The Swiss Feed-in Tariff System

Analysis of the Swiss Policy and its Implications on the Development of Photovoltaics in Switzerland

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Picture on front page: http://solarzyn.com/products.html

1. Introduction

In order to limit the climate change it is unavoidable to reduce the carbon dioxide emissions in electricity production. Fossil fuel plants, responsible for two thirds of the global annual electricity production, have to be replaced by less carbon-intensive technologies like nuclear, hydro, and new renewables (wind, solar, biomass etc.). Since the potential of hydropower is widely exploited and the use of nuclear energy is controversial, the new renewables are of utmost importance. Many countries have therefore introduced policies that support these technologies. One instrument are feed-in tariffs, a system creating financial incentives for the production of electricity from renewable sources. By now some form of feed-in tariff policy has been implemented in 78 countries or states (REN 21, 2010) in the world, making it one of the most widely used instruments to promote renewable energy technologies. Experts agree that feed-in tariffs represent the most effective policy to promote renewable energy technologies. (Mendonça et al., 2010)

The central element of feed-in tariff policies is a guaranteed payment over a period of about 20 years, which covers the high generating costs of renewable electricity. (Mendonça et al., 2010) Thus, these technologies, under market conditions usually too expensive to compete with conventional power generation, become much more interesting to investors.

In Switzerland a feed-in tariff system was introduced in March 2008, with a policy called "cost-covering remuneration for feed-in to the electricity grid." (Swiss Federal Office of Energy [SFOE], 2011b). It is considered "the most important instrument for the promotion of electricity from renewable sources". (Friedli 2009) Even though the Swiss system was appraised to be "one of the world's most aggressive systems of feed-in tariffs" (Paul Gipe, 2008), it met with criticism, particularly from the photovoltaic (PV) industry. The main problem is the annual total cost limitation for new projects which lead to a stop for new projects and created a long waiting list. The situation is especially unsatisfying for PV projects, for which the waiting list is by far the longest.

To find out how to improve the current situation it is of interest to analyze the Swiss feed-in tariff system and the overall situation of renewable energy technologies in Switzerland. The focus in this paper is on PV, because this technology struggles most with the current policy. With a simple model, the future development of PV in Switzerland can be predicted. In addition, the effect of some modifications in the current policy is studied. The goal is to point out an alternative policy that improves the situation for the PV technology and to discuss its advantages and shortcomings.

2. A general overview of feed-in tariff policies

A feed-in tariff is an umbrella term for policies using a fixed purchase price for electricity from renewable sources. The policy aims to substantially increase the production of renewable electricity by giving investors economic incentives. Feed-in tariff policies are designed to support a broad variety of renewable technologies and make them more competitive through economies of scale and technological innovation.

A feed-in tariff system guarantees the electricity producers a fixed payment for each unit of electricity they generate. This is usually paid with a surcharge on the electricity price for consumers. The general flow of money and electricity can be found in figure 1. Besides the fixed purchase price, feed-in tariff policies typically comprise several other orders. First, power companies have to guarantee for grid connection for the producers. Then they have to transmit and to purchase all the renewable electricity from the producers. (Mendonça et al., 2010) On one hand, this assures the investors in renewable energy technologies that they can actually sell all the power they produce. On the other hand it ensures that in case of a temporary oversupply, the renewable power is not turned off. Instead, conventional power plants have to be stopped, a procedure which can be costly for certain technologies. (Froitzheim, 2010) The law hence forces the power companies to make an economically unfavorable move in order to achieve a greater environmental benefit.

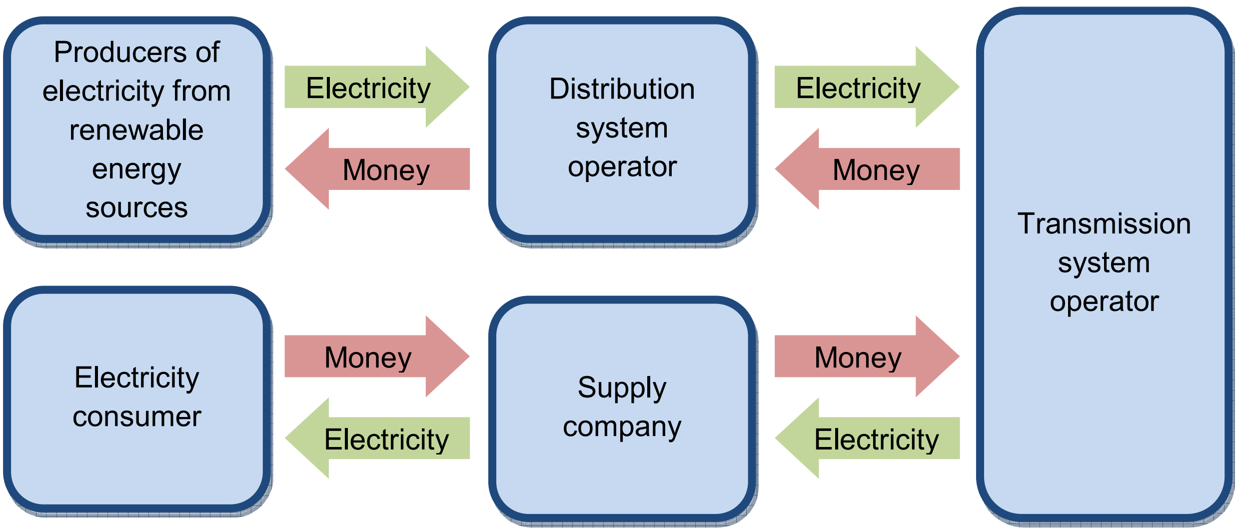

Figure 1: General electricity and financial flows in feed-in tariff systems.

Source: Adapted from Mendonça et al., 2010

2.1. Benefits of feed-in tariff policies

Environmental improvement through the deployment of eco-friendly technologies is the most obvious but not the sole gain from feed-in tariffs. First of all, feed-in tariffs create high-paying jobs in the region. Since the installations are often rather small, they can be realized by local companies, leaving a comparably large share of the invested money in the communities.

(Mendonça et al., 2010; Pomrehn, 2011) In Germany, feed-in tariffs created more than 150,000 jobs. (Mendonça et al., 2010) The investments further lead to positive externalities through a boost in innovation and research.

