ELECTRICITY AND HEAT FROM THE GLARNER SUN

Solar energy can be converted into warm water with solar collectors and into electricity with PV panels. The combination of the two methods in hybrid panels (PVT panels) promises a particularly high energy yield. Despite many efforts, PVT panels have to date only been used in special applications. A solar roof in Näfels (GL) has tested the PVT technology in a new setting. The concept is suitable for consumers with large hot water demands in summer.

Jürg Rohrer, Professor of Ecological Engineering at the ZHAW in Wädenswil, behind the PVT solar panels on the roof of Lintharena sgu in Näfels (GL). In the background: PV panels (from the outside they look identical). Photo: B. Vogel

A technical report about the results of a pilot and demonstration project in the field of photovoltaics, which is financially supported by the Swiss Federal Office of Energy. The report has been published on the website www.ee-news.ch (26.09.2016).

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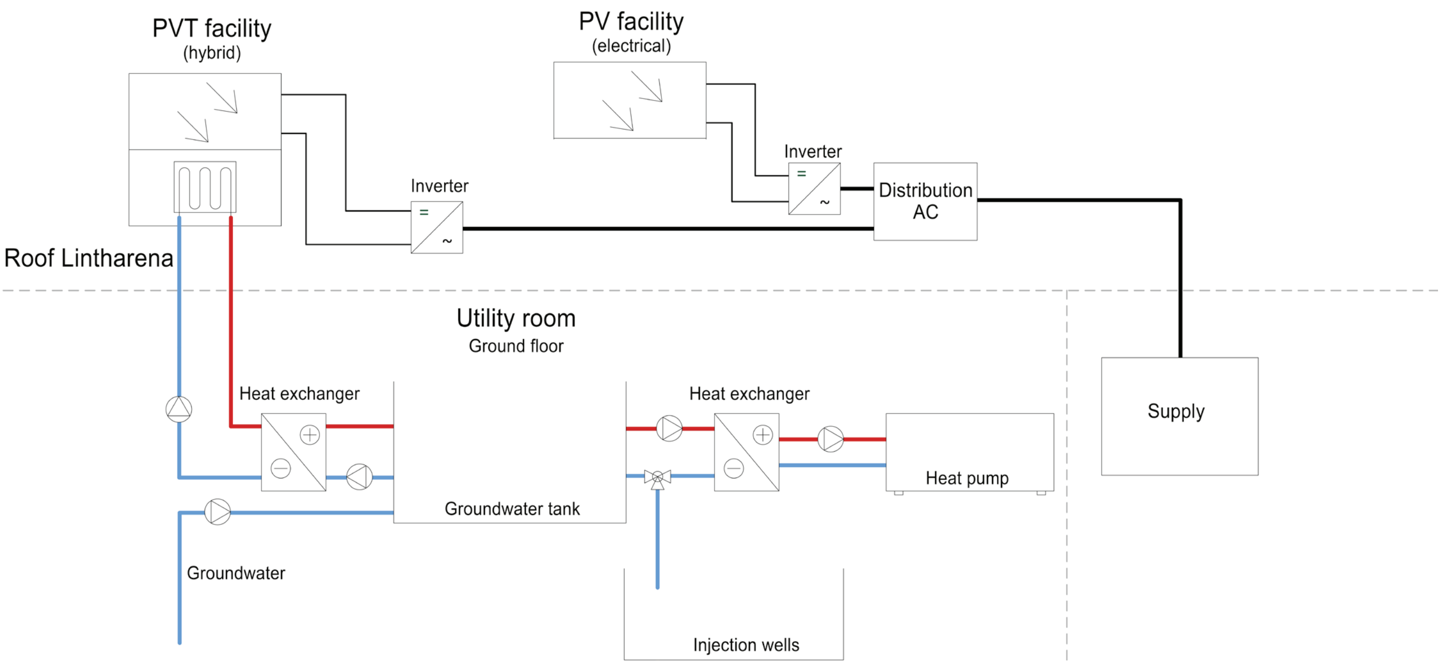
Glarus is a mountainous state. Anyone traveling from the villiage of Ziegelbrücke toward central Glarus is accompanied by proud mountain ridges on both sides of the valley. In the valley the sun rises a bit later and sets a little earlier. On the other hand there is less fog than in some other places in central Switzerland—so the use of solar energy has a chance. The EnergieAllianz of Linth has decided to seize this opportunity. The association wants to increase the self-sufficiency of the region with renewable energy. With financial support from SFOE, the state of Glarus, Service 7000, Meyer Burger, glarnerSach and Glarner State bank, the Alliance took this initiative to the roofs of Lintharena—a sport, hotel and leisure complex on the outskirts of Näfels. In March of 2015 a large solar plant went into operation. It consists of 880 solar panels with an area of 1400 m^2 and a peak power of 237 kWp that produces approximately 225,000 kWh of electricity annually, enough to meet the electricity needs of 75 energy-efficient homes.

