IEA INTERNATIONAL ENERGY AGENCY

National Survey Report of PV Power Applications in Switzerland 2015

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Prepared by

Pius Hüsser, Nova Energie GmbH

6. 7. 2016 PH

TABLE OF CONTENTS

Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organisation for Economic Co-operation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its member countries

The IEA Photovoltaic Power Systems Technology Collaboration Programme (IEA-PVPS) is one of the collaborative R & D agreements established within the IEA and, since 1993, its participants have been conducting a variety of joint projects in the applications of photovoltaic conversion of solar energy into electricity.

The participating countries and organisations can be found on the www.iea-pvps.org website.

The overall programme is headed by an Executive Committee composed of one representative from each participating country or organization, while the management of individual Tasks (research projects / activity areas) is the responsibility of Operating Agents. Information about the active and completed tasks can be found on the IEA-PVPS website www.iea-pvps.org

Introduction

The objective of Task 1 of the IEA Photovoltaic Power Systems Programme is to promote and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of PV power systems. Task 1 activities support the broader PVPS objectives: to contribute to cost reduction of PV power applications, to increase awareness of the potential and value of PV power systems, to foster the removal of both technical and non-technical barriers and to enhance technology co-operation. An important deliverable of Task 1 is the annual "*Trends in photovoltaic applications*" report. In parallel, National Survey Reports are produced annually by each Task 1 participant. This document is the country National Survey Report for the year 2015. Information from this document will be used as input to the annual Trends in photovoltaic applications report.

The PVPS website www.iea-pvps.org also plays an important role in disseminating information arising from the programme, including national information.

1 INSTALLATION DATA

The PV power system market is defined as the market of all nationally installed (terrestrial) PV applications with a PV capacity of 40 W or more. A PV system consists of modules, inverters, batteries and all installation and control components for modules, inverters and batteries. Other applications such as small mobile devices are not considered in this report.

For the purposes of this report, PV installations are included in the 2015 statistics if the PV modules were installed and connected to the grid between 1 January and 31 December 2015, although commissioning may have taken place at a later date.