Another benefit of feed-in tariffs is their price stabilizing effect. The electricity price is expected to rise in the future due to the increasing price of fossil fuels. Having a bigger share of renewable energy reduces the influence of fossil fuel prices on the electricity price. Furthermore, through the support from feed-in tariffs, more advanced renewable technology may soon produce cheaper electricity than some conventional technologies and thus lower the overall electricity market price. (Mendonça et al., 2010)

2.2. Factors affecting the size of the feed-in tariff

The challenge with feed-in tariffs is to "provide a balance between investment security for producers on the one hand and the elimination of windfall profits […] on the other." (Mendonça et al., 2010) It is therefore crucial, but also complex, to create a fair tariff system. The tariffs can be calculated with various methodologies. Most frequently used (e.g. in Switzerland) and, according to Mendonça et al., 2010, most successful, is a calculation based on the real generation cost of electricity. To provide a reasonable return on investment to the producers, a small premium is added.

Feed-in tariffs are usually differentiated by technology, plant size, and time. This differentiation is important to assure the support of a broad variety of technologies and to prevent windfall profits for any producers. The three aspects will now be discussed in more detail.

As it is desirable to promote all kinds of technologies, a specific tariff payment for each technology according to its actual costs is important. Without technology differentiation, only the most mature technologies would be promoted, as these would generate the highest profit. Producers could gain windfall profits and less mature technologies would remain uncompetitive.

The size differentiation accounts for the fact that bigger power plants are normally realized at lower specific costs than smaller plants. Additionally, in some technological areas like hydropower, large plants can already generate electricity at competitive prices and a promotion through feed-in tariff is not needed.

Finally, the time aspect plays an important role. Two points will be considered. First, the renewable technologies become cheaper with time, which is accounted for with a periodical discount factor on the tariffs. However, this factor should be different for each technology to account for higher learning rate of less mature technologies like PV, compared to more mature technologies such as wind power. Second, because tariffs are usually paid over a period of 15 to 20 years, an adjustment for inflation is necessary. (Mendonça et al., 2010)

2.3. Economic effect of feed-in tariffs

In general feed-in tariff policies provide subsidies for certain technologies by setting a fixed price for electricity produced. As the fixed price lies above the equilibrium price (the spot market price of electricity), also the quantity supplied rises. This behavior is shown in figure 2.

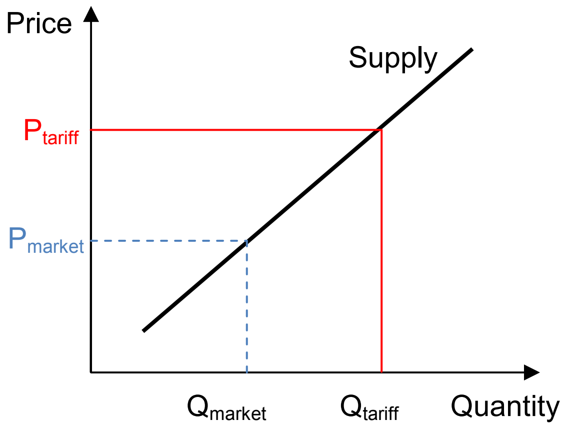

Figure 2: The influence of a feed-in tariff on renewable power supply.

Conventional technologies such as coal or nuclear produce electricity at costs below the market price. The market thus gives the producers an incentive to generate power as they can gain profits. Electricity from renewable technologies costs more than the spot market price for electricity. Since no incentive from the market to increase capacity exists, market regulation is needed in order to promote renewable technologies. This is achieved by covering the cost of each renewable energy technology plus allowing a fair return on investment through fixed feed-in tariffs. In figure 3 this principle is schematically shown. A cost comparison of various technologies for electricity generation can be found in figure 4.

As said before, feed-in tariff funds are usually fed with a surcharge on the electricity price of all consumers. This additional amount usually accounts for a small percentage of the overall price (about 2-3% in Switzerland). The consumers show little price sensitivity, partly because of a strong derived demand for electricity. Since both the increase in price and the elasticity of demand are small, the consumer response on feed-in tariffs is marginal.

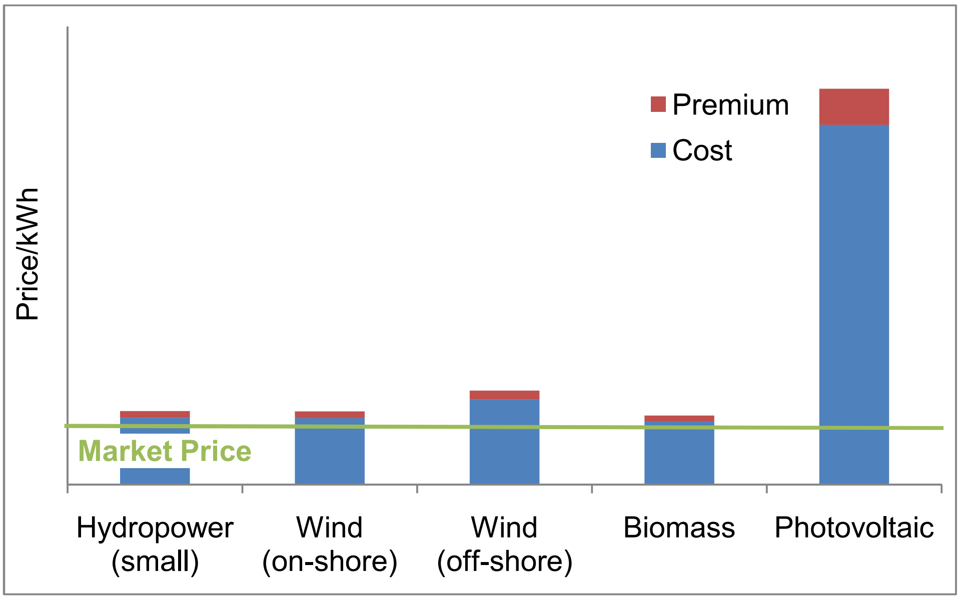

Figure 3: The principle of feed-in tariffs. The costs of renewable technologies exceed the market electricity price. A fixed tariff which covers both the cost and an additional premium is needed to make these technologies profitable.