The heat exchanger (blue) absorbs the heat from the solar circuit and supplies it to the groundwater, which is stored in the groundwater tank (brown). Photo: B. Vogel

This alone, however, would not be reason enough to make the system a pilot and demonstration project of the Swiss Federal Office of Energy. This facility was awarded this designation because in addition to electricity it also provides hot water through a novel solar concept: Just under a quarter of the panels (178 pieces with an area of 285 m^2) are in fact hybrid PVT panels that produce electricity and hot water. Thus with a thermal output of 160 kW per year, the system also provides approximately 165,000 kWh of energy in the form of hot water.

This water is used in the Lintharena all year for showers, other hotel needs, the indoor swimming pool and other purposes. The entire solar roof could have been equipped with solar



Functional diagram of the solar system on the roof of Lintharena sgu: The electricity from the PV panels (top center) is fed into the grid. The PVT collectors (top left) produce electricity and heat. The heat passes through a heat exchanger in the groundwater tank and is used from there to operate the heat pump. Subsequently, the groundwater in the soil is again supplied via the injection wells. Illustration: ZHAW Wädenswil

PVT panels. But they were only installed on part of the area to match warm water production to actual needs—and to limit costs of installing additional PVT collectors.

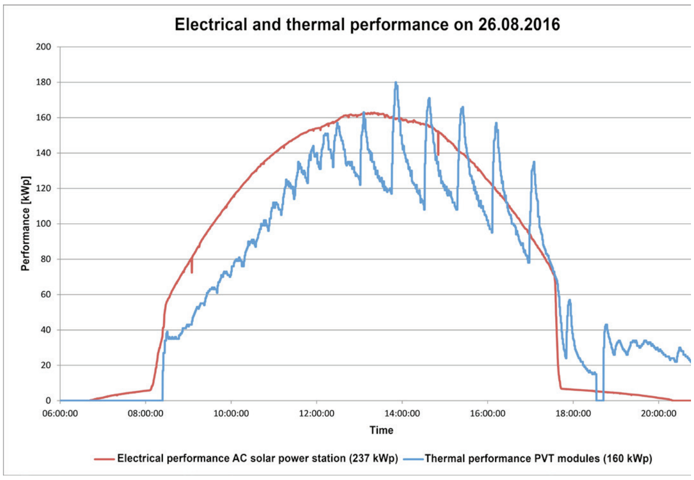
New PVT Concept for Use with Groundwater

Researchers have been developing PVT panels for decades. So far, they have not prevailed widely in the market, however. This is primarily because they were developed mainly for heat production without increasing electricity production at the same time (by panel cooling). They were also not developed before the cost of PV panels went down. Well tested to date is the use of PVT modules in systems that use solar heat for the regeneration of geothermal probe fields. Here the solar heat from the summer months is stored deep in the ground, where it can be then accessed in the winter months by heat pumps (for example, the SFOE flagship project in Reka holiday Village Blatten (VS), described in the technical article 'Kissed twice by the sun' available at www.bfe.admin.ch/ct/solar). In Switzerland the PVT project in Näfels is on a new and unique path: the warm water produced by the hybrid collectors is not stored but used directly to provide the warm water needs of Lintharena (see Box p.4).

