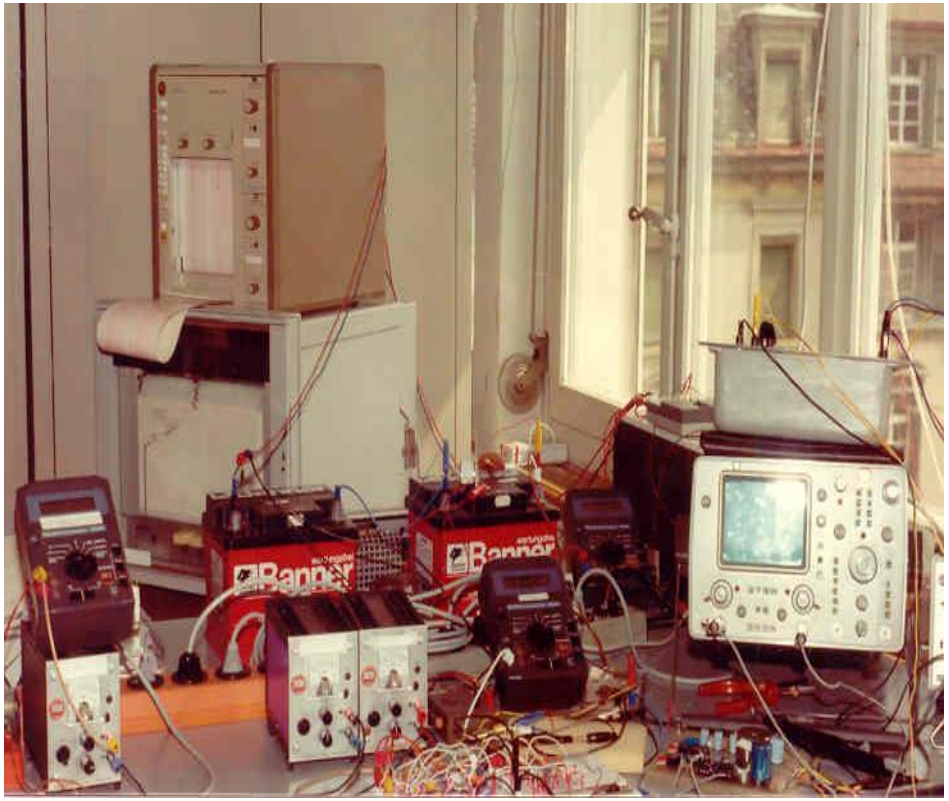
Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