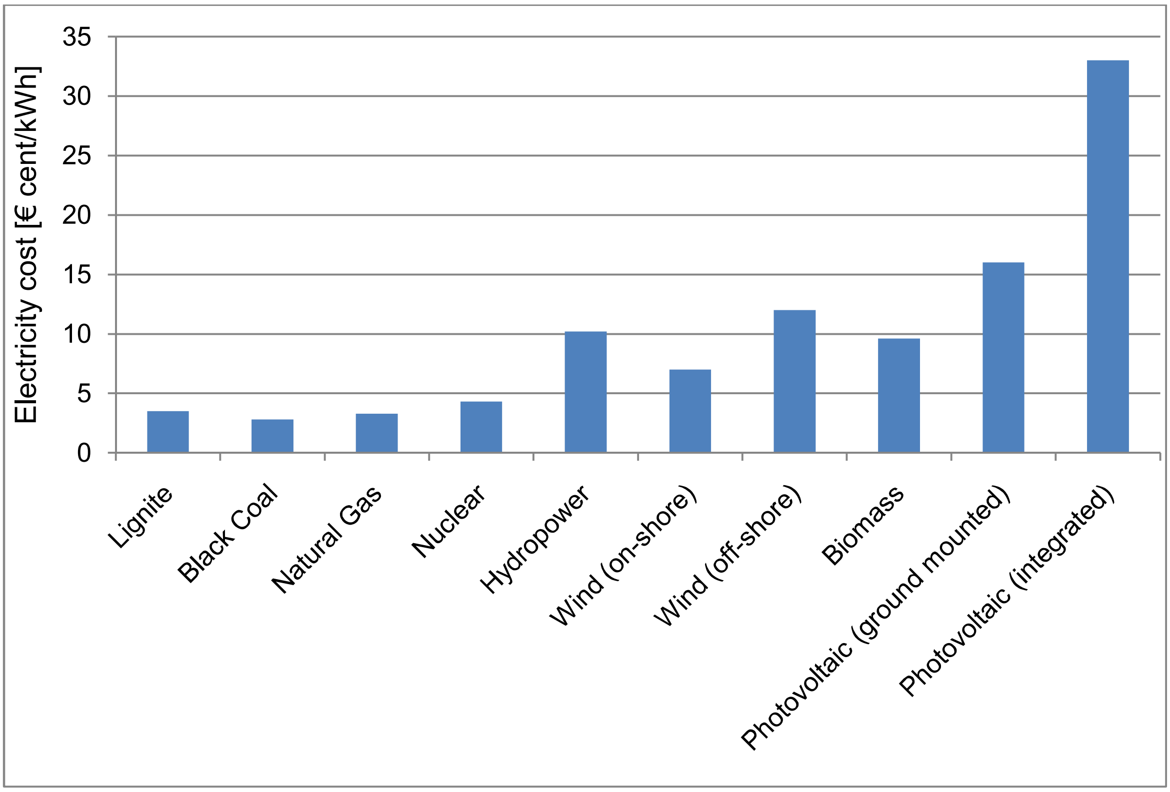

Figure 4: Average electricity generation cost in Germany for various technologies including investment, operation and maintenance, and taxes.

Source: Data from Kost and Schlegel, 2010, and Deutsches Bundesministerium für Wirtschaft und Technik. 2008.

3. The situation in Switzerland

3.1. Swiss policy before 2008

Despite its pioneer role in the photovoltaic technology, Switzerland did not install its first cost-covering feed-in tariff until 2008. Prior to that, several other policies were used to promote renewable energy technologies, but no significant boost occurred.

One instrument that is still applied is the certification of power from renewable sources. Because green power is per se not distinguishable from grey power, this certification is used to enhance transparency for the consumers. The certified green electricity is sold by power companies on the free power market to consumers which are willing to pay a premium to receive green power. (Mendonça et al., 2010) Today producers of renewable energy in Switzerland have to choose between this model and the cost-covering remuneration. (Swiss Federal Office of Energy, 2011b) With certified green power, only the consumers who explicitly want green power pay the extra costs. In contrast, with a feed-in tariff policy all power consumers have to pay an extra amount. A problem with certificates is their lack of transparency for the consumers. It is unclear whether the power companies actually invest all the additional money they charge into renewable electricity. Furthermore, this system tends to support solely mature and thus cheaper technologies.

Another mean to promote renewable electricity was the "financing of additional cost", which was introduced in 2005. This policy was a soft version of the later introduced cost-covering remuneration. Power companies were obliged to buy the electricity from independent producers at a fixed price of about 0.15 CHF/kWh. (Swiss Federal Office of Energy, 2007) For most technologies this amount was too low to make investments attractive.

3.2. Cost-covering remuneration for feed-in to the electricity grid

The Swiss parliament decided on March 23, 2008 to adopt a new feed-in tariff policy called "Cost-covering remuneration for feed-in to the electricity grid". Since May 2008, electricity producers can register their new installations at the Swiss national grid operator "Swissgrid". (Swiss Federal Office of Energy, 2011b) Installations using photovoltaic, geothermal, hydropower below 10MW, waste, biomass, or wind technology are eligible. For the latter, it is particularly notable that Switzerland was the first country to even include small wind turbines in its feed-in tariff policy. (Gipe, 2008b)

The local power companies are obliged to take all the electricity from the private producers and pay them a fixed tariff covering the producing cost of the specific renewable technology plus a premium. The costs are calculated for predefined reference installations. The payments occur over a period of 20 (geothermal, biomass, wind) to 25 years (PV, hydropower). (Swiss Federal Office of Energy, 2007) Depending on technology, application, and the size of the installation, different tariffs are valid. Photovoltaic installations receive the highest payments, while more competitive technologies like waste and hydropower are at the lower end of the scale. The exact tariffs for PV systems are shown in table 1.

Category	Output	Payment [Rp./kWh]
Ground mounted	≤10 kW	42.7
	≤30 kW	39.3
	≤100 kW	34.3
	≤1000 kW	30.5
	>1000 kW	28.9
Roof mounted	≤10 kW	48.3
	≤30 kW	46.7
	≤100 kW	42.2
	≤1000 kW	37.8
	>1000 kW	36.1
Building integrated	≤10 kW	59.2
	≤30 kW	54.2
	≤100 kW	45.9
	≤1000 kW	41.5
	>1000 kW	39.1

Table 1: Feed-in tariff for photovoltaic energy in 2011.