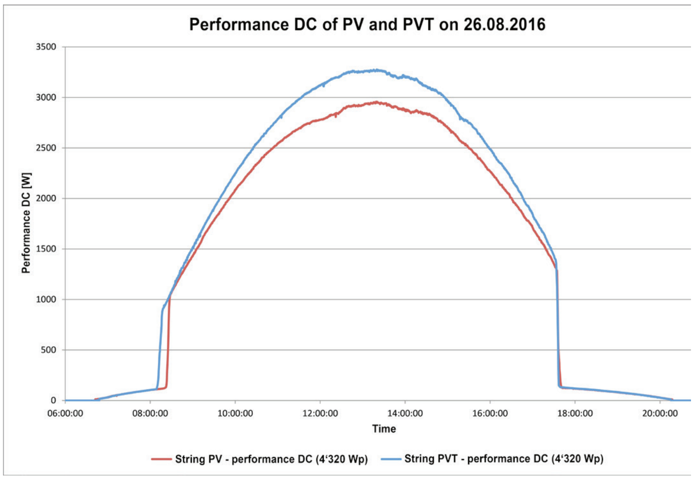
The PVT system in Näfels is thus designed for the direct consumption of heat. The system is custom tailored for environments that have a significant demand for hot water in summer. "I am personally convinced that PVT panels are a sensible solution for selected applications such as sports and leisure facilities as well as hotels or in conjunction with geothermal probes in larger apartment buildings or commercial buildings. For family houses we are developing together with Meyer Burger a solution as an alternative to air-water heat pumps. With significant contribution from public players in the region, we have with the Glarus project achieved the ability to not only use domestic energy, but also to keep added-value in the region," says Jürg Rohrer, President of EnergieAllianz Linth and Professor of Ecological Engineering at the Zurich University of Applied Sciences (ZHAW) in Wädenswil.

So far, about 5% more power thanks PVT

The positive experience of the first year of operation is confirmed by Jürg Rohrer's assessment of the hybrid technology: "The installation of the PVT panels by solar technicians went smoothly and could be done by the same company that erected the PV panels. The hybrid collectors are technically mature and work perfectly. The up to date analyses confirm previous reports that PVT collectors generate more electricity than PV panels, thanks to cooling by thermal fluid. According to the latest measurements, the increase in yield is around 5%, which conforms exactly to our simulation of a typical climate-year. With the optimization of system controls, we hope to increase this amount by 3 to 4 percentage points." The extra yield has a positive effect on the cost-effectiveness of PVT collectors. For the Lintharena project, the PVT panels were about twice as expensive as the rooftop installed PV panels. Thanks to the pre-heating of groundwater, the heat pumps save around 25,000 kWh of electricity per year. This



Recording the course of the thermal and electrical performance over a day. The fluctuations of the thermal power supplied by different supply temperatures, which are caused by the operation of the heat pump. Graphic: ZHAW Wädenswil

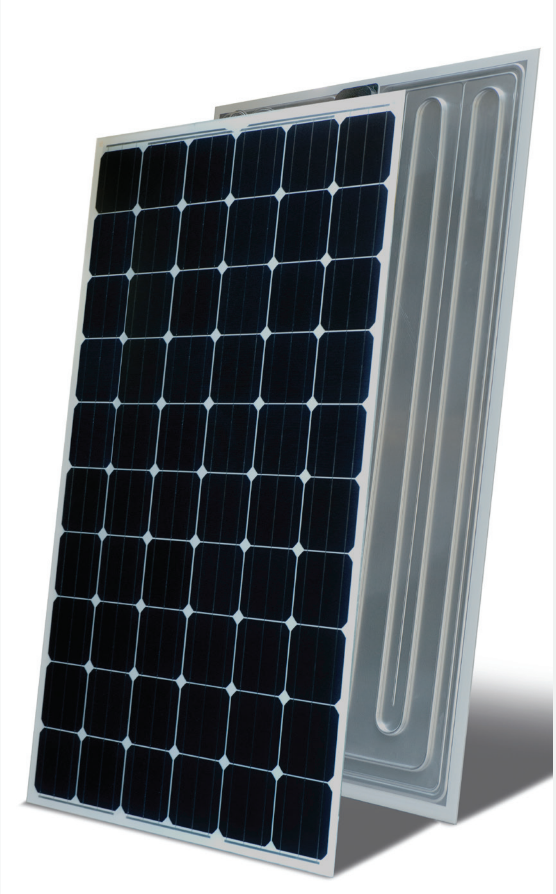


Comparison of DC power between a PV and a PVT cable with the same number of panels and thus the same electric nominal output shows that throughout the day, one fine day in August, the cooling of the PVT panels has a positive effect on performance. The PVT cable produced about 10% more electrical energy than the PV cable. Graphic: ZHAW Wädenswil effect is significantly greater in the demonstration plant than the increase in yield of the PVT panels by cooling. Whether the PVT panels over the long term are equal to PV panels from an economic perspective will be shown in the coming years by the SFOE supported measurement campaign.