History and future of PV reliability in Switzerland

Urs Muntwyler, Professor Photovoltaics/ head PV Laboratory, BFH Burgdorf

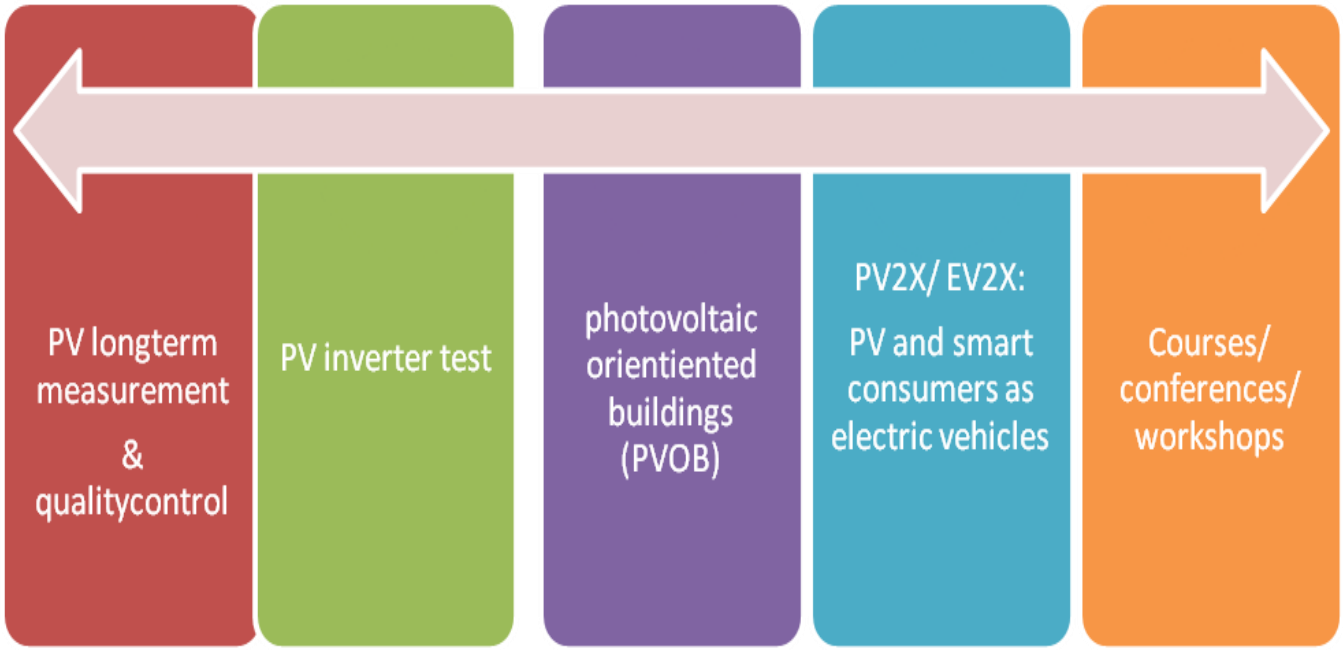
- PV-Labor, Jlcoweg 1, 3400 Burgdorf

Small start in 1982: Diploma work BFH-TI-Biel



Maximum power tracker
MPT for off-grid PV

The five competence centers of the PV-LAB in Burgdorf (CH)



Long tradition of PV reliability research:

Started in the late 70-ties by Hasler AG for the Swiss PTT as a P+D-programme for off-grid telecomm power supplies in Switzerland.

Several test sites from Swiss mainland to the Swiss alps (Ostermundigen/ Ulmizberg/ Burgdorf/ Feutersoey, Chasseral, Piz Corvatsch (3‘300masl)

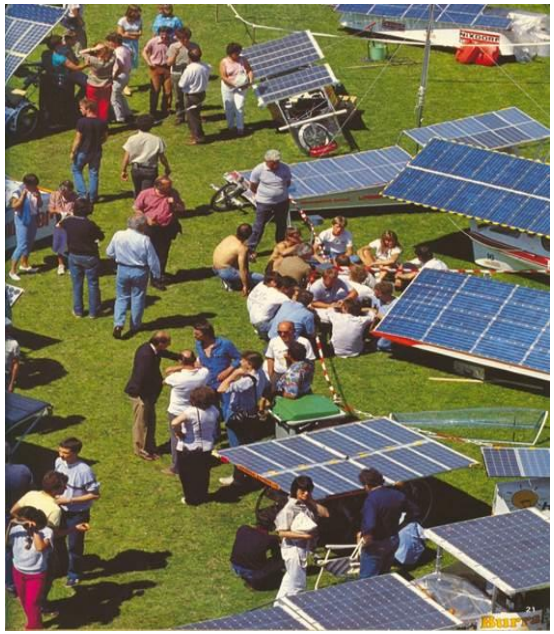
PTT Tower Chasseral: Solarex HE 51 m-Si with 2 kind of coverage of the solarcells (Photo 1983/ Muntwyler).

„Solarbreeder“ fromBP Solar/ Solarex (1982-about 2010) in Frederick/ USA

This PV production facility should demonstrate that PV is a reliable source of energy and can produce more energy as needed (several visits 1990-2008 – Muntwyler Energietechnik AG was only Swiss importer of Solarex)!

PR-Tour for solar energy: „Tour de Sol 85“ across Switzerland!

