# PV AS A MAIN SOURCE OF ELECTRICITY IN THE “ENERGY – STRATEGY IN SWITZERLAND”

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ABSTRACT: The energy supply of the industrialized world is based on renewable energy, nuclear and fossil energies. For countries like Switzerland, the import of fossil and nuclear energy is a great economic burden. The transition towards 100% renewable energy supply hence offers a lot of opportunities. Here, we explain how Switzerland tackles this issue in the frame of the “Swiss Energy Strategy 2050”. The main avenue is higher energy efficiency in houses, cars and industry what should economise about 20TWh electric energy per year (i.e., 30% of the total consumption). Most processes contribute to these savings will be “electrified”, examples are heat pumps (hot water production, heating houses) or electric cars. In order to feed such “new consumers” and thus to replace five old nuclear power plants in Switzerland, the electricity should be produced from photovoltaics (PV). The Swiss Government aims to produce 12 TWh with PV and 4 TWh with wind and geothermal, while some minor sources are hydro, biomass and others.

Keywords: Efficiency, Energy Strategy, Photovoltaic, Smart Consumers, Storage

## 1 INTRODUCTION

The energy supply in the history of mankind was mainly based on renewables from biomass, animals and slaves [1]. The switch to “non-renewable energies” past the last 200 years allowed the industrialized countries a much bigger consumption per capita. These “non-renewables” are mainly fossil (coal, oil and gas). Their resources are limited and consumption produces a lot of $CO_2$ leading to global warming. Countries without own fossil energy supplies have to invest a big amount of money to buy these energies.

Since the first oil shock in the 1970es, the search for alternative energy solutions has increased. Here, we illustrate this search for alternative energy and transition towards “100% renewable energy supply” and discuss data from Switzerland, a rich industrialized country in Europe (Fig. 1). The actual policy of Switzerland, the “Energy Strategy 2050”, supports this transition. It aims at switching the electricity production to 100% renewable and thus replacing five old 5 nuclear power plants.

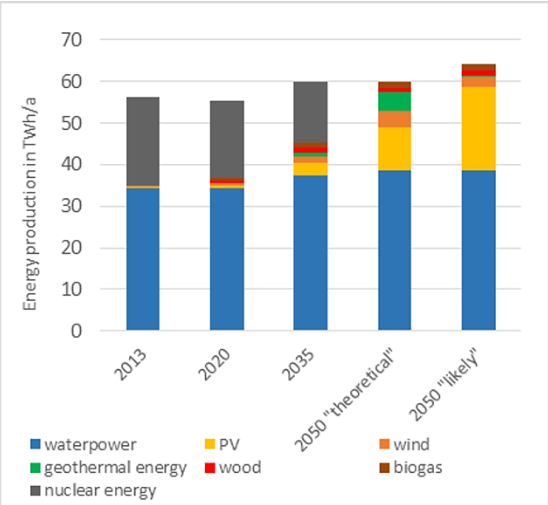


**Figure 1:** Evolvement of the Swiss electricity production over time and projections till 2050.

## 2 COST OF ENERGY CONSUMPTION

As evidenced in Fig. 1, Switzerland (8 million inhabitants) consumes a lot of oil and gas. In 2014, the consumers paid 30 190 sFr. for energy, of which 17 430 Mio sFr. for oil and fuel [2]. Similar to the world consumption, the main consumer groups in Switzerland are buildings, transport and industry.

## 3 NEARLY UNLIMITED POTENTIAL OF RES

Similar to agriculture, the diversity of sources and the potential for renewable energy are broad and differ from region to region. Alone the total potential of the solar radiation is about 10 000 times higher than the world’s consumption [3]. Yet, in contrast to fossil and nuclear energy, renewables have a lower energy density. It makes therefore sense to present (Fig. 2) the potential of different renewable energies in MWh/ km$^2$ [4].

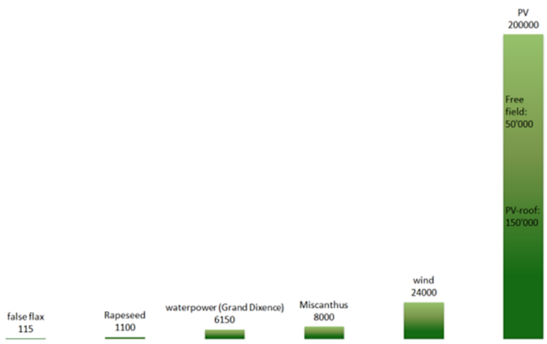


**Figure 2:** Energy production per MWh of renewable energies per m$^2$.

The lowest density comes from crop, but hydropower has a low energy density too, although the hydropower station at “Grand Dixence” in Switzerland has a unique 1 950 m height difference. Photovoltaics (PV) on inclined roofs has the by far best density – also as compared to ground-based, open-field PV installations.