Source: Adapted from Swiss Confederation, 2011

The annual payment reduction for photovoltaic installations amounts to 8%. In 2010 the tariff for photovoltaic installation was lowered by another 10% because the price for solar panels decreased faster than expected. (Swiss Federal Office of Energy, 2010a)

The payment for each unit of electricity is covered by two different money sources. The power companies pay the current spot market price of electricity and a central fund adds the difference between the spot market price and the fixed tariff. The fund is fed by all consumers through a surcharge on the electricity transmission price. This surcharge is currently set to 0.45 Rp./kWh and may not exceed 0.9 Rp./kWh by rights, adding up to a total annual fund of around CHF 247M (Swiss Federal Office of Energy, 2011b) at the current surcharge. A foundation ("KEV Stiftung") was set up to manage the fund. New projects are realized on a first come, first served basis until the fund is exhausted.

In addition, specific caps for each technology have to be respected. Each technology can only receive a fixed share of the total fund. The specific percentages can be found in table 2.

Technology	Maximum share of total fund
Photovoltaics	10% *
Wind	30%
Geothermal	30%
Biomass	30%
Hydropower	50%

* Depends on price of photovoltaic installations

Table 2: Maximum cap for each technology as percentage of the total fund.

Source: Adapted from Pedersen, 2008

The share for photovoltaic electricity was initially set at 5%. This limit has created a long waiting list as many more projects than expected applied for payments, thus the cost of all new projects would have far exceeded the limitation. This has been criticized repeatedly and finally led to an augmentation of the share to 10% in 2011, leading to an amount between CHF 25M to 32M per year for photovoltaic projects. (Swiss Federal Department for Environment, Transport, Energy and Communication, 2010) Together with this augmentation, an exceptional fund of CHF 20M for photovoltaic projects on the waiting list was granted. (Swiss Federal Office of Energy, 2009) The PV share of the total fund will further increase to 20% and to 30% if prices for PV power fall below 40 Rp./kWh and 30 Rp./kWh, respectively. (Swiss Federal Legislation, 2010)

3.3. Goals of the Swiss feed-in tariff policy

The goal of the Swiss policy is to raise the annual electricity production from new renewable sources (excluding large hydropower plants) to at least 5,400 GWh by 2030, an increase of about 500% from 1285 GWh in 2008. (Kaufmann 2009, Swiss Federal Legislation 2010) New renewable technologies could then contribute 10% to the total electricity consumption in Switzerland (today: 2%). (Kaufmann, 2009) Furthermore, this policy should increase the annual hydropower production by 2000 GWh until 2030. (Swiss Federal Legislation, 2010)

3.4. Comparison of the Swiss tariff system with those of other countries

According to Paul Gipe, 2008a, an expert for renewable energy policy, the Swiss tariffs for photovoltaic energy are high, but on par with France and Germany. The long payment period of up to 25 years can only be matched by Spain. Wind turbines get significantly higher payments in Switzerland than in other countries due to the more complex geography and thus higher specific costs. A cap for the funding of each technology is unique to the Swiss system. Other countries usually limit the payments through capacity caps instead of a total cost limit (e.g. Spain). (Mendonça et al., 2010)

Switzerland is in a somewhat different situation than most other countries. About 60% of the power consumption is already covered with renewable hydropower. The remaining share is mainly produced from nuclear power plants. Thus, the power production in Switzerland already has a very low carbon dioxide intensity and a high share of renewable sources. The pressure to increase the electricity production from new renewable sources to meet international agreements is therefore smaller than in countries with a more carbon-intense electricity production. However, the ongoing discussion about the future of nuclear power in Switzerland, fueled by the incident at the nuclear power plant in Fukushima, might rapidly increase the need to augment electricity production from renewable sources.

3.5. Obstructions for renewable energy technologies

Even though renewable energy technologies are now promoted with a feed-in tariff, their development is not fully satisfying. "Of about 200 projects in renewable energy technologies, more than half are blocked or delayed by objections" says Sebastian Vogler from the power company BKW. (Translated from Bracher, 2011) Because of their rather heavy impact on the scenery and the natural environment, mainly wind power and hydropower are affected. In contrast, PV is little affected; only around 10% of the Swiss rooftops are problematic because of historic preservation. (Bracher, 2010)

As mentioned before, the main problem for PV is the maximum cap for payments for PV projects. Even though the cap was raised from 5% to 10% the waiting list is still huge. Currently, the capacity of the listed PV projects is 6 times higher than the capacity of the actually installed or approved PV installations. (see table 3) This is particularly unsatisfying since most of these projects are uncontroversial. David Stückelberger, CEO of the Swiss solar industry association Swissolar, claims that "almost 100 percent of these projects could be realized quickly without problems." (Translated from Bracher, 2011)

A common problem of all technologies is the limited total fund for renewable energy projects. As only 0.45 Rp./kWh is collected to feed the fund, many projects cannot be realized. This has created a waiting list, not only for PV, but for all technologies. (see table 3)

Technology	Installed [MW]	Approved [MW]	Waiting List [MW]
Small hydro	69.3	289.5	240.2
Photovoltaics	24	4	165
Wind	25	817	1794
Biomass	57	132	825
Geothermal	0	No data	No data

Table 3: Capacity and additional capacity on waiting list of each new renewable technology.

Source: Data from Frei, 2011

The waiting list is not the only negative impact of the total cost limit. It also causes problems for the local industry because it inhibits sustainable market growth. Instead, the market grows strongly just before the cap is reached and collapses afterwards. (Mendonça et al., 2010) It is therefore more difficult to establish a strong local industry.

3.6. Potential of photovoltaics in Switzerland

PV electricity production strongly depends on solar irradiation. But unlike solar heat collectors, it also utilizes diffuse radiation and is thus also applicable in regions with less direct irradiation such as Central Europe. Figure 5 shows a map of the solar irradiation in Europe. The potential in the Swiss midlands is comparable to Southern Germany, while it is much higher in the Alps due to the thinner atmospheric layer and the favorable weather conditions. According to Energie Trialog Schweiz, 2008, PV has the potential to produce 1-2 TWh/a by 2035.