Tour de Sol 85



PV moduls only on the vehicules

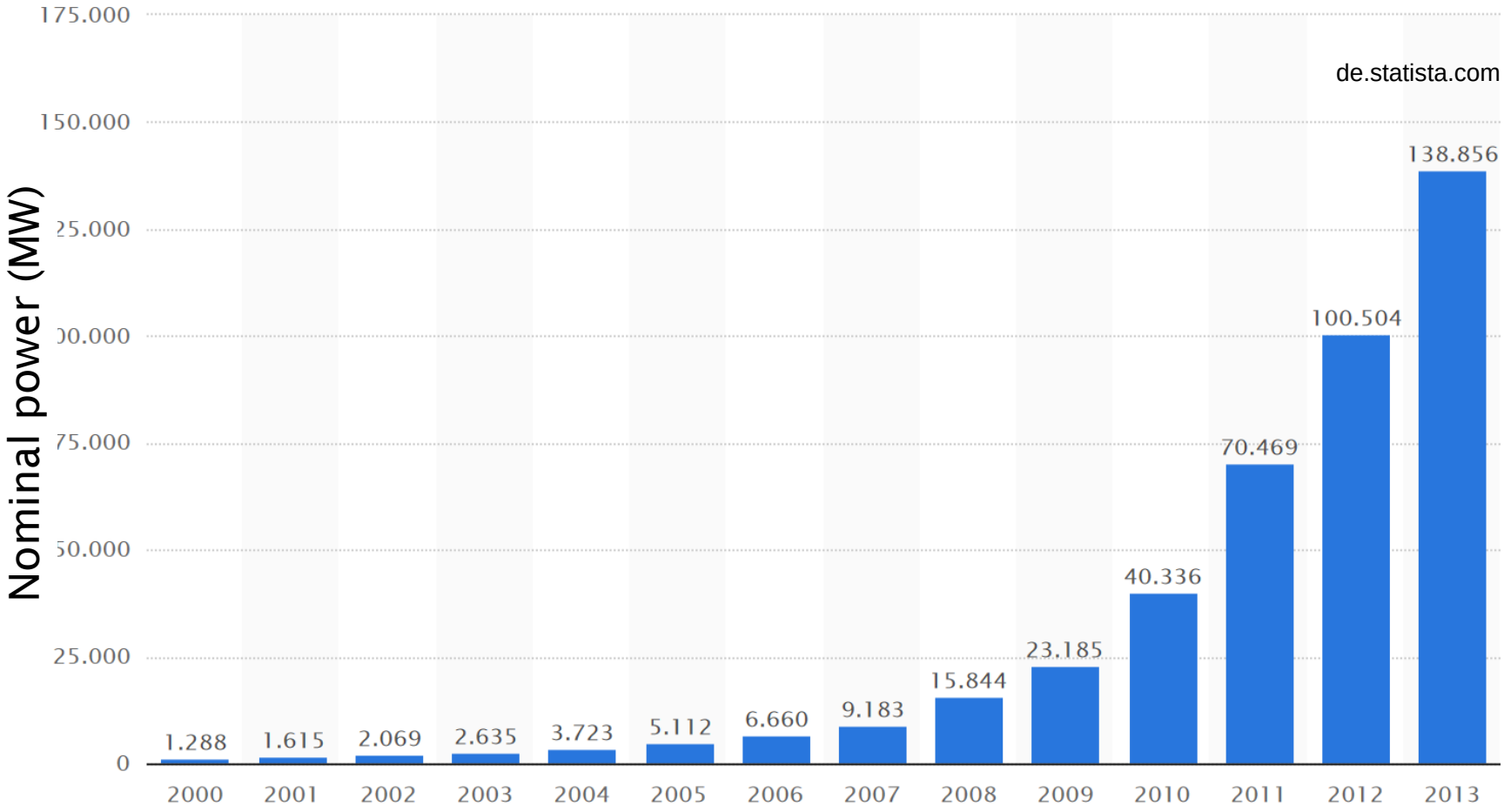
Tour de Sol 86

New: PV modules on solar gasoline stations

Tour de Sol 87

New: grid connected PV installations

