Lightning at the touch of a button: Extreme situations can be simulated in the high voltage room at the HTI PV laboratory.

Theories for the industry

The HTI is the leading PV R&D lab for solar system quality testing in Switzerland

Whether it has to do with the efficiency of inverters, system damage caused by lightning, or even yields of solar modules in Jungfraujoch, the PV lab at the Bern School of Engineering and Information Technology has a finger in every pie. Under the guidance of professor Heinrich Häberlin, the group is not only well known in Switzerland for its evaluation of PV system technology, it is an important part of the bright PV research scene.

Dirk Hasskarl / photon-pictures.com (2)

Irradiation sensor and calibrated reference solar cell.

When the rapeseed is in bloom, Heinrich Häberlin sees it immediately in his PV system yield. »The rapeseed pollen is the worst,« says the professor from the School of Engineering and Information Technology (HTI) based in Burgdorf. The pollen covers the solar module with a film, and this can cause a loss in yields of quite a few percent. However, many other sources of dirt from the air or algae vegetation can detrimentally affect the yield of the modules: »Losses of up to 10 percent in yields are possible if the modules are not cleaned,« estimates Häberlin. He has derived this from testing modules that he only cleans every four years for research purposes.

But the engineer from Burgdorf certainly doesn't only deal with the yields of the 60 kW system installed on the roof of the HTI. He is interested in all solar technologies available on the market. The PV lab of the HTI specializes particularly in inverters.

Product testing has been part of his work for many years. »When I read that a new inverter is said to achieve an efficiency of 98 percent,« says Häberlin, »I order this device to check it.« The necessary equipment – a system that simulates the output of solar modules – was developed by students under the professor's guidance. And the tests quite often show that the units do not perform exactly as they should: »Efficiencies in the brochure quite often have a marketing add-on of 1 to 2 percent,« says Häberlin. But the numbers being published are getting ever more realistic: »In the past the discrepancies were even larger – but now the actual values are getting closer and closer to the figures listed in the brochures.«

Years of working in this profession is what allows Häberlin to identify such trends. The engineer founded

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»When I read about an efficiency of 98 percent, I order this device to check it.«

Heinrich Häberlin, HTI Burgdorf

the PV lab in 1988 after he had installed a first stand-alone system with a power of 1.2 kW the year before. The first grid-connected system was added in 1988 and the large roof-mounted system in 1992. »We were only able to build those when Burgdorf introduced the first cost-covering tariff,« says Häberlin. The school isn't very well funded, and the PV system is an all the more welcome source of income for the teaching and research departments: »I finance projects at the school from the feed-in tariff.«

Using in part technology developed in-house, HTI PV components are put to the test – here is the module testing site.

Know-how

The spectrum of Häberlin's work is very wide. He measures solar modules on the roof to diagnose the aging process. He alters the angle of the modules to survey the changes in the yield data and to study the different levels of self-cleaning for the module surfaces from the rain. He analyzes inverters looking at their electromagnetic compatibility and also does long-term tests.

Therefore the professor is aware that a lot has happened with inverters over the last few years: until 1993, he says, units were ruined every so often if they received a ripple control signal from the grid, for example. »Luckily, that is not a problem anymore.« However, he says there are still problems with electromagnetic compatibility (EMC): »Each newcomer first has to learn how to get it under control.« Those who have been in the business for a long time have enough experience, he says, »but with new players, especially those from the Far East, one always has to take a look at it.« Laypeople also notice the corresponding failures when the radio shortwave reception is disturbed. However, the EMC measuring process at the school – also partially developed in-house – makes more exact checks possible.

Häberlin also developed a sun simulator with students. The luminescent tubes emit up to 500 W per m² onto the modules in the test chamber. This makes it possible to reproduce measurement parameters. The tubes in the case don't emit light within the solar spectrum norms and only achieve half the energy set out in standard testing conditions (STC). However, these limitations are not so much of a worry for the professor: »The device is used mostly for training purposes.«

With as much progress as has been made in the PV sector, not every development gets Häberlin's personal approval. He actually prefers inverters with transformers, unlike the majority of manufacturers nowadays, as he has experienced the least amount of failures with these devices. He is also critical of the trend of PV systems having higher and higher voltages on the DC side: »I personally wouldn't work with more than a couple of hundred volts,« he comments, adding that there is not enough experience of working with high voltages over an extended period when it comes to the durability of insulation.