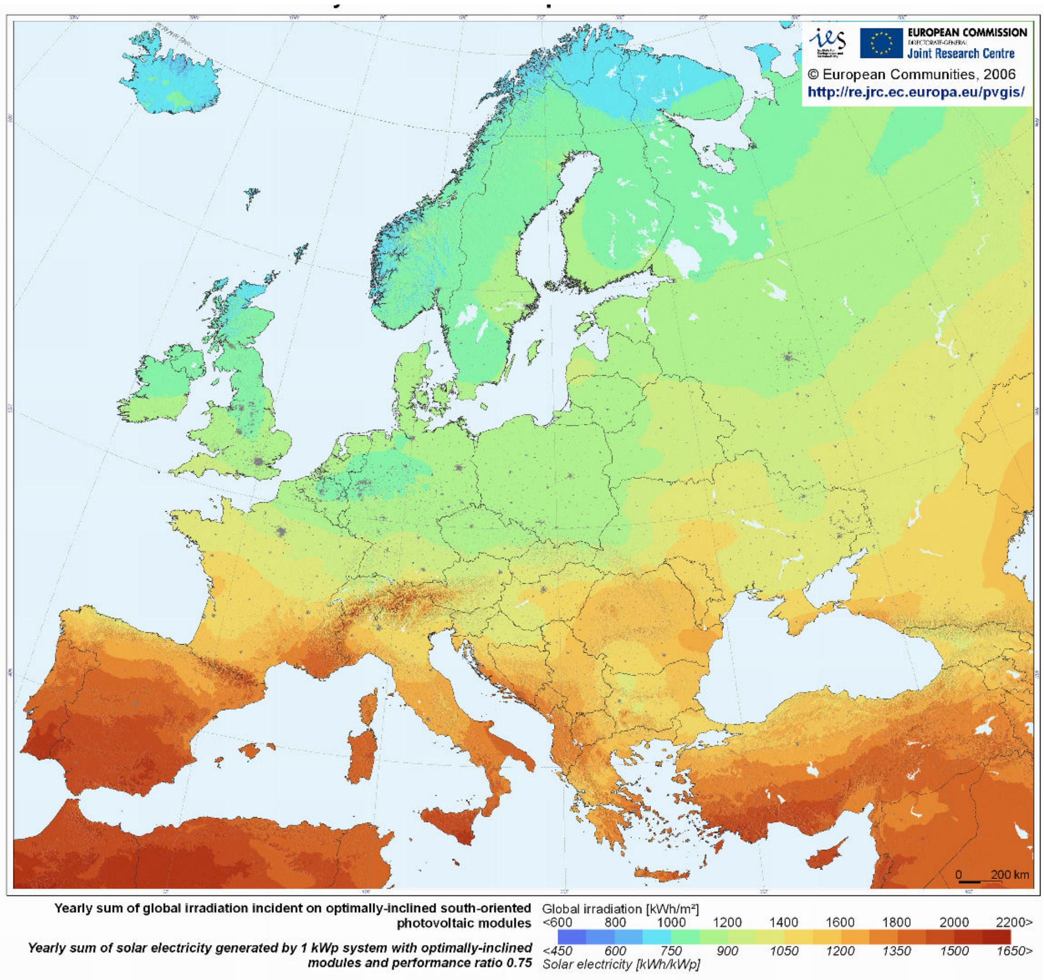

Figure 5: Photovoltaic Solar Electricity Potential in European Countries. Incident radiation is high in red areas and low in blue areas.

Source: JRC Europe

Even though the potential of PV is similar to Germany's, the installed capacity is much smaller. While Switzerland produced 6.4 kWh per capita (49 GWh total) in 2009, Germany generated 80.4 kWh per capita (6575 GWh total), more than ten times as much. (Hostettler, 2010; Bundesnetzagentur, 2011) This difference mainly exists because Germany introduced its feed-in tariff policy much earlier. However, since 2005 the capacity in Switzerland has increased significantly and it is expected to grow continuously in the following years. (Figure 6)

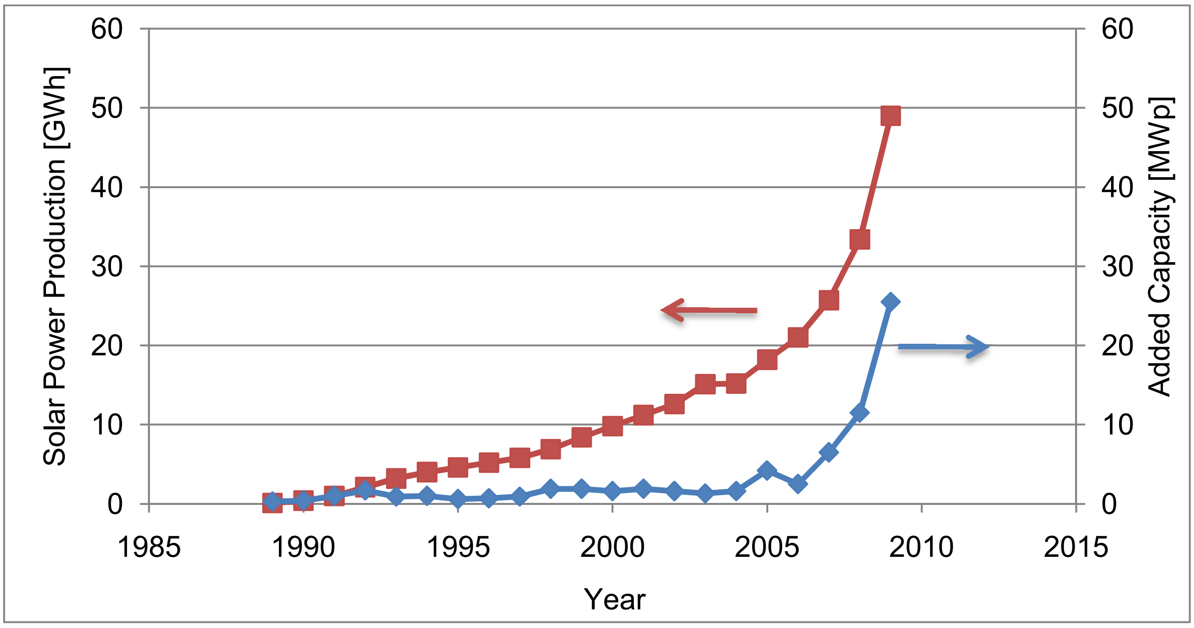

Figure 6: Solar power production in Switzerland.

Source: Data from Hostettler, 2010

3.7. The Swiss photovoltaic industry

Switzerland has a strong photovoltaic industry. Besides many small regional firms that assemble the installations, some globally active companies are located in Switzerland. Best known are the Meyer Burger Group, a producer of manufacturing equipment for silicon solar cells, and Oerlikon Solar, which sells thin-film solar cell manufacturing equipment. Another important company is Sputnik Enigneering AG, a company that sells electric components for photovoltaic installations worldwide. These numerous companies all benefit from strong domestic and global promotion of photovoltaic systems.