## 4 HISTORY OF RENEWABLES IN SWITZERLAND

In the 1970s, the potential of renewable energy in Switzerland was only realised by pioneers, while the broad public, mass media, research organisations (e.g., EIR - Eidgenössisches Institut for Reaktorforschung) highly underestimated the potential of the new renewable energies like solar and wind [5]. Institutions in neighbouring countries like Germany (German electric companies and the German Umweltbundesamt) pointed out until the 1990s (Fig. 3) that it was impossible to ever produce more than 4% with renewable sources as solar, wind, biomass and hydro energy [6]. Today (2014), Germany produces more than 30% of its electricity consumption from renewables [7].

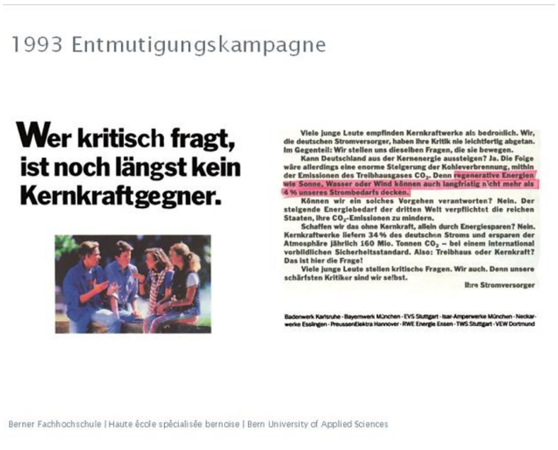


**Figure 3:** Campaign of German utility company in 1993 "... we can never produce more than 4% with RE". In 2014, Germany produces more than 30% [7]!

### 4.1 Tour de Sol Switzerland

To change the perception of renewable energy in Switzerland, mainly solar energy, three Swiss engineers launched 1985 the first solar car race of the world in 1985.

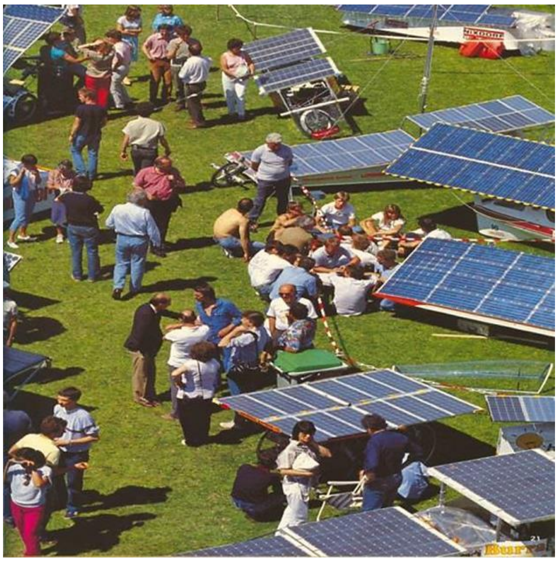

**Figure 4:** Tour de Sol 85 in Switzerland, organised by Prof. Urs Muntwyler, with fifty-eight solar cars participating.

The goal of this "Tour de Sol Switzerland" (Fig. 4) was to drive across Switzerland in five days with a nominal power of not more than 480Wp. What was then termed "a crazy idea which will never work" turned out to be a big success, and the race was repeated in Switzerland and in many other countries for many years [8]. Such pioneering activities in renewable energy have remained popular in Switzerland up to the actual times, as demonstrated by Bertrand Piccard and his "Solar Impulse 2" project [9].

### 4.2 First "Feed in tariff" for solar electricity in Burgdorf

As a result coming out of the Tour de Sol, the Swiss city of Burgdorf invented the worldwide first "feed in tariff" for solar electricity in 1989. The price for one kWh solar electricity was then around one US$. This "feed in tariff" model was later adopted by Germany and launched the "economy of scale" race for worldwide cheaper solar electricity [10].

### 4.3 From the Minergie label to "Plus-houses"

One of the "Tour de Sol" participants, Dr. Ruedi Kriesi, studied a way to motivate house owners, architects, etc. to adopt a new low-energy housing standard. He created a label, called "Minergie" (Fig. 5), which asked for an energy consumption of no more than 38 kWh/ $m^2$ heated area in the Swiss climate (which is very cold in winter) and a better standard of the air climate in the house. This level has been lowered several times since the introduction of the label, and is now similar to other energy standards in Europe and all around the world.