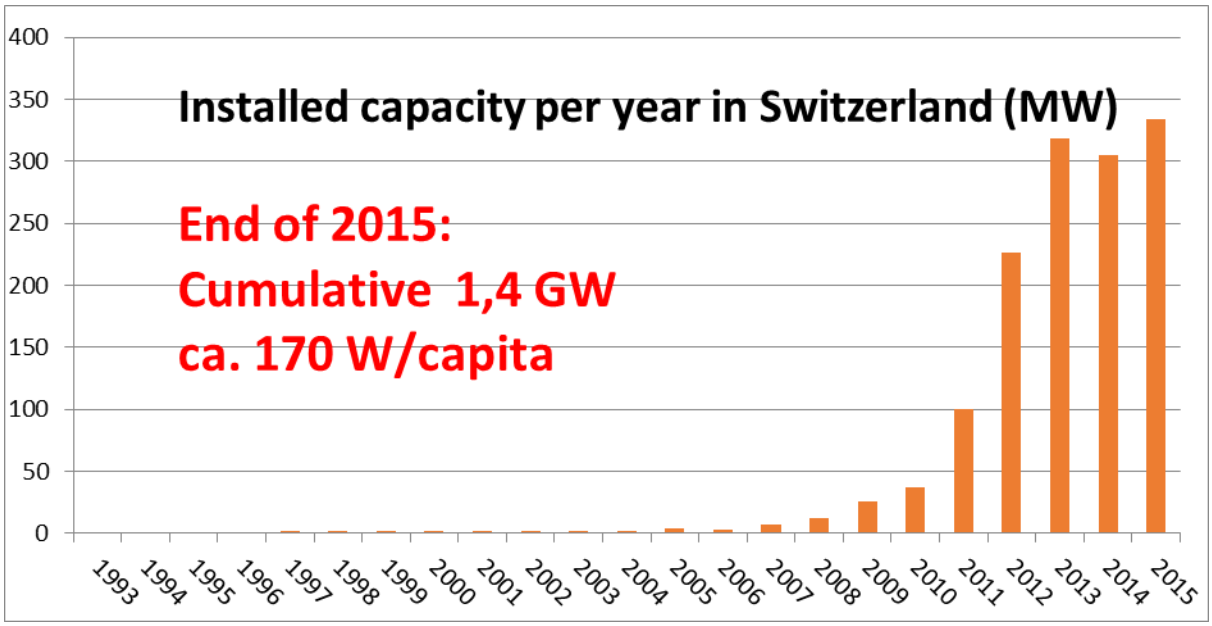
1.1 Applications for Photovoltaics

2015 the Swiss market stabilized on a record high level of more than 330 MW (approx. 40 W / capita).

Also some large plants by Swiss standards of more than 5 MW have been installed the market shifted to installations below 30 KWp. This is mainly driven by the subsidy scheme which is split in direct subsidies for installations below 30 kWp and no waiting list and a FiT scheme with a very long waiting list and even very small chances to get an approval bevor the parliament may stop the FiT subsidy scheme in about 6-8 years.

The installed capacity of almost 1,4 GW by the end of 2015 will approximately produce 2,5% of Switzerland's electricity demand in 2016.

Self-consumption has become an important marked driver for residential as well as commercial sized systems. Depending on tariff conditions for grid costs as well as energy buy back tariffs some DSO[1] allow the operation of PV systems to be profitable for the time being.



[1] In Switzerland almost 700 DSO distribution system operators are active. Some of them are very small on serving only some hundreds of costumers, others like the utility of Zurich (ewz) serving almost half a million people.

1.2 Total photovoltaic power installed

On behalf of the federal office of energy, Swissolar, the solar professional association does each year a survey of sold modules and installed PV systems among the distributers and installers in Switzerland. These aggregated data are compared with the amount of installations > 30 KVA which, by law, should be registered by the Federal Inspectorate for Heavy Current Installations ESTI . Unfortunately the size of the installations are not registered yet thus only the approx.. amount of systems > 30 kVA being commissioned in 2015 is known. Besides this, PV systems > 30 kVA should also be registered in the certificate of origin database (HKN Herkunftsnachweis-Register). Since there are still some delays in the registering process, the reliability of these register is not granted yet. The situation has been improved in 2015 and about 85% of the installed capacity is now registered in the HKN database.

Table 1: PV power installed during calendar year 2015

AC			**MW installed in 2015**	**MW installed in 2015**	**DC**
Grid-connected	BAPV	Residential* *<30kW$_{DC}$	Approx. 85%	Approx. 120 – 150 MW	MW/y
		Commercial*	>98	70 – 90 MW	
		Industrial* > 250 kW$_{DC}$	>99%	70 – 90 MW	
	BIPV	Residential*	Approx. 15%	Approx 20 MW	MW/y
		Commercial*		Approx.. 5 MW	
		Industrial* > 250 kW$_{DC}$	<2% <1%	0	
	Ground-mounted	cSi and TF	2%	6	MW/y
		CPV	0	0	
Off-grid		Residential	0		
		Other	100%	0,15	
		Hybrid systems	0		
		Total	**333 MW**		

*Best estimate based on FiT registered installations 2015

Table 2b: PV power installed during calendar year 2015 – System size

System size (kW)	Numbers of Systems 2015	capacity installed 2015 (MW)
<4	931	2 600
4 - 20	5673	50 500
20 - 30	1315	33 000
30 - 50	369	12 300
50 - 100	921	36 400
100 - 1000	672	164 300
>1000	17	33 900

*Market Survey Solar Power 2015, June 2016, Swiss Federal Office of Energy

Table 2: Data collection process:

<table>
<tr><td>Data are collected in DC</td><td></td></tr>
<tr><td>

- The data collection process is done by Swissolar on behalf of the Swiss government.
- It is based on a questionnaire sent to all importers, installers and manufacturers. It is estimated, that about 85% of the market is covered with this survey.
- To validate the data, there is a compulsory registration for systems above 30 kVA since the beginning of 2013 (Guarantees of origin and electricity labelling). Unfortunately, not all PV systems have been registered up to now.
- The report has been published by the Swiss Federal Office of Energy in June 2015 and also serves as a base for the annual renewable energy statistics.