3.8. Swiss electricity price development

Electricity prices had been decreasing in Switzerland for the last two decades until 2008, when a law about market liberalization was passed. This, and the introduction of the feed-in tariff policy, caused an average increase in electricity price of around 10%. (Figure 7) Today the price is around 21 Rp./kWh for normal households. The price is made up of 45% grid costs, 40% energy costs, and 15% taxes and fees. (Verband Schweizerischer Elektrizitätsunternehmen, 2010c) Future price development is highly dependent on political decisions and technological progress. An important factor is the highly discussed shutdown of some nuclear power plants. This rather cheap electricity would have to be replaced by electricity from other sources, which would probably amount in higher generating costs and thus raise the electricity price. Another price driver is the need for a more complex grid in order to distribute the electricity from small dispersed power installations.

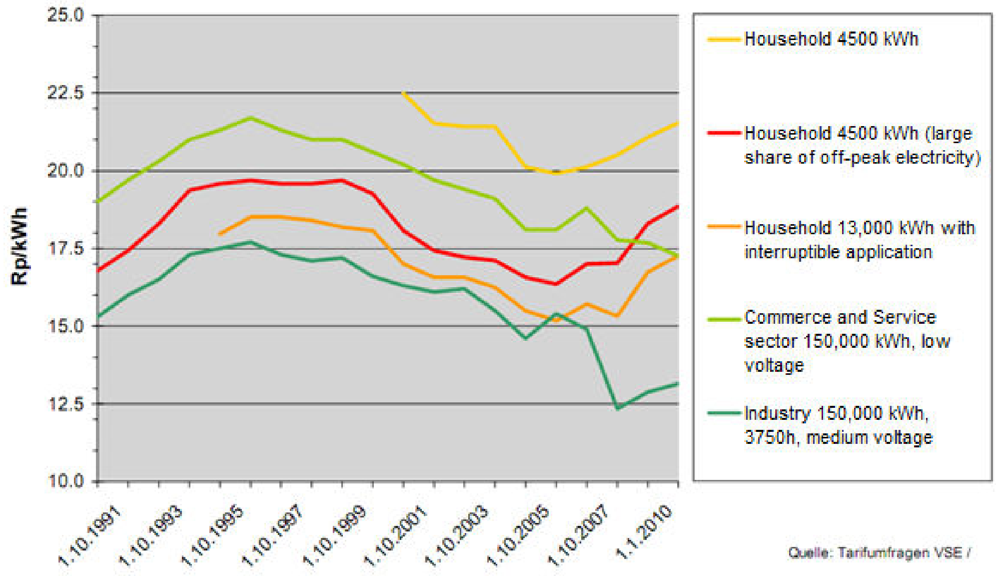

Figure 7: Electricity price development in Switzerland.

Source: Adapted from Verband Schweizerischer Elektrizitätsunternehmen, 2011a

The European electricity prices vary strongly between countries, mainly due to the different power sources and legal differences. Despite the currently high exchange rate for Swiss Francs, Switzerland has one of the lowest electricity prices among the Western European countries. (Figure 8)

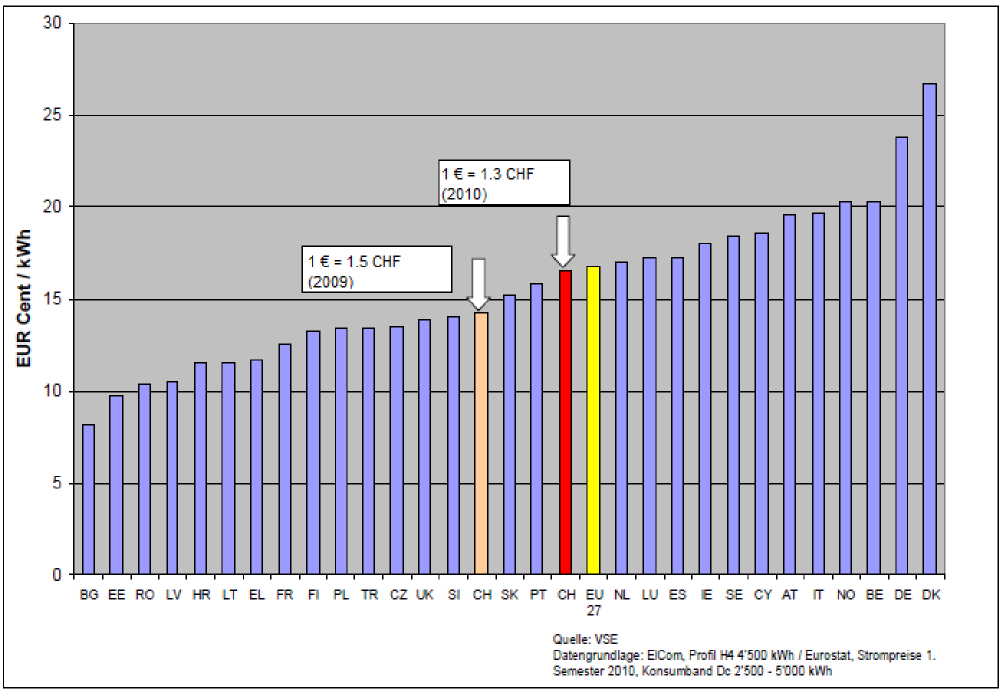

Figure 8: Electricity prices in Europe.

Source: Adapted from Verband Schweizerischer Elektrizitätsunternehmen, 2010b

4. Scenarios for the future PV development in Switzerland

The future development of PV is highly dependent on renewable energy policy. In order to analyze the development in Switzerland, a simple model is applied to find the PV energy production from now to 2030. Two different scenarios are investigated. One looks at the development under the current legal conditions. The second scenario studies the impact of a more ambitious policy.

4.1. Factors affecting the PV development

The amount of the feed-in tariff has a strong influence on the PV development. Currently Swiss feed-in tariffs appear to be attractive considering the many applications for new installations. If the size of the tariff is adjusted regularly according to the PV price development, the demand should be constant, as profits remain unchanged.