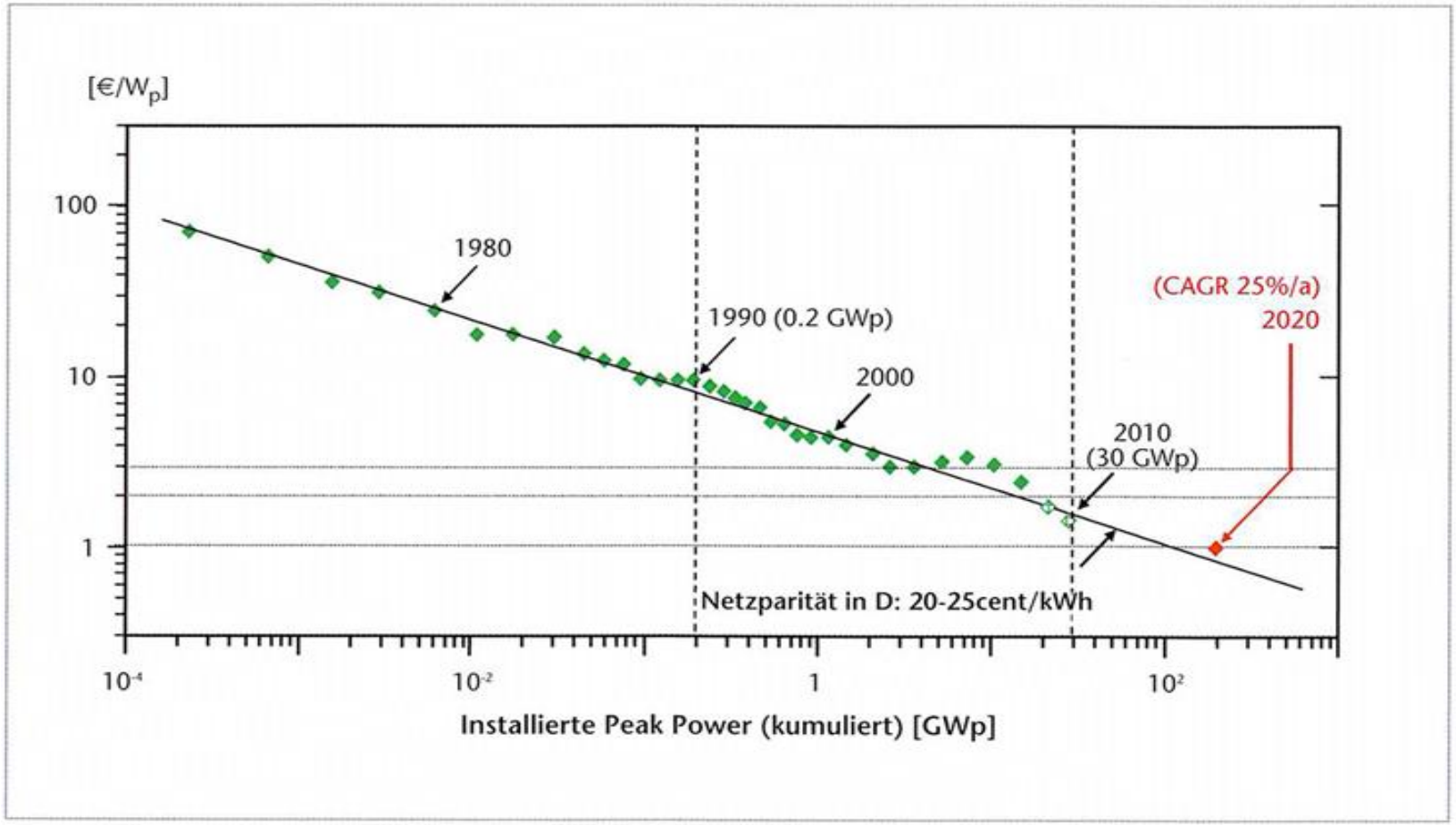
Worldwide installed PV-power



Production 2014: 38,7 GWp

Price-learning curve of PV-modules

(G.Willeke, Frauenhofer ISE, 2009)