</td><td> 
</td></tr>
<tr><td>Link to the Swiss Federal Office of Energy www.bfe.admin.ch

Electricity Statistics 2015 (DE/FR):
http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_883496391.pdf

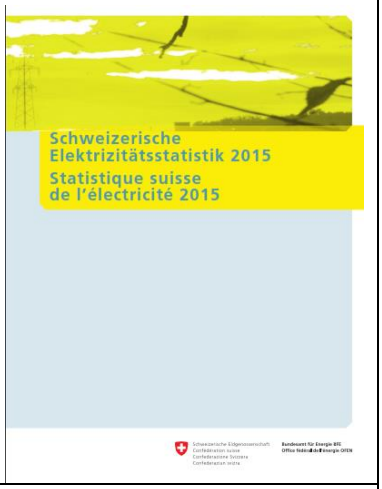
Overall Energy Statistics 2014:
http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_208577679.pdf</td><td> 
</td></tr>
<tr><td>The quality and accuracy of the data is expected to be around +- 10%.</td><td></td></tr>
</table>

Table 3: PV power and the broader national energy market.

MW-GW for capacities and GWh-TWh for energy	2015 numbers	2014 numbers	2013 Numbers
Total power generation capacities (all technologies)	Approx. 19,6 GW	Approx. *19,1 GW*	Approx. 18,7 GW
Total power generation capacities (renewables including hydropower)	Approx. 15,6 GW	Approx. 15,1 GW	Approx. 14,7 GW
Total electricity demand (= consumption)	58,2 TWh	57,5 TWh	59,3 TWh
New power generation capacities installed during the year (all technologies)	Approx. 0,5 GW new RES	Approx. 0,4 GW RES and very few Co-Generation plants	0,4 GW
New power generation capacities installed during the year (renewables including hydropower)	Approx. 0,5 GW new RES incl. 330 MW of PV	Approx. 0,4 GW RES very few Co-Generation plants	0,4 GW
Total PV electricity production in GWh-TWh	Approx. 1 120 GWh	Approx. 850 GWh	544 GWh
Total PV electricity production as a % of total electricity consumption	1,9%	1,4%	0.9 %

Table 4: Other informations

	2015 Numbers
Number of PV systems in operation in your country	**Approx. 50 000** **Split in market segments see below**
Capacity of decommissioned PV systems during the year in MW	0
Total capacity connected to the low voltage distribution grid in MW	Approx. 95% Normally up to 1 MVA can be connected to the low voltage grid
Total capacity connected to the medium voltage distribution grid in MW	Approx. 5%
Total capacity connected to the high voltage transmission grid in MW	0%

Table 4a: PV systems - market segmentation (numbers)*

Type of system	2015 Newly added	2014 Newly added	2015 Cumulated
single family homes:	**6300**	**5 136**	**28 000**
apartment buildings:	**868**	**817**	**4 200**
Industrial buildings	**957**	**768**	**7 200**
Farm houses	**1216**	**987**	**6 500**
Commercial buildings	**153**	**168**	**800**
Municipal & state owned buildings	**343**	**280**	**2 600**
Traffic infrastructure and buildings	**2**	**23**	**85**
others:	**59**	**2**	**290**
Total:	**9898**	**8 181**	**49 844**

*Market Survey Solar Power 2015, June 2016, Swiss Federal Office of Energy

Picture © Schweizer Solarpreis 2015

Table 5: The cumulative installed PV power in 4 sub-markets.