Another important factor is the PV price. Since it should be covered by the feed-in tariff, the investor and hence the demand is not affected. However, in Switzerland the maximum cap for PV investments depends on the price for PV installations. If the price falls below a certain limit, the share of the total fund for PV installations becomes larger and more installations can be built. Moreover, the same amount of money finances more capacity as the electricity produced becomes cheaper. Hence the capacity is affected in two ways by the price for PV installations. An additional reason for an increasing fund for feed-in tariffs is the growing electricity consumption, as for each extra unit of energy consumed an additional surcharge to feed the fund is collected.

The price of electricity from non-renewable sources and the fuel price play a role as well. Generally higher prices make renewable sources more attractive. (Mendonça et al., 2010) In Switzerland the fuel price is of less importance, because little electricity from fossil fuels is consumed. It is therefore neglected in the model.

4.2. Calculations and parameters

The price development of PV installations was modeled using two specific learning rates, one for the PV module and one for the other parts of the PV system. Together with an estimated projection of the annual PV capacity growth rate the future price could be calculated. The following formulas were applied, as suggested by Novak, 2010:

$$p_i[CHF] = p_{i-1} \cdot \left[0.5 \cdot \left(gr_{PV,i} + 1\right)^{-b_1} + 0.5 \cdot \left(gr_{PV,i} + 1\right)^{-b_2}\right] \quad [1]$$

$$b_k = -log_2(1 - lr_k) \quad [2]$$

p_i = PV installation price in year i, $gr_{PV,i}$ = annual global PV capacity growth rate in year i, lr_{module} = learning rate for the PV modules, lr_{system} = learning rate for PV systems without the module

The behavior of the feed-in tariff was assumed to be congruent to the price development, hence formula [1] could be used again only by replacing the starting price p_{2010} with the starting feed-in tariff t_{2010}. To facilitate the calculation the price and feed-in tariff were not distinguished by size and type, instead an average value was used. Thus all predictions are based on the average PV installation price and the average feed-in tariff in 2010.

The annual additional energy production from PV could then be calculated with the following formula:

$$\mathrm{E_{PV,i}[kWh/a]} = \frac{\mathrm{E_{elec,i}} \cdot \mathrm{c_{FiT}} \cdot \mathrm{max_{PV}}}{(FiT_{\mathrm{i}} - \mathrm{p_{elec}}) \cdot \mathrm{lt}} \qquad [3]$$

$E_{PV,i}$ = Additional annual energy production from PV in year i, $E_{elec,\,i}$ = Electricity consumption in year i, c_{FiT} = surcharge for the feed-in tariff fund, FiT_i = feed-in tariff in year i, p_{elec} = Spot market price of electricity, lt = lifetime of installation, max_{PV} = PV share of total fund

The annual fund for new PV capacity is calculated using the product of the annual energy consumption, the surcharge per unit electricity, and the PV share of the total fund. It is assumed that this fund is entirely used or, to put it more economically, demand for feed-in tariff payments always exceeds maximum supply. The long waiting list for PV installation shows that this assumption is reasonable, at least for the upcoming couple of years. As shown in the formula, the electricity spot market price can be subtracted from the feed-in tariff because this amount is paid by the power company and not with the PV fund. A lifetime factor is incorporated because only 1/lt of the additional energy is produced each year.

As mentioned before, two different scenarios are analyzed. Under current conditions, the surcharge for the feed-in tariff fund is 0.45 Rp./kWh, and the share for PV installations has an upper limit that depends on the PV price (see above). In the scenario that analyzes a more ambitious policy, the surcharge is set to 0.9 Rp./kWh, the highest possible amount in the current Swiss energy law. In fact, the surcharge is expected to go up in 2013. (Swiss Federal Office of Energy, 2010b) The second, less probable assumption is a change of the PV cap to 30% of the total fund immediately. All the other parameters remain the same in both scenarios. They can be found in table 4.

Parameter		Symbol	Scenario current policy	Scenario ambitious policy	Reference
PV power production 2010		C_{2010}	74 GWh		Estimated from Hostettler, 2010
Learning rate module		lr_{module}	10%		Novak 2010
Learning rate PV system without the module		lr_{system}	22%		Novak 2010
Average PV installation price 2010		p_{2010}	49.0 Rp./kWh		Novak 2010
Average feed-in tariff 2010		t_{2010}	53.8 Rp./kWh		Novak 2010
Power consumption 2010		E_0	59,800 GWh		SFOE 2011
Power consumption growth rate		gr_E	1%		Energie Trialog Schweiz, 2009
Installation lifetime		lt	25 years		Novak 2010
Electricity spot market price		p_{elec}	10 Rp./kWh		Estimation based on eex.com
Surcharge on electricity price		c_{FiT}	0.45 Rp./kWh	0.9 Rp./kWh	Based on Swiss Federal Legislation 2009
PV share of total fund	p > 40 Rp./kWh	max_{PV}	10%	30%	Swiss Federal Legislation 2011/ Free choice
	p > 30 Rp./kWh		20%	30%	
	p < 30 Rp./kWh		30%	30%	
PV capacity growth rate	2011	gr_{PV}	50%		Bank Sarasin, 2009 (years 2011-2020); EPIA, 2010 (years 2021 – 2030)
	2012		50%		
	2013		45%		
	2014		40%		
	2015		32%		
	2016		30%		
	2017		28%		
	2018		26%		
	2019		24%		
	2020		22%		
	2021		20%		
	2022		19%		
	2023		18%		
	2024		17%		
	2025		16%		
	2026		15%		
	2027		14%		
	2028		13%		
	2029		12%		
	2030		11%		

Table 4: Parameters used in the calculations.

4.3. Results

The price of PV power will reach the 40 Rp./kWh limit by 2012 and the 30 Rp./kWh by 2016 according to the calculations. Finally, it will fall to 16 Rp./kWh by 2030. The detailed curve is shown in figure 9.