Swiss “Energy Strategy 2050”

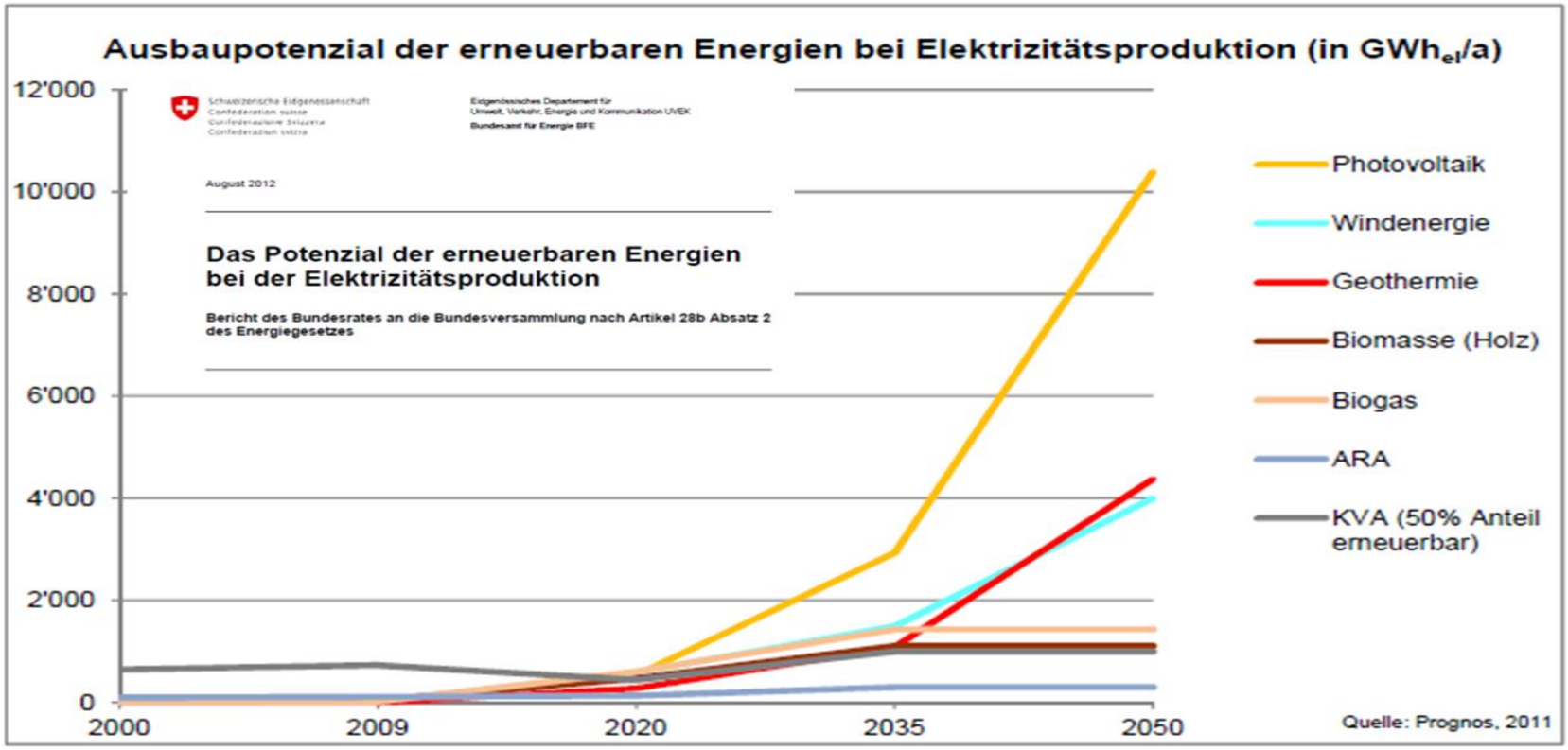


Abb. 3: Ausbaupotenzial der erneuerbaren Elektrizitätsproduktion nach Technologie[9]

