SWITZERLAND

PV TECHNOLOGY STATUS AND PROSPECTS

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Fig. 1 - Solar Impulse on a test flight over Abu Dhabi, a few days before take-off for the world tour (Photo: ©Solar Impulse).

GENERAL FRAMEWORK AND IMPLEMENTATION

Photovoltaic power systems continue to form 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 2015). The recent deployment trends (1,15 TWh end of 2015) are presently above the long term scenarios and underline that such contributions appear as feasible and possibly well before 2050.

In 2015, on the levels of Swiss policy and administration, work continued 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. 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.

Among these, an action plan for an increased energy research activity throughout all relevant energy technologies has been launched and implemented. Building on existing research activities, eight new national competence centres for energy research (SCCERs) have taken up their activities during 2014 and are now fully operational. The goal of these centres is to build up new permanent research and innovation capacities and institutional networks in the different technology areas. In addition to the SCCERs, CSEM (Centre Suisse d'électronique et microtechnique) recently established 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) – started their projects in 2015. 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 for pilot and demonstration projects have been further increased, 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, 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 is defined by an energy RTD master plan updated every four years. The master plan developed by the Federal Commission for Energy Research

Fig. 2 - Self-consumption 658 kW PV system on a MIGROS supermarket with bifacial glass-glass modules, Schönbühl (Photo: Genossenschaft Migros Aare).

Fig. 3 - Inauguration of the Flisom 15 MW flexible CIGS module pilot line in Niederhasli (Photo: Flisom AG).

(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).

On the implementation level, three elements characterize 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, 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 particularly 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 (Figure 2).

With a strong research base and leading activities 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.photovoltaic.ch). 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. SOLAR-ERA.NET (www.solar-era.net) is coordinated by Switzerland and continued in 2015 with a third joint call covering both PV and concentrated solar power (CSP) which again had a high resonance in the research community.

RESEARCH, DEVELOPMENT AND DEMONSTRATION

In 2015, more than 70 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. On the technical level, the topics of priority are silicon heterojunction cells, passivating contacts for high-efficiency crystalline silicon solar cells as well as different thin-film solar cell technologies for building integration. New concepts such as 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. On the more fundamental R&D side, in a recent project on perovskite tandem structures, a perovskite silicon tandem solar cell of 21 % efficiency was presented. Another highlight of the photovoltaic research at CSEM in Neuchâtel was achieved in collaboration with NREL in the United States: A dual junction gallium indium phosphide / crystalline silicon solar cell achieved a record efficiency of 29,8 %. 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 high efficiency 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. A new, more fundamental project explores the route towards 25 % efficiency CIGS solar cells. On the way towards industrial implementation, cooperation continued with the Flisom company which has inaugurated a new 15 MW pilot production plant in 2015 (Figure 3).

Fig. 4 - New 70 kW PV façade at the CSEM building in Neuchâtel (Photo: CSEM SA).

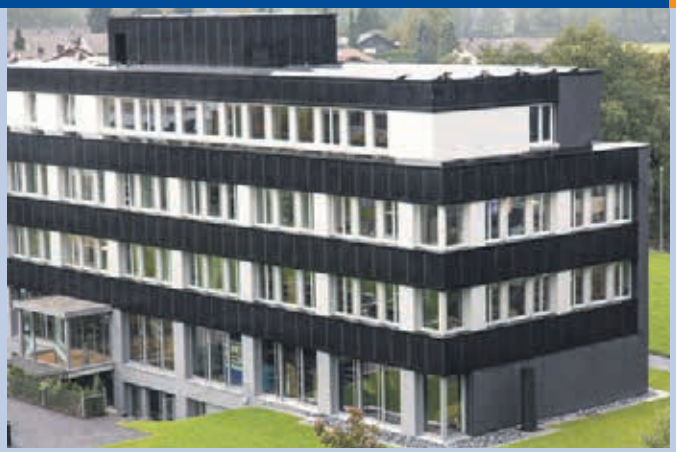

Fig. 5 - PV rooftop and façade systems on an office building in Flums (Photo: © NET Ltd. / DanielForster.com).

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 which have reached solar cell efficiency values of 21 % (world record).

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 2015, the EU project TREASORES led by EMPA was concluded. The project concerned the cheaper production of large area organic electronics and focussed on developing materials and processes compatible with roll-to-roll processing technology – in particular transparent electrodes, barrier foils and encapsulation layers.

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 started to test these new technologies.

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. Methods to considerably increase the share of PV in distribution grids have been identified based on detailed modelling work. 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, Rapperswil, Wädenswil) have strengthened 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.

The solar powered airplane SolarImpulse (www.solarimpulse.com) by Bertrand Piccard, André Borschberg and their team has undertaken the attempt for their first round the world flight between March and June 2015. Taking off from Abu Dhabi (Figure 1), the plane has successfully flown to India, China, Japan and Hawaii. The record flight from Japan to Hawaii was the longest and most challenging one, bringing the technologies to their ultimate limits and covering a distance of more than 7 000 km in 118 hours of uninterrupted flight.

INDUSTRY AND MARKET DEVELOPMENT

Swiss industrial PV products cover the full 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. After the consolidation period related to the global PV industry development of the past years, the signs increase that the Swiss PV industry is overcoming this difficult period, based on new competitive technologies and products which very much relate to recent technology innovations.

