

# Photovoltaics or Solar Thermal? The Winner Takes It All!

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## 1. Introduction

Of all renewable energy sources, solar energy has by far the most comprehensive potential. Solar energy can be used for heating, cooling and the production of electricity. In the past, the solar thermal applications have had a significant share of the portfolio. However, the market for PV has gone up in the last years, while the solar thermal market has declined. Several factors are responsible for this shift, among them being the low price for PV modules, PV components and PV electricity. Based on the market in Switzerland, the most important factors underlying this shift are presented. An outlook to the worldwide market complements the analysis.

**Keywords:** Photovoltaics (PV), solar thermal (ST), solar air, solar passive

## 2. Development of the Solar Market in Switzerland

In Switzerland, the solar thermal market started in the 1980es. It has declined since 2009 (Fig. 1) and now has the same size as about 10 years ago, i.e., below > 50% of its peak in 2009.

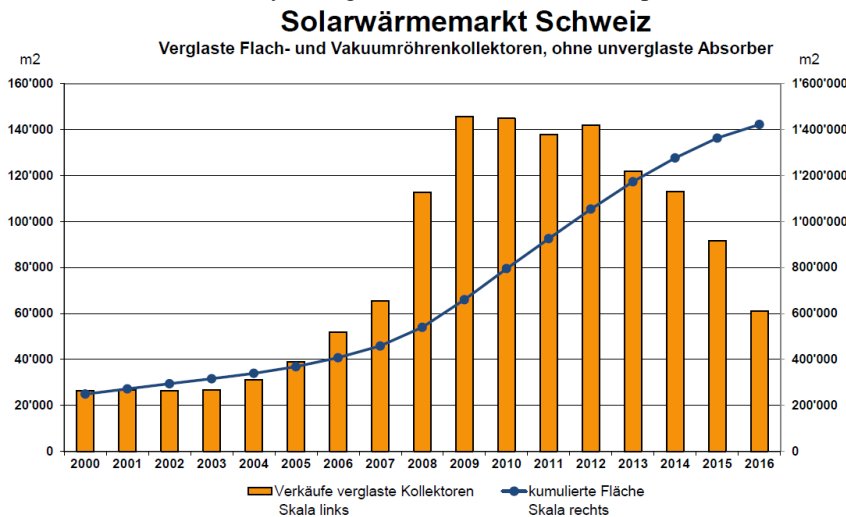


Fig. 1: Solar thermal market development in Switzerland from 2000 to 2016. Source: Swissolar.

The PV market in Switzerland (Fig. 2) played a minor role from 1975 to 1985 and was mainly an off-grid market. After 1986, grid-connection allowed bigger PV installations and the market started to grow from a very low level. When the “feed-in-tariff” was introduced in Switzerland in 2008, the PV market increased from 10MWp (2008) to 250 - 300MWp per year.

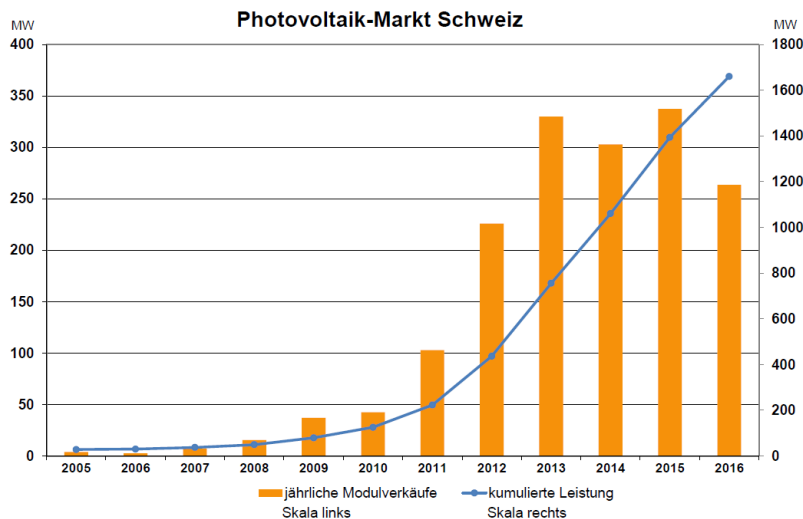


Fig. 2: Development of the PV market in Switzerland (2005-2016). Source: Swissolar.