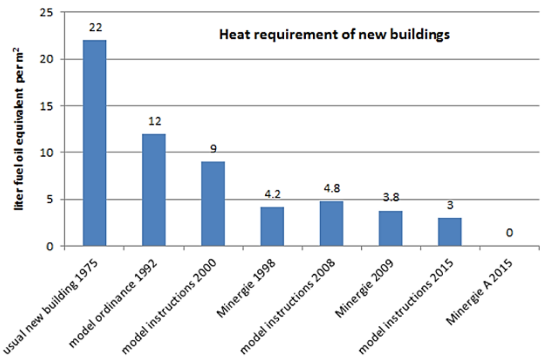


**Figure 5:** Energy consumption per $m^2$ in Swiss houses and the new energy saving standards of the "Minergie" label.

With a normal, roof-integrated PV installation (Fig. 6), a "Plus-house" can now be constructed with lower costs in mid Europe. Such a house (see Figs. 7-8) can cover the annual energy consumption for heating, hot water, electricity needs, the energy for an electric car and the "grey energy" of the house itself [11].

**Figure 6:** Multi-family retrofit house in Switzerland: the roof is an east-west-oriented PV-installation producing 34,6 kWp and a vacuum solar collector for hot water. It covers 187% of the consumption of the house – much more than needed for electric cars or the "grey energy" of the house.

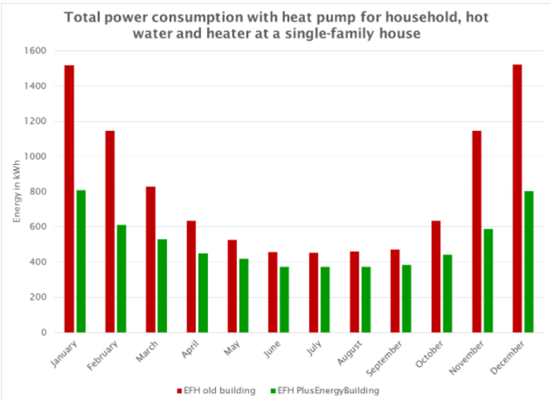


**Figure 7:** Total power consumption in a single-family house, difference between an "old" building and a "Plus-house".

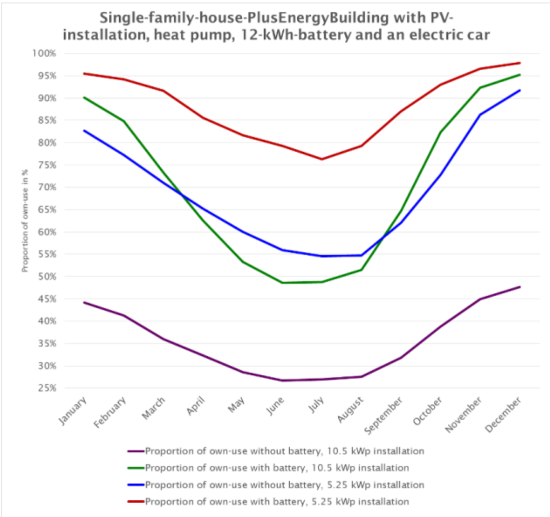


**Figure 8:** Comparison of the proportions of own-use in four different utilizations.

## 5 "ENERGY STRATEGY 2050" IN SWITZERLAND

### 5.1 Fukushima – the tipping point for the new policy

After the Fukushima nuclear accident, the Swiss Government immediately stopped all projects for new nuclear power plants and published the new "Energy Strategy 2050".

### 5.2 Content of the "Energy Strategy 2050"

The objectives of the "Energy Strategy 2050" are illustrated in Fig. 9. Not included in this graph is a higher efficiency of electricity of about 20TWh (about 30%). The new production of electric energy will mainly come from PV (12 TWh), while wind and "deep geothermal" both contribute with about 4 TWh, and biomass, biogas, sewage plants and waste-to-energy plants the remaining. In reality, the 4 TWh from wind and "deep geothermal" are not very realistic as public resistance against the about 600-1 000 wind generators is considerable. "Deep geothermal" has proven a high risk investment causing small earthquakes and hence, the price of the electricity is higher than from PV. Therefore, the expected solution is likely more PV (about 20TWh) and probably imported wind power in wintertime.

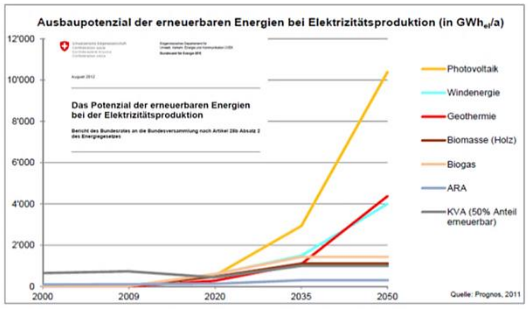


Abb. 3: Ausbaupotenzial der erneuerbaren Elektrizitätsproduktion nach Technologie[9]

**Figure 9:** PV is by far the most important new electric energy source in the "Energy Strategy 2050" of the Swiss Government.