According to findings by Jürg Rohrer, Swiss municipalities make numerous inquiries to use PVT technology. Consequently, the hybrid technology experts at ZHAW Wädenswil have calculated through several projects that would like to use the PVT panels, to heat swimming pools before and af-

THE SECRET OF OPTIMAL CONTROL

PVT panels are PV panels that are fitted with an absorber on the back. Thermal fluid flows through the absorber to transport heat from the collector. On hot summer afternoons, a PV panel on the roof of Lintharena sgu typically reaches temperatures of 54 °C. At the same time, PVT panels reach only about 35 °C because part of the heat is dissipated through the thermal fluid. This cooling is the reason why PVT panels produce a higher electricity yield than PV panels, which experience decreases in performance with increasing panel temperature. During the project, the yield of PVT panels is expected to improve in the future.



On the roof of Lintharena in Näfels are uncovered hybrid modules made by Meyer Burger, which are manufactured in Switzerland. They produce low temperature heat with high yields. With increasing temperature of the warm water produced, the thermal (and electrical) yield decreases. Conseqeuntly, in Näfels the direct use for hot water production will be avoided. Instead, the heat will be used to warm groundwater via a heat exchanger, which will subsequently be used in two heat pumps to produce hot water for Lintharena. This makes it possible to achieve high thermal yields.

The PVT system consists of three cycles: first, the thermal fluid circuit of the solar collectors, second, the groundwater circuit of the heat pump, and third, the hot water circuit. In the first months of operation, the heat pump operated on demand as usual: they then went into operation when the tanks of the warm water circuit were empty; thereby continuous operation of the heat pump could be been achieved. This operation mode is suboptimal from the perspective of the PVT system; the aim of the PVT operators is to transport away as much heat as possible, which is then only possible if the inflow in the thermal fluid circuit is as cool as possible. The higher the inflow temperature of the thermal fluid circuit, the less likely that the PVT modules can be cooled, which reduces the efficiency of power generation. To avoid this, the heat pump must start running when the panels generate a lot of heat.

"We want to take the heat pump into operation,when the water in the groundwater reservoir reaches a value of 25 °C," Rohrer said about the new operating concept, which will be evaluated during the course of the five-year measurement and test period. The scope for corrections is however limited. The groundwater is now warmer than when the system plans were adopted—10 to 12 °C instead of 5 to 13 °C. But the heat pump benefits from this as the higher inflow temperature improves numerical efficiency over the course of the year. However, it will be difficult to cool the PVT panels with the higher temperatures such that they can make full use of their advantages in the production of electricity. BV ter the bathing season or even in the winter, for example. However, studies have shown that the heat production is not sufficient for a year-round operation and extending the swimming season must supplemented by covering the swimming pool overnight. For Jürg Rohrer, communities remain an important target group for the combination of PVT collectors and the use of groundwater: "Whether the use makes sense, depends on each individual case."

↗ For more **information** on the project, please contact Dr. Stefan Oberholzer (stefan.oberholzer [at] bfe.admin.ch), head of the BFE-research program photovoltaics.

↗ Additional **technical papers** on research, pilot, demonstration and flagship projects in the photovoltaic sector are available here: www.bfe.admin.ch/CT/PV.

PILOT, DEMONSTRATION AND FLAGSHIP PROJECTS

The innovative solar design on the roof of Lintharena sgu in Näfels (GL) is one of the pilot, demonstration and flaghsip projects with which the Swiss Federal Office of Energy (SFOE) promotes the economical and rational use of energy and is driving the use of renewable energy. The SFOE promotes pilot, demonstration and flagship projects with 40% of the eligible costs. Applications may be submitted any time.

↗ **Information**:
www.bfe.admin.ch/pilotdemonstration
www.bfe.admin.ch/leuchtturmprogramm

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