### 3. User Needs for Solar Thermal Energy and Photovoltaic Electricity

Based on the user needs, we develop a customer value that can be turned into a sales process and a project. Regarding the user needs, we state that the basic electricity / energy needs of humans these days are:

- a) Electricity for light, mobile phones, entertainment systems, cooling of nutrition, power for several purposes
- b) Hot water as an important hygienic and comfort factor
- c) Heating and cooling according to the climate zone
- d) Energy for mobility

The need for heating and cooling purposes varies with the ambient temperature (climate zone). Global warming lowers the need for heating and puts the cooling application as a priority in the agenda. New house construction techniques lower the need for heating energy by a factor of 7 and more. With its electric energy production, photovoltaics (PV) serves all four needs (a)-(d). Specifically, combined with heat pumps, PV is very effective for cooling and heating devices, too. Solar thermal and passive solar systems are well suited for the needs (b) and (c).

### 4. Technology Development

Solar thermal (ST) applications have been known for decades and have improved over time. Yet, they still look very much the same as 30 years ago. The possibility to reach temperatures above 200 degrees Celsius even with flat plate collectors created new problems. Prevention against overheating needs special attention. In cold regions with pumped anti-freezing liquids, the control and service of these systems is a challenge, expensive and adds to the complexity of the system. In financial terms, solar thermal installations with flat plate collectors haven't improved very much past the last 20 years in industrialized countries. Some producers of solar thermal collectors disappeared from the market. More severely, the knowhow of the hot water industry is also gradually receding. Therefore, some professional investors have turned away from solar hot water applications and towards PV installations. Solar thermal installations with cheap vacuum tubes from, e.g., China could - in theory - lower the total costs but have, until now, not been very popular. On the positive side of solar thermal installations are the high rate of subsidies and the possibility to lower the income tax if such a system is installed in an existing building.

Hot air collectors are an interesting device, still a market niche and only few producers such as GRAMMER (D), Solar Venti Ltd. and home-built constructions. The big market in Switzerland was in the 1990s for hay-drying purposes for farmers but has completely disappeared because of new hay storage techniques.

Passive solar energy systems are less important as the heating needs of modern houses has continuously dropped. Low energy houses today are totally different than 30 years ago.

On the other hand, PV has improved the efficiency by a factor of 2 and lowered the price by a factor of more than 200 in the last 40 years. Together with an increase in size and lifetime of the PV modules, the overall efficiency increase has been more than 4'000 since 1975!

### 5. Prices are Influenced by the Market Development and Material

The market development of ST and PV have been different since 2010 (Fig. 3). In 2016 (Fig. 4), ST still had more installed power than PV. But the growth rate of PV is much higher what leads to the assumption that PV will still be cheaper in the future even if the growth rate will continue rising.

30 years ago, a PV module with 64 Wp (Solarex MSX 64) and a surface of about 0,5 m<sup>2</sup> had a price of about 500 sFr. (US\$) or 900 sFr. / m<sup>2</sup> (quantity of about 100 modules). A ST collector (Solahart Kf) with a surface of 1,8m<sup>2</sup> had a price of about 900 sFr. or 500 sFr. / m<sup>2</sup>. Today, a PV module with 1,6 m<sup>2</sup> and 300 Wp costs about 150 sFr. and below sFr. 100 / m<sup>2</sup>. The price of the solar collector is still similar. A PV module earns about 200 kWh / m<sup>2</sup> in mid-Europe and costs about 100s FR. / m<sup>2</sup>. The ST flat plate collector earns up to 500 kWh / m<sup>2</sup> for costs of about 500 sFr. Per 100 kWh annual yield, PV is half the price of a flat plate solar thermal collector. The product is on one hand electric energy which costs 25 Rp. / kWh (cent/US\$) and on the other hand thermal energy, which costs about 10 Rp. / kWh. The difference is now a factor of 5.