PV market has many applications:

Applications	Technology	Important	Remarque
Satellites	GaAS/ c-Si	Efficiency/ wheight	Small market
Consumer goods	a-Si/ thin films	price	Calculators/ outdoor lights
Off-grid power supplies	p-Si/ mono-c-Si	Power/ lifetime/ efficiency	Remote sites/ telecomm
Private homes/ farms/ SME‘s	p-Si/ mono-c-Si	Price/ efficiency	Grid connected
Stand-alone sites	c-Si/ CIS/ CdTe	Price/ efficiency/ Temp. Coeff. Tc	>100 kWp - 1GWp
Building skins (PVOB)	c-Si	Construction/ price/ aesthetics	Very small market
Others?			Energy harvesting

1. Slope roofs

Expensive installation – high soft costs - limited space but high own consumption!

2. Part of a flat roof: Stade de Bienne: biggest PV plant of a stadium in the world (2,1 MWp)

Installation of an east/ west PV installation with 2,1 MWp (25th may 2015)

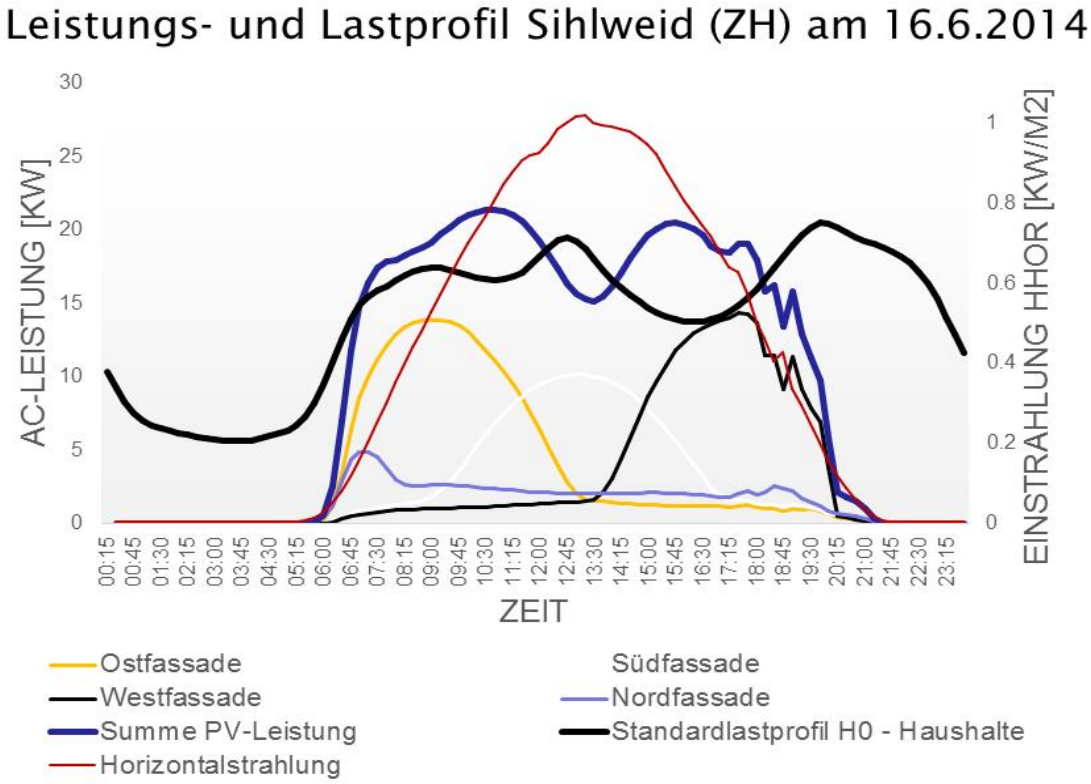
3. Free standing PV installations in hilly regions of Europe