	Cumulative installed capacity DC as of 31 December (kW)																							
Sub-market	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Stand-alone domestic	1 540	1 675	1 780	1 940	2 030	2 140	2 210	2 300*	2 390*	2 480*	2 570*	2 740*	2 810*	2 930*	3 050*	3 200*	3 800	4 000	4 100	4 200	4 MW	4 MW	4 MW	4 MW
Stand-alone non-domestic	70	100	112	143	162	184	190	200*	210*	220*	230*	260*	290*	320*	350*	400*								
Grid-connected distributed	2200	2900	3 600	4 050	4 850	5 950	7 630	9 420	11 220	13 340	15 140	16 440	18 440	21 240	23 740	30 040	41 540	67 040	104 140	206 700	433 MW	752MW	1 057 MW	1390 MW
Grid-connected centralised	900	1 100	1 200	1 350	1 350	1 450	1 470	1 480	1 480	1 560	1 560	1 560	1 560	2 560	2 560	2 560	2 560	2 560	2 560					
TOTAL (kW)	4 710	5 775	6 692	7 483	8 392	9 724	11 500	13 400	15 300	17 600	19 500	21 000	23 100	27 050	29 700	36 200	47 900	73 600	110 900	211 100	437 MW	756 MW	1 061 MW	1394 MW

- Swiss PV market increased by 9% in 2015 to 333 MW newly installed capacity (40 W/capita). Although the capped FIT scheme only contributed marginally to this new record in annual installed capacity, the direct subsidy scheme, introduced in 2014 helped to support the market remarkably.
- Besides a large ground mounted system (>6MW) the market shifted towards smaller installation due the direct subsidies only eligible for system sizes below 30 kW(DC).

2 COMPETITIVENESS OF PV ELECTRICITY

2.1 Module prices

The market for modules and other components was quite stable in 2015. Due to the change in exchange rate to the Euro and other currencies in January 2015 (The Swiss National Bank (SNB) is discontinuing the minimum exchange rate of CHF 1.20 to the Euro on January 15th 2015).

On the other side, due to a smaller European PV market in relation to the rest of the world, also the Swiss market has not the highest priority by the manufacturer in China and elsewhere.

Table 6: Typical module prices for a number of years

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015[1]
Standard module price for small systems in the range of 3 to 10 kWp	4.30	4.80	5.20	5.00	5.00	3.80	3.60	2.50	1.30*	1.00*	0.95*	0.90*
Avarage price, large systems (> 100 kWp)	4.10	4.60	5.00	4.80	4.80	3.30	2.20	1.30	0.85*	0.80*	0.57**	0.55**

[1] Positive effect on costs due to stronger Swiss currency

*Source: Der Photovoltaik-Markt: Marktbeobachtung 2016, Februar 2016, Bundesamt für Energie

** Estimation based on several offerings for small and large systems in 2015

2.2 System prices

Table 7: **Turnkey Prices of Typical Applications – local currency**

Category/Size	Typical applications and brief details	Current prices per W (CHF)
OFF-GRID Up to 1 kW	Holiday houses, traffic control and many other applications	6.00 to 15.00
OFF-GRID >1 kW	Alpine huts, alpine dairies Maximum size for large alpine huts in the range of 10 to 20 kW	4.00 to 12.00
Grid-connected Rooftop up to 10 kW (residential)	Roof mounted (BAPV)	2.50 to 4.00*
Grid-connected Rooftop from 10 to 250 kW (commercial)	Roof mounted (BAPV)	1.50 to 3.00*
Grid-connected Rooftop above 250kW (industrial)	Industry or public buildings (BAPV)	1.30– 1.80*
Grid-connected Ground-mounted above 1 MW	No market in Switzerland	n/a
Other category (hybrid diesel-PV, hybrid with battery…)	Hybrid system with hybrid modules (PV and solar thermal).	n/a (Pilot stage)

* Estimation based on several offerings for small and large systems in 2015

Table 8: National trends in system prices (current) for different applications – local currency