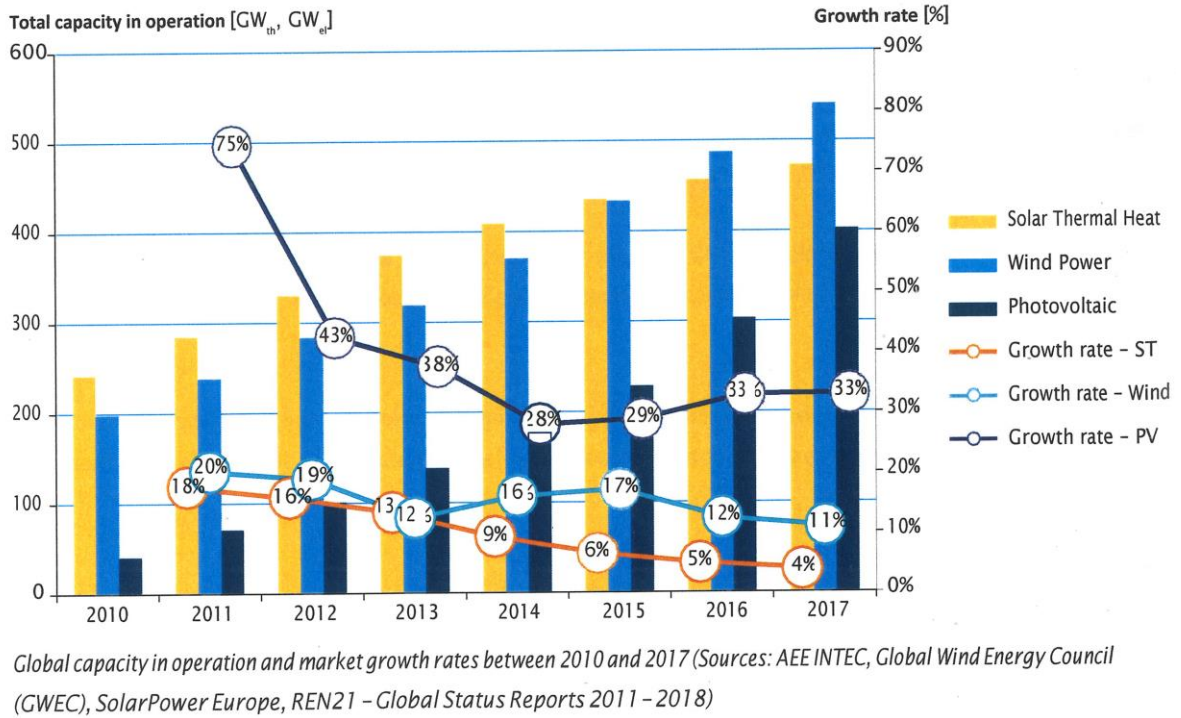


Fig. 3: Market growth rate of ST and PV between 2010-2017 and projections. Sources see Figure.

ST technology utilizes relatively expensive material such as copper for the absorbers of the flat plat collectors. Copper is a relatively rare material. If the production volume goes up, the price follows. In comparison, solar modules are mainly composed of silicon, a cheap material with sizable global resources (no. 2 of all the elements on earth). If more silicon material is used, the mass production drives the price further down. This and the massive production volumes in China pushed the price of PV up in some regions on the globe, what now disrupts the energy industry. These developments might suggest that the ST technology should shift to cheaper material such as, for example, vacuum tube collectors from China. Nevertheless, it is expected that the price gap between PV and ST will continue to grow in future.

