installed photovoltaic capacity in Switzerland since the year 2000 (total and annual installed capacity, estimated values for 2017).