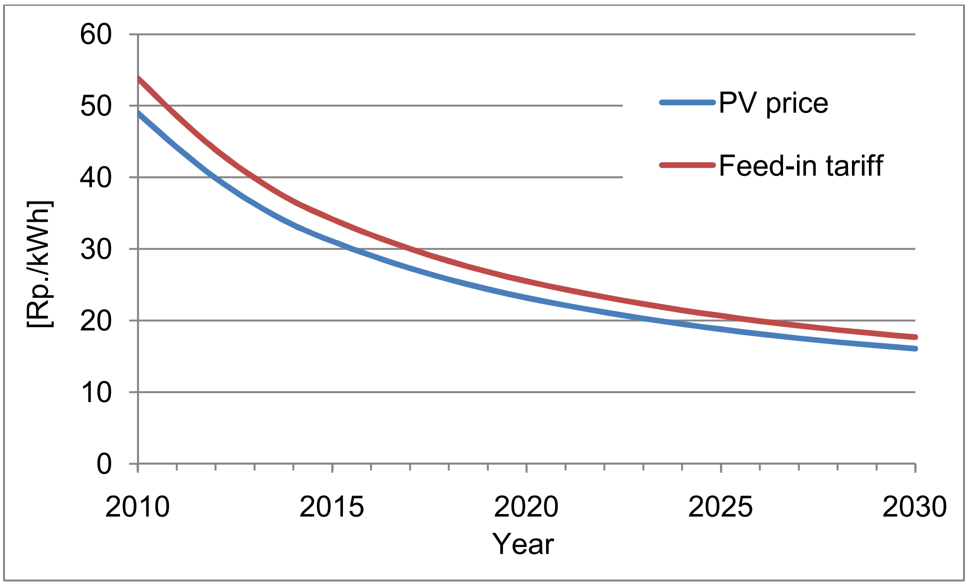

Figure 9: Calculated price and feed-in tariff decline.

Under the current conditions, an electric energy production of 578 GWh can be achieved by 2030 (figure 10). This would then account for 0.79% of the total energy consumption. The more ambitious policy gives an electric energy production of 1124 GWh, or 1.54% of the total energy consumption. The additional cost for the electricity consumer would be 0.45 Rp./kWh, which is about 2.3% of the current electricity price for households.

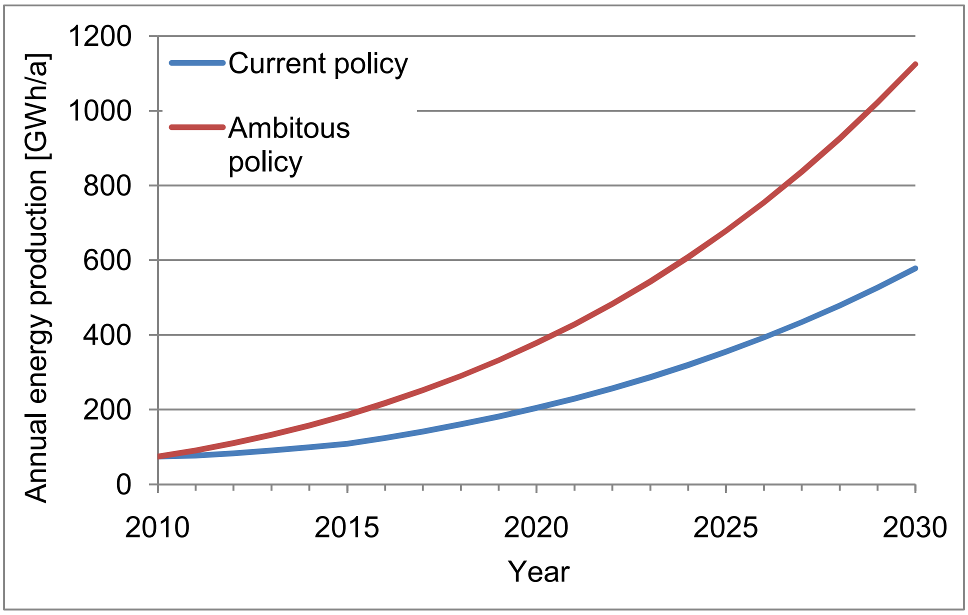

Figure 10: Increase of electric energy production from photovoltaic installations.

5. Conclusion

The analysis shows that the current Swiss legislation for the promotion of new renewable technologies is not satisfying. Whilst less expensive technologies like wind and small hydropower struggle with legal restrictions and objections from private parties, the growth of photovoltaics is strongly inhibited by the restrictions of the Swiss feed-in tariff system. This is one reason why photovoltaic power still only composes around 0.1% of the Swiss power consumption even though private producers are willing to build new PV installations and their construction is rarely obstructed. The calculations state that under current conditions, the electric energy production of PV would only grow to 578 GWh. To attain the estimated potential of 1000-2000 GWh in 2035 (Energie Trialog Schweiz, 2008), this number is insufficient.

The growth rate could be significantly increased with a more ambitious policy. Calculations show that PV could generate more than 1000 GWh in 2029. Such growth requires a surcharge of 0.9 Rp./kWh on the electricity price for all consumers, raising the current price by 2.3%. Furthermore the PV fund has to make up for a higher share of the fund for feed-in power payments. Under current conditions it is doubtable if it makes sense to restrict PV for its high price and instead grant money to wind and hydropower installations that are heavily threatened by objections. By increasing the share for PV to 30% a smaller share of the total fund would be blocked in such projects and at the same time a PV capacity of 1000 GWh could be achieved by 2029. Facilitating the realization of new projects as an alternative to unblocking the money would involve a much larger and more controversial modification of current legislation and would thus be difficult and protracted.

The other renewable technologies are not inhibited through this policy, since the increase of the total fund exceeds the money removed for PV. Altogether the policy would provide a bigger fund for each technology and simultaneously avoid much money from being blocked.

With the current mechanisms, the additional money needed would be paid by all Swiss power consumers. Electricity prices have been discussed in the past years because they have experienced a rise of around 10% in the course of market liberalization. It is therefore likely that a policy inducing a further price increase would meet with political opposition that has to be overcome. However, a comparison of European electricity prices shows that Switzerland has one of the lowest prices across Western Europe, even if the surcharge is raised. An increase in price can thus be justified in an international context. The additional money spent for PV would have a high domestic content and promote the already strong Swiss PV industry. For a country like Switzerland, with an industry depending on innovation and top-notch technologies, PV is an interesting industry sector. The example of Germany shows the high potential impact of feed-in tariffs on the renewable energy industry. In addition, the installation of new capacity would not have to be stopped that often due to the PV cap. Hence the industry would face a less fluctuating and a more predictable demand for new installations, facilitating sustainable growth.

In summary, a more ambitious policy would help to enable the energy producers to exploit the potential of photovoltaics in Switzerland and contribute a significant share to the overall goal of 10% renewable electricity in 2030. Positive effects would spill over to other renewable technologies through a higher fund for feed-in tariffs and to the Swiss PV industry, while electricity consumers would still pay one of the lowest electricity prices in Western Europe.

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