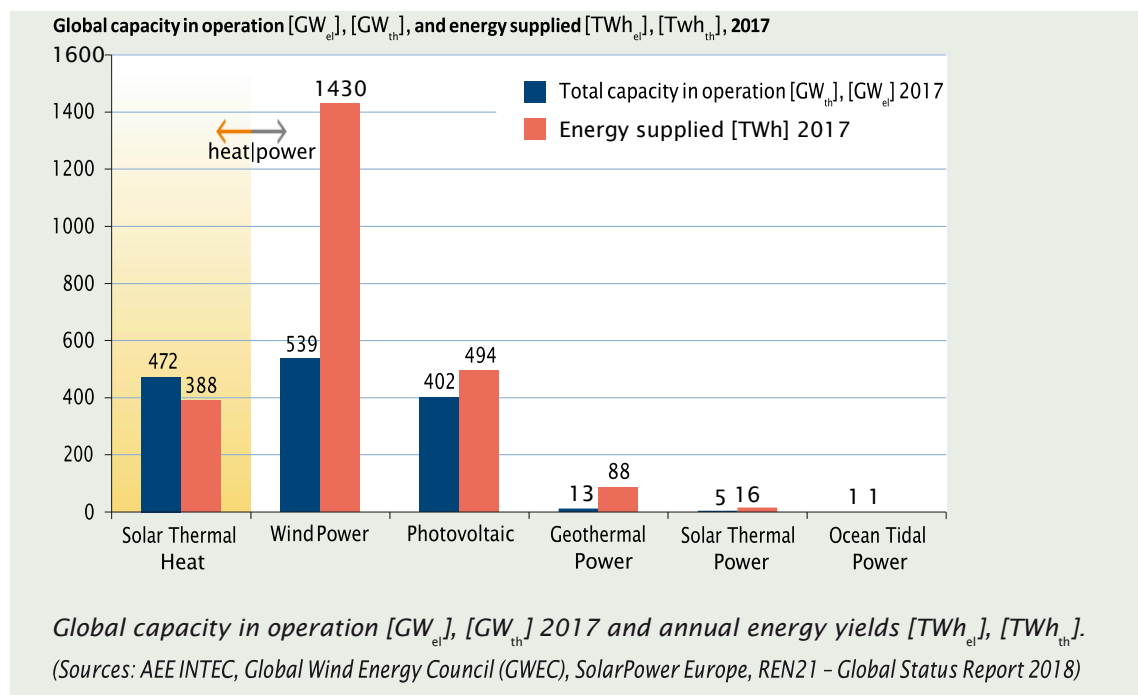


Fig. 4: Total global capacity in operation of new renewable energy, ST and PV in 2017. Source see Figure.

In 2015, the market for ST was 40.2 GW, i.e., a decline of 14%. PV was at 50.9 GWp with a growth of 29%; in 2016, PV sold 76,8GWp (+32%) with a total of 306,5 GWp. In 2017, PV sold over 100 GWp, reaching over 400GWp installed power. The produced energy of PV exceeds the ST energy for the first time (Fig. 4). In 2018, the installed PV power is expected to equal the ST power.

The dependency of the PV market from China is strong (2016: 45%; 2017: <60%) but not so strong as compared to the ST market (China: 75% market share). There are over 20 countries with a PV market over 1 GWp annually. For 2018, a market decline is expected in China. This will drive the price of the PV panels further down and will stimulate the other markets again.

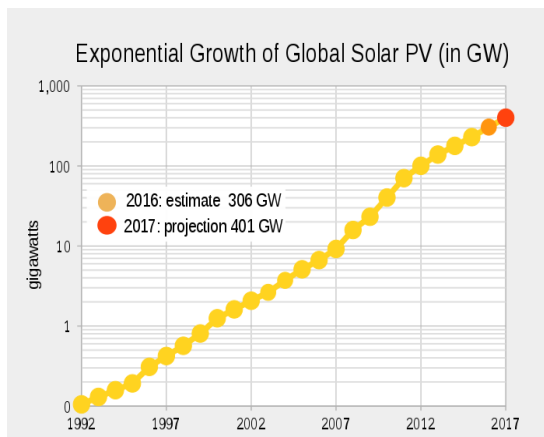


Fig. 5: Strong growth rate of the global PV market.