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
10-20 kW	13.00	13.00	12.50	11.80	11.00	10.40	10.20	10.10	9.90	9.40	9.20	8.40	7.50	8.5	9.00	9.10	8.70	7.25	6.50	4.5	3.50	3.25	2.50 - 3.50	2.20 – 3.50
3-4 kW	13.40	13.30	13.20	12.80	12.60	12.30	12.30	11.90	12.50	12.20	11.00	9.25	9.10	10.00	10.0	9.65	9.80	8.80	7.00	6.50	5.00	4.50	4.00 - 5.00	3.00 – 5.00

The standard size for single family houses, for many years in the range of 2 to 4 kW, increased considerably in the last few years to a range of 5 to 15 kW. The specific costs for systems of 3 kW or less thus remained comparatively high due to fixed costs, such as administration (grid connection), security issues while working on a roof, etc.

The direct subsidy scheme for installations up to 30 kW_{DC} has also a certain effect on prices paid for smaller PV systems (Less pressure on costs).

Source: Der Photovoltaik-Markt: Marktbeobachtung 2016, Februar 2016, Bundesamt für Energie

2.3 Cost breakdown of PV installations

The cost breakdown for PV systems is based on offers comparison, market experience, studies published by the federal office of energy. It has to be noted that each installer has its one way of offering a PV system. At the end, only the overall costs are important and will be compared among competitors. Some installers put a higher margin on the modules, other charge more for the labor costs etc.

2.3.1 Residential PV System < 10 kW

Table 9: Cost breakdown for a residential PV system – local currency

Cost category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module	0.90	0.60	1.20
Inverter	0.25 - 0.40		
Other (racking, wiring…)	0.20 – 0.60		
Soft costs			
Installation	0.40 – 1.00		
Customer Acquisition	5% to 10% of overall costs		
Profit	5% to 10% of overall costs		
Other (permitting, contracting, financing…)	n/a (very small)		
Subtotal Hardware	1.80	1.30	2.20
Subtotal Soft costs	1.00	0.80	1.50
Total	2.80	2.10	3.70

2.3.2 Utility-scale PV systems > 1 MW

Table 10: Cost breakdown for an utility-scale PV system – local currency

Cost category	Average (local currency/W)	Low (local currency/W)	High (local currency/W)
Hardware			
Module	0.60	0.50	0.70
Inverter	0.15 - 0.25		
Other (racking, wiring…)	0.15 – 0.30		
Soft costs			
Installation	0.25 – 0.50		
Customer Acquisition	5% of overall costs		
Profit	5% of overall costs		
Other (permitting, contracting, financing…)	n/a (very small)		
Subtotal Hardware	1.00	0.80	1.20
Subtotal Soft costs	0.40	0.35	0.60
Total	1.40	1.15	1.80

2.4 Financial Parameters and specific financing programs

Table 11: PV financing scheme

Type of system	Average Cost of capital (Interest rate)
Residential systems are mainly financed by increasing the mortgage	0.8% - 1.5 %
PV on commercial buildings owned and operated by the building owners also obtain low interest mortgages	1% - 3.0 %
Third party investors on rented roofs have to pay higher interest rates, depending also on the bankability of the project and the credibility of the investor	1.5% - 5%

2.5 Specific investments programs

Third Party Ownership (no investment)	Practically not existing in Switzerland
Renting	n/a
Leasing	n/a
Financing through utilities	Very small share of the market, mainly by only renting the roof
Investment in PV plants against free electricity	No market
Crowdfunding (investment in PV plants)	No market
Other (please specify)	Citizen owned PV systems - Prepaid solar electricity consumption for 20 years –> like an interest free loan to the utility. Prize is fixed for 20 years - Cooperatives founded to build a PV plant, normally the initiators promise also a small dividend on the invested capital

2.6 Additional Country information

Table 12: Country information

	2015	2014	2013	2012
Swiss Average: Retail Electricity Prices for household, commercial company and industrial company see below	n/a	0.1695/kWh	0.1670/kWh	0.1685/kWh
Average consumption per capita (kWh/a)	Approx. 7000	7 018	7 333	7 375
Population (average)	8,325 Mio	8,238 Mio	8,140 Mio	8,040 Mio
Country size (km^2)		41 285 km2		
Average PV yield in kWh/kWp	1000	995	975	950
Name and market share of major electric utilities.		Approx. 700 utilities, mostly DSOs, from very small (< 100 customers) to municipality owned utilities, such as ewz (City of Zurich) with their own hydro production and serving > 200 000 customers.		