The largest equipment supplier for complete PV module manufacturing lines and advanced PV module technologies continues to be Meyer Burger. The company increased its efforts in advanced solar cell technology (silicon heterojunction, smart wire, glass-glass modules) and further developed a silicon heterojunction solar cell pilot production line together with CSEM. The pilot line has a production capacity of 600 kilowatts from which heterojunction manufactured cells are built into modules and tested in both the laboratory and in the field (Figure 4). The target upon further process optimisation is to reach a PV module efficiency of 21 % with a production cost below 0,6 CHF/Wp. After commissioning of the pilot line, first promising results have been achieved. Measuring equipment for PV module manufacturers is produced by Pasan (a part of Meyer Burger Group).

Another company in the PV industry supply area is Evatec which is active in thin film technology, namely PVD systems for antireflection coatings and back side metallization of crystalline silicon solar cells. Moreover, solar plugging systems are offered by Multicontact as well as Huber & Suhner.

Flisom, a young company active in CIGS thin film technology, has inaugurated its facilities for a 15 MW pilot production of flexible CIGS modules in Switzerland. The targets of the pilot line are certified 1 m wide flexible CIGS modules with 12 % efficiency. Flisom continues to work closely with the Swiss Federal Laboratories for Materials Testing and Research EMPA. Further companies are active in the manufacturing of coloured PV modules (swissinso) and dye-sensitized solar cells (glass 2 energy, Solaronix).

Based on the US company Power One, ABB has strengthened its business in the inverter market and is 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.

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 (Figure 5). System sizes have increased over the past years with up to 5 MW systems being installed on building complexes.

There has been a strong development in the framework of the different support schemes in recent years which were formerly mostly driven by utilities own green power marketing schemes. Depending on size and type of the PV system, different support conditions apply. Moreover, in order to compensate for the long waiting list for the feed-in-tariff, intermediate support schemes by regional governments and utilities have diversified 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 estimated to at least 300 MWp, which represents about the same market size as for 2014. The total installed capacity by the end of 2015 has risen to above 1,3 GW (Figure 6) corresponding to about 160 W/capita. With this installed capacity, more than 2 % 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 hydro power.

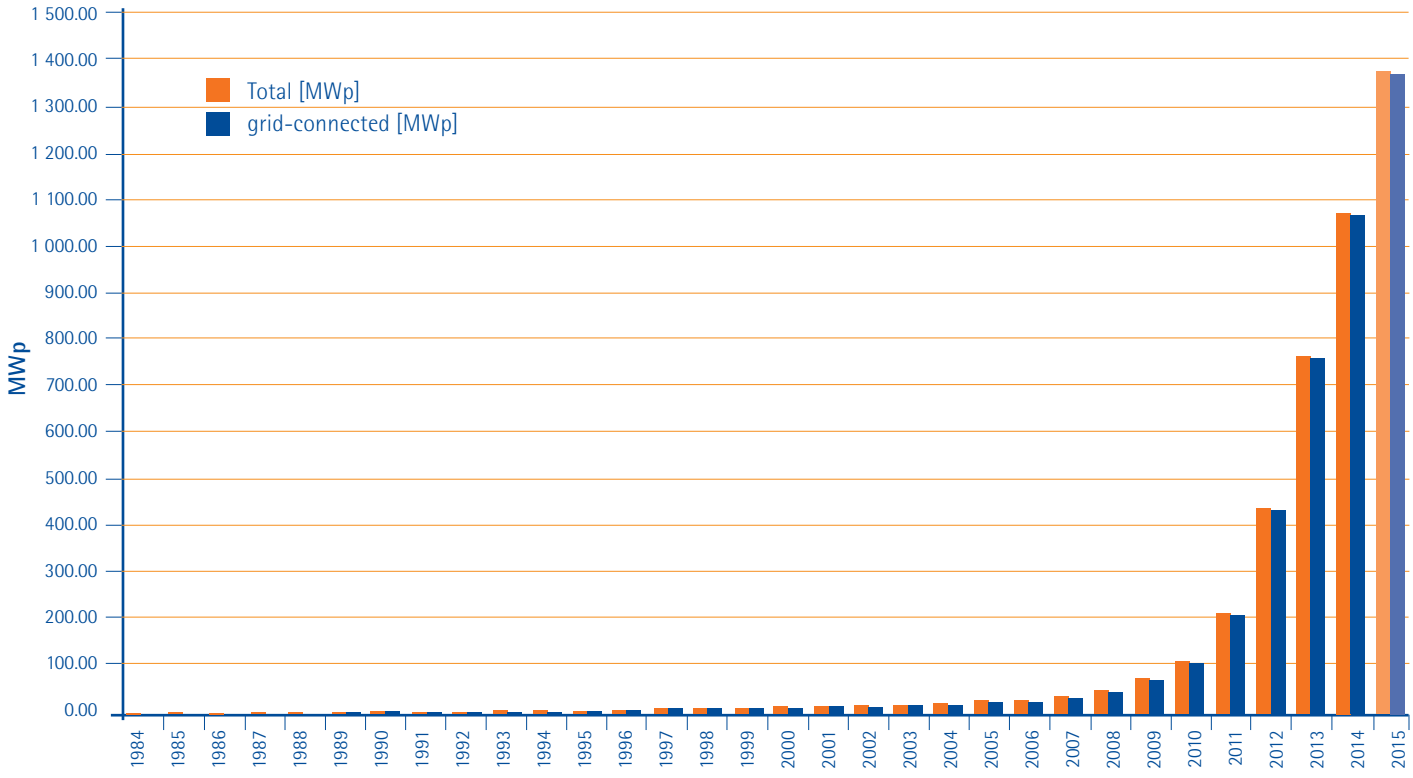

Fig. 6 – 30 years of PV in Switzerland: Evolution of the installed photovoltaic capacity in Switzerland between 1984 and 2015 (total and grid-connected, estimated values for 2015).