PV installations from EDF «Les més» near Sisteron (southern of France) – more than 35 MWp – growing in 2015

4. Free standing PV installations in the desert:

Topaz (Ca/ USA) 550 MWp – good for temperature resistant very cheap moduls

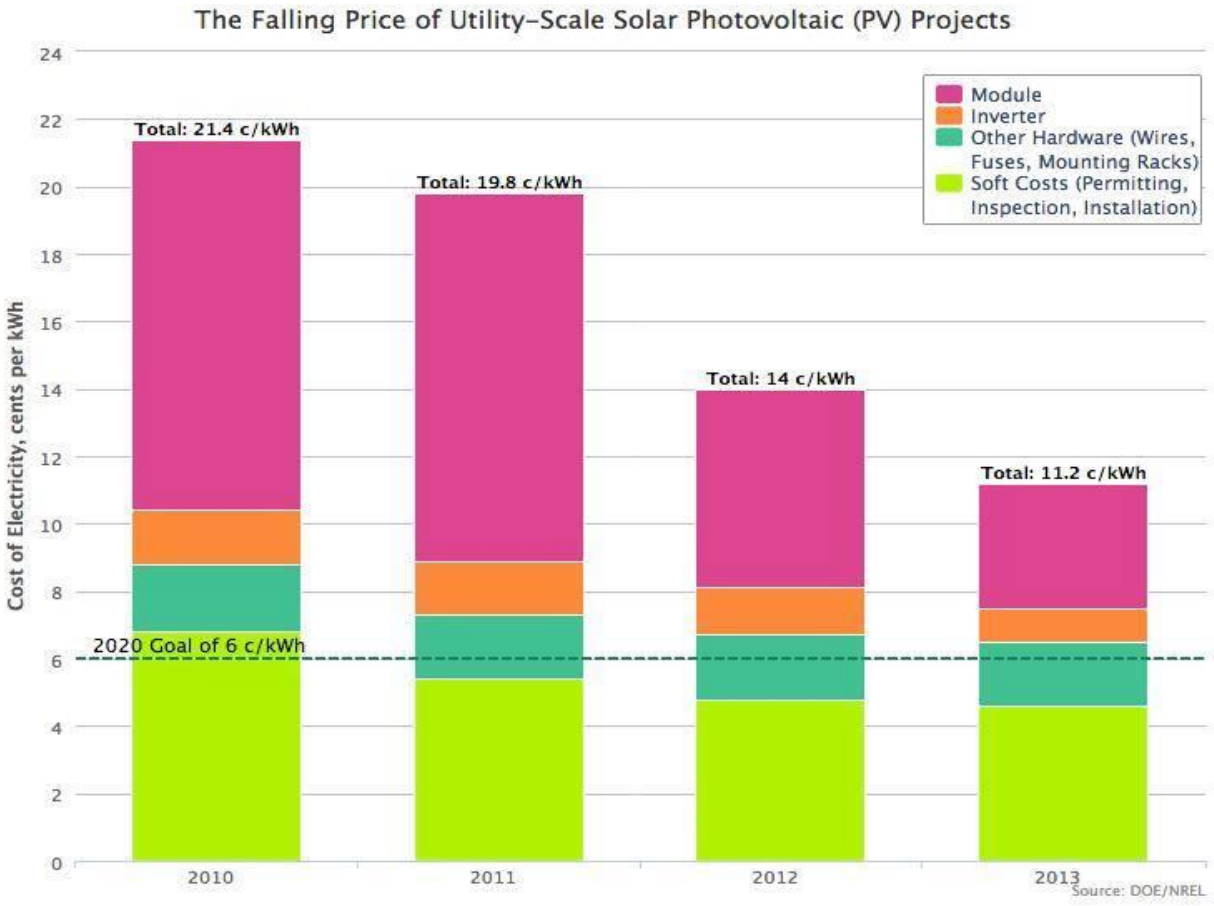
5. PV as part of a façade solution - PV-oriented buildings (PVOB) – expensive planning!