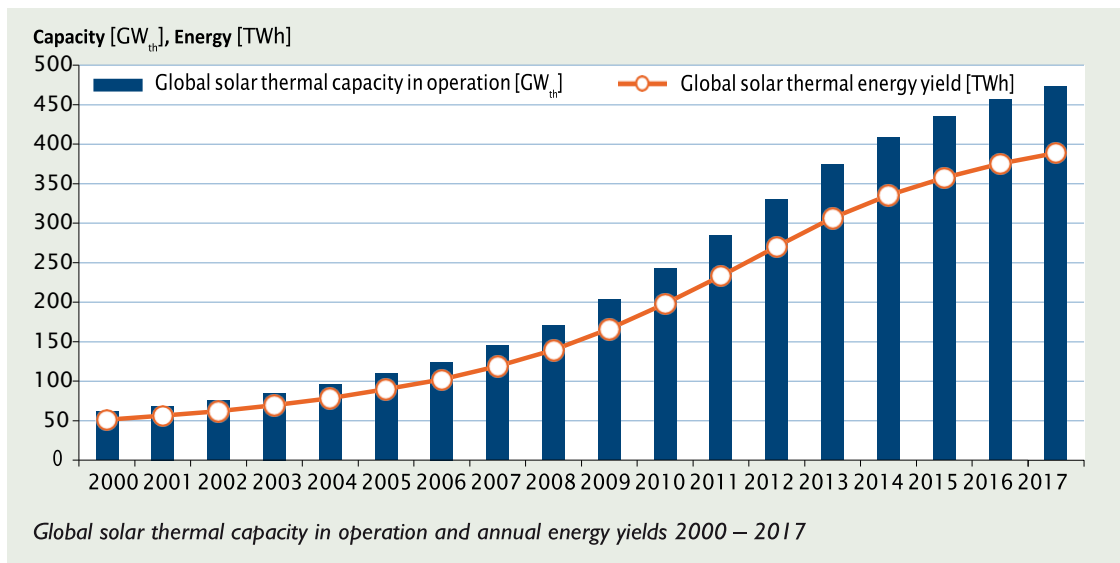


Fig. 6: Stagnation in the solar thermal market.

ST installations are normally small. The biggest plant, a district heating system in Denmark, has an installed power of 110 MW. In comparison, PV systems have reached the 1 GWp size and there are now more than 40 plants over 200 MWP on the globe. PV has a strong market for big utility-size installations. This gives PV a further advantage over ST to drive the “economy of scale” and lower the price of PV installations. For cost-optimized PV plants, prices below 2 cent/US\$/ kWh are realistic.

### 6. Synergies in the Swiss market of PV and ST in the Past

In the past, there has been a significant synergy for solar thermal and PV in the Swiss market. Customers tended to restrict the size (and costs) of the expensive PV installations and added solar thermal installation for hot water and the heating support (Fig. 6). Heating in these houses was / is predominantly with oil, gas or wood and so, a solar thermal installation was an interesting and relative cheap start into the “solar technology”.



Fig. 6: Typical houses of a solar energy consumer around the year 2005. The hot water solar thermal device (left picture) cost about 15'000 sFr. (or US\$). The 6 kWp PV plant (right picture) was about 50-60'000sFr. (Photos: Muntwyler).

### 7. The Energy Consumption in the Last 40 Years

In the last 40 years, the energy consumption in a single-family house went down and/ or has been covered with electricity (see Table 1).

Table 1: Comparison of electricity and energy consumption in 1975 and 2018 in Switzerland. Own calculations.