A big issue in the renewable energy discussion in Switzerland is the implementation time of the "Energy Strategy 2050". We currently (in 2015) produce more than 1 TWh PV, whereas the Government aims at 0,6 TWh in 2020. This means that the transition towards renewable energy in Switzerland is much quicker than anticipated.

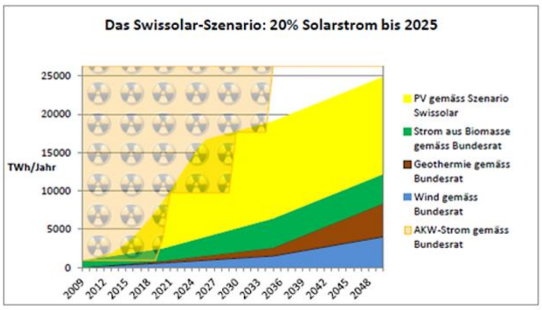


**Figure 10:** Scenario for a rapid transition to renewable energy in Switzerland (source: Swissolar", the Swiss solar industry association).

To give room for PV electricity, the old nuclear power plants in Switzerland need to be "shut down", a conflict that is also stressed by Swissolar (Fig. 10). The "Swissolar" scenario is quite similar to the one communicated by the "Green Party" in Switzerland in the beginning of 2011, i.e., before the Fukushima accident.

### 5.4 Swiss Parliament agrees to new Energy Policy in 2014

In December 2014, the first Chamber of the Swiss Parliament agreed to the new Swiss Energy Policy. The small Chamber will discuss the issue in 2015.

## 6 SWISS ENERGY RESEARCH PROGRAMMES

To support the implementation of the "Energy Strategy 2050", the Swiss Government finances a series of research programmes (Swiss Competence Centres for Energy Research, SCCER). These bundle, for the first time, the energy research competence of the two Federal Universities in Zürich (ETH) and Lausanne (EPFL), the Swiss Cantonal Universities, the Universities of Applied Sciences in Switzerland and industry [12].

## 7 ENERGY RESEARCH AT THE PV LAB AT BFH

Bern University of Applied Sciences BFH participates in several SCCERs and opened, for example, a new battery research centre in Biel [13]. Within the SCCER-FURIES, the PV Lab at BFH in Burgdorf expands its activities to new fields (e.g., PVOB and PV2X), and is now organised in five competence groups (Fig. 11).

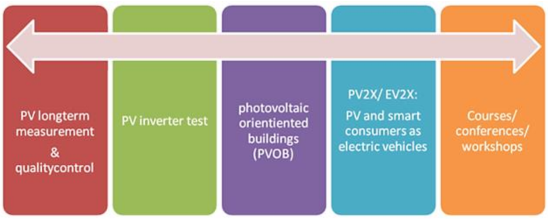


**Figure 11:** The five competence groups in the PV LAB at BFH.

## 8 CONCLUSIONS

The transition to mainly renewable energy offers countries without and with fossil energies more chances than threats. In the case of Switzerland, the country can save 13-15 billion US$ each year (260-300 Billion US$ in 20 years) [14]. This money can be invested in sustainable energy production in Switzerland, with reduced $CO_2$ emission and at lower cost, and to create jobs. In addition, Switzerland becomes less vulnerable with regard to blackmail from oil-exporting countries. Many problems still need to be solved on the avenue towards 100% renewable energy, but Switzerland today has the technology needed to realise the "Energy Strategy 2050". No doubt that renewable energy, in 2050, will be even cheaper, more efficient and more powerful than today. All we have to do is to start and to go ahead!

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Urs Muntwyler got his degree as an electrical engineer at the Institute of Technology Bern - HTA Biel. He is a specialist in solar and renewable energies and has published many books such as "Praxis mit Solarzellen" (Franzis Verlag 1986), newsletters and articles since 1975.

Urs Muntwyler has been the co-founder and manager of the „Tour de Sol", the first solar mobile race in the world (1985 - 1992) in Switzerland. He also started the first solar boat race in 1988 and founded, in 1989, the "Alpine European solar car championship" and in 1990 the winter race for solar cars "Tour de Sol Alpine".

Muntwyler has owned consulting companies that he founded in 1985 and 1988. He sold his solar energy company in 2010, in which he mounted and sold thousands of off-grid installations all over the world and realized more than thousand grid-connected PV-installations in Switzerland from 1988 to 2010.

In 2010, Urs Muntwyler was elected a Professor for Photovoltaics at Bern University of Applied Sciences BFH in Switzerland, where he has been directing the Photovoltaic Laboratory (PV LAB) in Burgdorf since then. He published more than 30 books on solar energy and electric solar cars and served as an elected Member of Parliament of the State of Berne.

In 2015, Urs Muntwyler refused a seat in the Swiss National Parliament to concentrate on research and education at Bern University of Applied Sciences BFH, and to link energy engineering with policy in view of implementing the "Energy Strategy 2050" of the Government in Switzerland.

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