Tests for the industry

Even famous contractors go and see Häberlin – such as the renowned Swiss balloonist Bertrand Piccard from Lausanne. Having circled the world in a hot-air balloon, he now wants to do the same with a solar airplane (see PI 2/2004, p. 14). »We are testing the energy converter that Piccard wants to have on board,« he says proudly. »The technology has to handle temperatures between -40 and +70 °C,« he explains. Moreover, the tracking behavior of the system is also being checked, and this ensures that the PV electricity generation is always at the maximum power point (MPP). Piccard wants to start the trip next year.

Most customers are typically not circumnavigators of the globe but rather companies from the solar industry. Some manufacturers, primarily those that produce inverters, want to have their goods evaluated by the critical experts in the PV lab. »Then the companies have to pay of course,« he comments. This kind of commercial activity is covering a growing part of his research budget.

Although the work is traditionally industry-oriented, it is also sometimes the case that the analysis HTI makes

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Fresh air: The in-house system on the roof of the school is just one of many to have its work logged by the PV lab.

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doesn't always provide clear suggestions for product development. There is a conflict of objectives, Häberlin explains, using module design as an example. When he looks at his test installation he can see quite clearly that the bottom edge of the framed modules collects dirt, and moss grows there, too. »In this case frameless modules are better of course,« says the engineer. But then he goes to his cellar and takes a look at the modules in the high voltage room, where simulated lightning strikes pelt down or are discharged by the lightning rod installed. »Thereby I recognize that the framed modules sustain the voltages three to five times better,« he says. The bypass diodes are the critical point here. In short? Says Häberlin, »Ideal modules would be those that still have a complete frame, but whose bottom frame is designed in a way that no dirt can collect there.«

Häberlin is unarguably the go-to practitioner of Swiss PV R&D and the tester of system technologies. However, Switzerland also has other aspects of PV research covered. The Institute of Microtechnology from the University of Neuchâtel is researching certain thin-film cells together with Unaxis AG, a company offering deposition systems to the PV industry. The thin-film cells are labeled as micromorph – meaning they have two different layers of silicon: one of microcrystalline and the other of amorphous silicon.

A research group from the Laboratory for Solid-State Physics of the Swiss Federal Institute of Technology Zurich (ETH) is working on CIGS thin-film cells that are not deposited onto glass or metal, but rather plastic foil. The cells are thus extremely light and flexible and can be put onto textiles, for example. A global name for solar R&D is also the Ecole Polytechnique Fédérale de Lausanne (EPFL), where Michael Grätzel, the inventor of dye-sensitized cells (DSC), has been working on the technology for years. DSC cells absorb the light via organic dye rather than using a semiconductor material. Then there's the solar energy lab LEEE TISO (Laboratorio Energia Ecologia Economia) based in Canobbio-Lugano. System technology is also a topic of interest at the Interstate University of Applied Sciences of Technology Buchs (NTB) based in St. Gallen.

Be that as it may, the most well known product tester and researcher in the field of Swiss PV is still Häberlin. On his computer he has an overview of many PV systems in different places throughout Switzerland. One of these is a ground-mounted installation at Mont Soleil at an altitude of 1,270 m with 550 kW of power. Another is a facade-integrated system in Jungfraujoch at an altitude of 3,454 m, and there is also an 855 kW system installed on the soccer stadium in Bern-Wankdorf. He also has many smaller installations listed. Practical conclusions can be made from making comparisons here. »Facade installations make sense in the Alps,« says Häberlin. They do not collect snow and also have the advantage that they produce a disproportionately large yield when the sun is low in the sky during the winter. The system in Jungfraujoch, which produced a record value of 1,537 kWh per kW of installed power in 2005, is reported to produce 48.5 percent of its annual yield in winter. Häberlin explains that utilizing such locations by installing unusually-placed modules will become more and more important as more PV electricity is being fed into the grid. Facade installations could help balance out the seasonal effects on PV electricity generation – »and we will need that in the future,« says Häberlin.

Dirk Hasskarl / photon-pictures.com

Research and teaching: Besides the four full-time employees, PhD students and other HTI students work in the PV lab.

The engineer likes to think far in advance. He is already concerned with questions of how the electricity grid and the generation structures will have to be altered in the future if PV is to contribute a considerable amount to the energy mix. Which new transport and storage capacities will become necessary? How will PV interact with the other renewable energies? But right now these are questions for the distant future – PV currently only contributes 0.03 percent to the mix in Switzerland.

But Häberlin is hoping for such a huge development in PV that the solar branch one day will likewise need to confront these questions. He has no doubt that the technical challenges can be overcome. Perhaps even the use of »anti-adhesion layers« could possibly become widespread to solve the problem of rapeseed pollen.

Bernward Janzing