Application	1975	2018	Due to...
Electricity	Ca. 6,5kWh / person	6,96 kWh / person	Stable due to more but efficient consumers
Hot water	About 50 l / person	Similar	Trend to smaller families
Heating and cooling	220kWh / m <sup>2</sup>	30 kWh / m <sup>2</sup>	<b>Massive reduction:</b> new construction codes
Energy for displacement	900 l gasoline / 9'000kWh	2250 kWh / year	<b>Massive reduction:</b> 15'000km / year

Energy savings in houses led to dramatic decreases in energy consumption for the heating system; with a heat pump by a factor of seven or much more! The figure reflects the new energy guidelines in the energy law for Swiss cantons (MuKen 2014) compared with the standard from 1975. For a 100 m<sup>2</sup> house with a heat pump, 1'000 kWh electricity or less is needed today instead of 22'000 kWh thermal energy in 1975. The installation of heat pumps has declined the need for thermal energy dramatically, even more so as the heat pump for heating and hot water has been the leading technology for thermal energy in Switzerland past the last 40 years. Today, with a PV system of about 8-10 kWp and a heat pump, a “Plushouse” (i.e., a house producing more energy than can be consumed by itself), can be achieved, including the electricity for an EV. This also saves a massive amount of money for the user. The energy need for the car went down at a factor of 4 due to the electric drive train and is electric too.

The electric consumption is stable, but only usable for PV. Only the hot water consumption is the same or went up due to comfort behavior of the consumers in the last 40 years. But the hot water consumption in a single-family house is not stable. Often, these systems are installed in existing houses with elderly people. If the children leave the house, the hot water consumption goes down and the economy of the solar hot water system is gone forever.

The profile of the two technologies (PV and ST) shows strong advantages for PV:

	Strong	6	5	4	3	2	1	Weak
Price/ kWp			PV			ST		
Price/ m <sup>2</sup>		PV			ST			
Price/ kWh			PV		ST			
Efficiency			ST			PV		PV without heat pump
Efficiency with heat pump		PV	ST					
Technical complexity				PV		ST		
Life time			PV		ST			
Flexible in size			PV		ST			
Service + maintenance			PV			ST		
Technical problems in use			ST			PV		Overheating in the system.
Optical appearance			PV		ST			
Subsidize			ST	PV				

It can be expected that PV costs further decline in the future while, at the same time, the lifetime goes up to 40 years. New PV modules with different colors and sizes also fit the requirements of the architects.

A further disadvantage of the ST is the need for a storage tank. Some niche market applications such as swimming pool heating have no tank. ST systems have normally a storage tank. The tank is an expensive, but necessary method to store the heat energy. In contrast, the PV has the philosophy to use the electricity on time. The grid is the “storage”. This is very efficient but not for free. Only in recent times are battery storage systems widely used in certain markets such as Germany. This is the result of a low feed-in tariff for surplus injected electricity and another way to slow down the growth of the PV.

#### **8. Nearly no Synergies between PV and ST in the Future**

In the previous Sections, it has been discussed that the synergy between PV and ST has now disappeared. Today, PV is so cheap that it makes sense to mount a PV installation covering the entire roof. In Switzerland roof-integrated PV installations have a market share of about 20%. This leads to an overproduction of PV electricity. If the electricity can be fed into the grid under a “feed-in-tariff (FIT)” scheme, the maximum economic benefits can be reached. The user then makes profit of the “economy of scale” and can sell each kilowatt-hour electricity to the grid. However, in Switzerland, the “feed-in-tariff” system for PV is closed for new projects and all electricity produced has primarily to be used by the producer itself. The surplus electricity may be sold to the local electricity company at often a very low price (in Switzerland 5-10 cents sFr. / kWh). This has the effect of a “virtual storage” tank and the producer and consumer (= Prosumer) hence look for smart electric consumer. All energy converters such as hot water device, heating system and later an electric car will be turned into an electric consumer to reach a high “own consumption” and to find additional consumers for his “cheap” electricity. This is first the hot water supply, the heating systems and an electric vehicle. They all have a storage system that improves the “own consumption”. A solar hot water system will downgrade this situation. In certain markets, battery storage systems also enhance the “own consumption rate”. In the future, bi-directional EVs can optimize this function. Another important factor is the complexity of solar thermal systems being one of the reasons underlying the disappearance of experienced solar thermal companies from the market in the past. It is hard to find the needed specialists for planning, installation and maintenance. PV on the other hand improved the situation very much. Under such a regime, ST lowers the financial performance of the PV system and ST is pushed out of the market. The argument of the high efficiency and low use of surface is also gone. A PV system with a heat pump can easily reach efficiencies over 50%. In such an efficient “energy world”, ST systems will disappear and only appear in niche markets any more.