Retail electricity prices 2015 (https://www.strompreis.elcom.admin.ch)

Retail Electricity Prices for an household (range)	0,17 – 0,25 CHF/kWh
Retail Electricity Prices for a commercial company (range)	0, 14 – 0,21 CHF/kWh
Retail Electricity Prices for an industrial company (range)	0, 11 – 0,18 CHF/kWh

3 POLICY FRAMEWORK

This chapter describes the support policies aiming directly or indirectly to drive the development of PV. Direct support policies have a direct influence on PV development by incentivizing or simplifying or defining adequate policies. Indirect support policies change the regulatory environment in a way that can push PV development.

3.1 Direct support policies for PV installations

3.1.1 New, existing or phased out measures in 2015

3.1.1.1 Description of support measures excluding BIPV, and rural electrification

In 2014 Switzerland introduces direct subsidies for small installations up to 30 kW. This scheme is very successful and has already a market share of about 25%.

Also in 2014 self-consumption has been allowed by low. This has become a marked driver also for commercial installations.

The FiT scheme introduced 2009 has still to deal with a very long waiting list. Due to a limited number (about 100 MW in 2015) of new contracts for new PV systems, the FiT scheme is only a weak driver for the Swiss PV market compared to self-consumption and direct subsidies.

3.1.1.2 BIPV development measures

The Swiss FiT and direct subsidy scheme offers a premium for BIPV installation.
Since there is still a cap on the FiT scheme with a long waiting list, the share of BIPV is decreasing. The premium with direct subsidies is also not sufficient the drive the residential BIPV market considerably.

3.1.1.3 Support for electricity storage and demand response measures

Some cantons introduced direct subsidies for storage.

Table 13: PV support measures (summary table)

	On-going measures residential	Measures that commenced during 2015 - residential	On-going measures Commercial + industrial	Measures that commenced during 2015 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2015 – ground mounted
Feed-in tariffs Minimum is market price	Different prices depending on local DSO. In average above market price		Different prices depending on local DSO In average above market price		Different prices depending on local DSO In average above market price	
Feed-in premium (above market price, financed by a levy on a federal lever)	Yes, but with cap, huge waiting list		Yes, but with cap, huge waiting list		Yes, but with cap, huge waiting list	
Capital subsidies	Yes. Up to 30 kW_{DC} Max. 30% of installation cost, 500 CHF/kWp		Yes. Up to 30 kW_{DC} Max. 30% of installation cost, 500 CHF/kWp		none	
Green certificates	Some utilities	Some utilities	Some utilities	Some utilities	Some utilities	Some utilities
Renewable portfolio standards (RPS) with/without PV requirements	*none*	*none*	*none*	*none*	*none*	*none*
Income tax credits	yes					
Self-consumption	yes		yes		yes	
Net-metering	Few utilities		Few utilities		Few utilities	
Net-billing	Few utilities		Few utilities		Few utilities	

	On-going measures residential	Measures that commenced during 2015 - residential	On-going measures Commercial + industrial	Measures that commenced during 2015 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2015 – ground mounted
Commercial bank activities e.g. green mortgages promoting PV	few		few		few	
Activities of electricity utility businesses		Some utilities take over installer companies		Some utilities take over installer companies		Some utilities take over installer companies
Sustainable building requirements		The cantons agreed in 2015, that in future residential buildings must install 10W of PV per square meter heated area		The cantons agreed in 2015, that in future commercial buildings must install 10W of PV per square meter heated area		
BIPV incentives	yes		yes		yes	