Design of production profiles (daily/ saisonal) with PV plants (Sihlweid Zürich 2 x over 100kWp on all four sides of the building)

Future: Falling prices of PV-Installations (USA)

PV is another disruptive technology: with prices of about 6c/kWh produced nearby the consumer!



More and more – the costs are no longer dominated by the PV module – **soft costs** are in the focus!

Costs of a grid connected PV installation (100 kWp) – fixed on a roof

PV module:	sFr. 0.5/ Wp
Inverter:	0.1/ Wp
Mounting Structure:	0.1/ Wp
Cables and grid connection:	0.1/ Wp
Planning/ preparation/ safety:	0.15/ Wp
Labor costs:	0.15/ Wp
Profit (5-10%):	0.1/ Wp
Total investment costs:	1‘200sFr. / **kWp**

PV costs: 1‘000kWh/ kWp/ 3 % interest/ no subsidize/ 2Rp/ kWh für service and maintenance:

25 years lifetime:6,8 Rp/kWh + 2Rp/kWh = 8,8 Rp/kWh

Future of cost optimized installations:

- The PV module is about 40% of the costs
- Planning and installation are another 40%

Idea for the future:

➔ We must lower the planning costs etc. (soft costs) by a longer lifetime of the installation and therefore of the modules!

Installation lifetimes:

25 years: 6,8 Rp/ kWh + 2Rp/ kWh =8,8Rp/kWh

20 years: for 6,8 Rp/ kWh the PV module must be 0,2/ Wp cheaper ➔ 0,3sFr./ Wp!

40 years: 4,8 Rp/ kWh + 2Rp/ kWh = 6,8 Rp/ kWh

20 years: for 4,8 Rp/ kWh the PV module must be 0,45/ Wp cheaper
+ ¼ of the installation costs ➔**- sFr. 0,075/ Wp!**

➔ **We want the PV module for free and some extra money too!**

We need cheap PV moduls with high efficiency and 40 years lifetime and nearly no degradation!

Future of cost optimized installations:

The key to cheap solar electricity is the lifetime of the PV-module and installation (3% interest+2Rp/ kWh for service and maintenance):

20 years: 8 Rp/ kWh + 2Rp/ kWh = 10 Rp/ kWh
25 years: 6,8 Rp/ kWh + 2Rp/ kWh = 8,8 Rp/ kWh
40 years: 4,8 Rp/ kWh + 2Rp/ kWh = 6,8 Rp/ kWh

PV modules with 20 year lifetime:
20 years: for 6,8 Rp/ kWh you must be 0,2/ Wp cheaper + ¼ of the installation costs ➔0,3125/ Wp or sFr. 0.1875/ Wp!

We need cheap PV moduls with high efficiency and 40 years lifetime and nearly no degradation!

Future of PV – combination with consumers:

Best applications: Plusenergy houses, energy for SME and e-Mobility

Example of BFH in Burgdorf:

With our solarcarport of 2,5 kWp we save in 30 years 27'000 liter of gasoline with a traditional EV – as this Opel Ampera!

For the 5 Mio cars in Switzerland we need about 12 TWh (=12 GWp) – 15'000km/ year with 15 kWh/ 100km – with more efficient EVs 2/3 therefore 8 TWh or 8 GWp!

So my final remark: buy PV and an EV!

Professor Urs Muntwyler,
PV Laboratory – www.pvtest.ch
Institute for Energy and Mobility Research (IEM)
BFH-TI Burgdorf, Switzerland

urs.muntwyler@bfh.ch