#### **9. What are the Niche Markets for Solar Thermal?**

There are still niche markets for solar thermal:

- Very cheap small solar hot water systems in sunny regions (thermosiphon)
- Swimming pool heating - not only in sunny regions
- Big district heating systems (example Denmark)
- Solar thermal electricity plants with night storage
- Solar air collectors for heating and ventilation
- Solar houses with a solar thermal concept (example Jenni Energietechnik AG in Burgdorf, Switzerland)

To remain in or enter these market niches, marketing is crucial. The desire to have hot water available is a strong driver for every human and has an increasingly growing buying power. This opens a huge market for solar hot water systems in developing countries that are often located in sunny climate regions. As more and more electric systems are in use, PV get a higher penetration. For sunny regions, this can be the air conditioning system. Such a house can have an electricity consumption that is almost the same as in a Europe house with a heat pump heating system.

For industrialized countries, ST can be placed in market niches with clever marketing and system concepts. The Swiss ST company Jenni Energietechnik AG sells multi-family houses with huge hot water tanks suitable for a seasonal storage of the heat energy. The product is therefore a 100% heated solar house.

#### **10. PV or ST - the Winner takes it all - or is there still a Market for Solar Thermal?**

The future will see a further growth of PV. This depends on many factors but the worldwide trend for PV is still a growing market. In industrialized countries with heating systems and air conditioning, PV will push ST out of the main markets outside the niches described above. There are several markets for solar thermal. One is for very cheap compact solar hot water systems in the sunbelt-regions. As many regions still don't have a (reliable) grid, PV is more concentrated on small solar home systems (SHS) and micro-grids. On the other hand, in cold alpine climates with high sunshine, solar thermal is still interesting. Solar air systems could find their place in such systems. In the range of big system, the district heating is a market for solar thermal systems, too.

Switzerland currently needs about 60 TWh of electricity, which are mainly produced by hydro- and nuclear power. PV contributes about 3%. In the “Swiss Energy Strategy 2050” of the government, the five nuclear power

plants will be phased out in the future. The replacement is mainly PV, wind, geothermal and other renewable sources such as small hydro, waste combustion etc. PV is expected to produce about 12 TWh (1,5 kWp or 8-12 m<sup>2</sup> per person). Considering the low possibility for geothermal, the problems with the construction of wind power sites in Switzerland and new consumers such as EVs, up to 24 GWp PV production are possible (3kWp or 15-20m<sup>2</sup> per person). As Swiss utilities own more than 6TWh wind energy outside Switzerland, wind is expected to fill the electricity gap in the winter.

The Swiss PV market needs to grow from 300 MWp to 600 - 1'000 MWp each year to fulfill the targets of the Swiss "Energy Strategy 2050" and to cover the needs of 5 million electric vehicles. The worldwide PV market needs to grow from 100 GWp to 1'000 GWp and more.

The solar thermal market will still be under pressure as the demand for heating is going down. Clever marketing strategies for 100% multi-level houses could open a very small market niche in Switzerland. Small hot water systems will increasingly be replaced by PV and heat pumps. Unfortunately, the market of district heating has never been tackled in Switzerland so far. In the big picture, PV will be the dominant technology in the active solar applications in Switzerland. Here, it's the winner that takes it all!

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