3.2 Self-consumption measures

PV self-consumption	1	Right to self-consume	Yes
	2	Revenues from self-consumed PV	Savings on the electricity bill
	3	Charges to finance Transmission & Distribution grids	non
Excess PV electricity	4	Revenues from excess PV electricity injected into the grid	In average, the remuneration was 0.105 CHF/kWh (Source VESE, www.vese.ch)
	5	Maximum timeframe for compensation of fluxes	15min
	6	Geographical compensation	no
Other characteristics	7	Regulatory scheme duration	Not defined
	8	Third party ownership accepted	yes
	9	Grid codes and/or additional taxes/fees impacting the revenues of the prosumer	Few utilities changed their tariffs for prosumers (power metering)
	10	Regulations on enablers of self-consumption (storage, DSM…)	There are recommendations from the Swiss association of utilities re metering schemes for PV & battery storage. The solar association Swissolar has its one recommendation which differs to the one mentioned above. DSM is standard for large consumers to avoid power peaks but can be used for self-consumption optimization as well. For residential self-consumption there are some regulations and provisional

			schemes how to handle it.
	11	PV system size limitations	There is no limitation in system size.
	12	Electricity system limitations	no
	13	Additional features	

3.3 Tenders, auctions & similar schemes

There are no tendering schemes in Switzerland

3.4 Direct Support measures

See above

3.5 Financing and cost of support measures

The federal support scheme is financed by a contribution paid by electricity consumers on an kWh base.
Only very large consumers are exempted from this levy.

In 2015, the levy was 0.013 CHF/kWh.

3.6 Indirect policy issues

The cantons agreed in 2015, that in the future residential buildings must install 10W of PV per square meter heated area.
This regulation has yet to be set into force by the 26 cantons.

Coffee break during a PV installer's workshop, Mai 2015

4 HIGHLIGHTS OF R&D

4.1 Highlights of R&D

Excerpt from the PVPS annual report 2015, by Stefan Nowak

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).

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.

4.2 Public budgets for market stimulation, demonstration / field test programmes and R&D

Table 14: Public budgets for R&D, demonstration/field test programmes and market incentives.

	R & D	Demo/Field test
National/federal	n/a	n/a
State/regional	n/a	n/a
Total		

BAPV Installation, Aarau, Switzerland

5 INDUSTRY

5.1 Production of feedstocks, ingots and wafers (crystalline silicon industry)

There is no feed stock, ingots and wafers production in Switzerland

5.2 Production of photovoltaic cells and modules (including TF and CPV)

Table 16: Production and production capacity information for 2015

Cell/Module manufacturer (or total national production)	**Technology** (sc-Si, mc-Si, a-Si, CdTe)	**Total Production (MW)**		**Maximum production capacity (MW/yr)**	
		Cell	Module	Cell	Module
Wafer-based PV manufactures					
1 Sunage	sc-Si, mc-Si	0	17	0	n/a
2 Megasol	sc-Si, mc-Si	0	15	0	n/a
3 Meyer Burger	sc-Si, mc-Si	*0*	13	0	n/a
All others	sc-Si, mc-Si	*0*	*5*	*0*	*n/a*
Total	sc-Si, mc-Si	*0*	*Approx. 50*	*0*	*n/a*
Thin film manufacturers					
1 Flisom	CIGS		n/a		Pilot line 15MW
TOTALS			**Approx.. 50**		**n/a**

a) There is no cell production in Switzerland, except for pilot lines for new technologies such as SmartWire Connection Technologie SWCT (Meyer Burger) or CIGS (Flisom).

b) About 25 MW of the manufactured modules in Switzerland were exported (Mainly Sunage and Megasol).

c) Swiss manufacturers are specialized in BIPV products. This is supported by enhanced support schemes for BIPV installations. Besides this, there is also a pilot production of hybrid collectors (PV and solar thermal).

5.3 Manufacturers and suppliers of other components

Switzerland has a strong industry for BOS-components. Among them are the following companies:

Inverters:
Studer electronics manufactures inverters for stand-alone and storage solutions.

Junction Boxes/connectors:
Multi Contact AG is the leading manufacturer of junction boxes, cables and connectors. They claim to have a market share of 50% with module connectors.

Cables:
Huber & Suhner has a variety of dedicated PV cables for more than 20 years.

Supporting structures:
montavent offers mounting systems for profiled metal and corrugated roofs.
ALUSTAND has mounting structures for tilted and flat roofs.

Storage batteries:
Leclanché develops and produces energy storage systems with large format lithium-ion cells, amongst other products.

6 PV IN THE ECONOMY

6.1 Labour places

Table 17: Estimated PV-related labour places in 2015

Research and development (not including companies)	200
Manufacturing of products throughout the PV value chain from feedstock to systems, including company R&D	4200*
Distributors of PV products	
System and installation companies	
Electricity utility businesses and government	300 ((estimated)
Other	1000*
Total	5700

*Based on the value of business in table 18

6.2 Business value

Table 18: Value of PV business

Sub-market	**Capacity installed *in 2015* (MW)**	**Price per W** *(from table 7)*	**Value Mio CHF**	**Totals Mio CHF**
Grid-connected	**333**	**2.0**	**666**	**660**
Export of PV products				**360**
Change in stocks held				**0**
Import of PV products (Modules, Inverters, etc.)				- **230**
Value of PV business				**790**

7 INTEREST FROM ELECTRICITY STAKEHOLDERS

7.1 Structure of the electricity system

About 700 utilities operate in Switzerland. Most of them serve only one village or town (DSO, Distribution System Operators) and are mostly publicly owned or organized as a cooperative of the customers.

For PV, there is only one regulation on the national level which defines how much a utility has to pay for solar electricity as a minimum. A lot of utilities pay a premium which is normally below the national FiT but still helps their local producer to cover at least a part of the production costs.

Grid connection is allowed by law but each of the DSO may have it's one specific technical regulations (which do not vary much among them).

7.2 Interest from electricity utility businesses

2015 showed a growing interest of the "old" utility industry. Alpiq acquired one of the big installers in Switzerland, Helion Solar, Energiedienst, a German utility took over 60% of TRITEC, also a big installer in Switzerland and BKW bought the rest of the share of EES Jäggi Bigler AG.

Many DSOs start to develop new support schemes for prosumers within their servicing area.

Besides this, they begin to build their own PV installations in order to sell the solar production within the national grid scheme; but also more and more for specific electricity products with a high share of PV, besides other renewables.

Within the FiT scheme, utilities still take a considerable share of the FiT revenues from PV production.

7.3 Interest from municipalities and local governments

There is still a growing interest by municipalities in Switzerland. For new buildings, such as schools, it becomes a quasi-standard to build a PV system on the roof.

Besides this, municipalities are purchasing increasingly solar electricity within the framework of switching to 100% renewable electricity for community needs.

Since also many DSO are owned by municipalities, the DSO are sometimes forced to either build PV systems or buy solar electricity from local prosumers at a premium tariff.

8 HIGHLIGHTS AND PROSPECTS

2015 was the best year for PV in Switzerland since the first grid connected systems have been installed in the eighties of last century. With an increase of 10% over 2014 numbers, 333 MW have been installed.

The market for residential systems grew by more than 20% due to the new direct subsidy scheme introduced in April 2014.

Besides residential buildings also installations on farm houses had a remarkable share. Some of them were extensions of existing FiT plants (plants which are within the FiT scheme can be extended and get additionally the tariff which is in force at the time of commissioning the extension).

PV in Switzerland will be the second largest source of renewable energy in 2016 in Switzerland with 2.5% (after hydro power which has a share of about 56%).

The future depends partly on the discussion in the Swiss parliament, which should be finalized in 2016. If the levy per kWh to finance the FiT scheme and the direct subsidies will be increased to 2.3 Swiss cents/kWh, the market is expected to grow steadily. But this is uncertain yet since there might also be a referendum and Switzerland than has to vote on this subject.

The Swiss professional solar association (Swissolar) still hopes to reach a market share of more than 5% until 2020.

IEA INTERNATIONAL ENERGY AGENCY