Name of research institute or organization:

Bern University of Applied Sciences BFH, Photovoltaic Laboratory

Title of project:

Long-term study on the efficiency of photovoltaics at alpine sites

Project leader and team:

Prof. Urs Muntwyler, project leader
Dipl. El.-Ing. HTL Thomas Schott, assistant
PD Dr. Eva Schüpbach, senior consultant

Project description:

1. New Photovoltaic Power Installation

In 2013, the opportunity was seized to plan the extension of the 1993 Jungfraujoch PV installation with new technology, as renovations were scheduled on the façade of the Jungfraujoch research building operated by the "International Foundation High Altitude Research Stations Jungfraujoch and Gornergrat" (www.hfsjg.ch). The planning work was carried out by a Bachelor student registered at BFH and supervised by PV LAB staff. The underlying idea was to mount the most recent technology alongside the existing 20 year old technology.

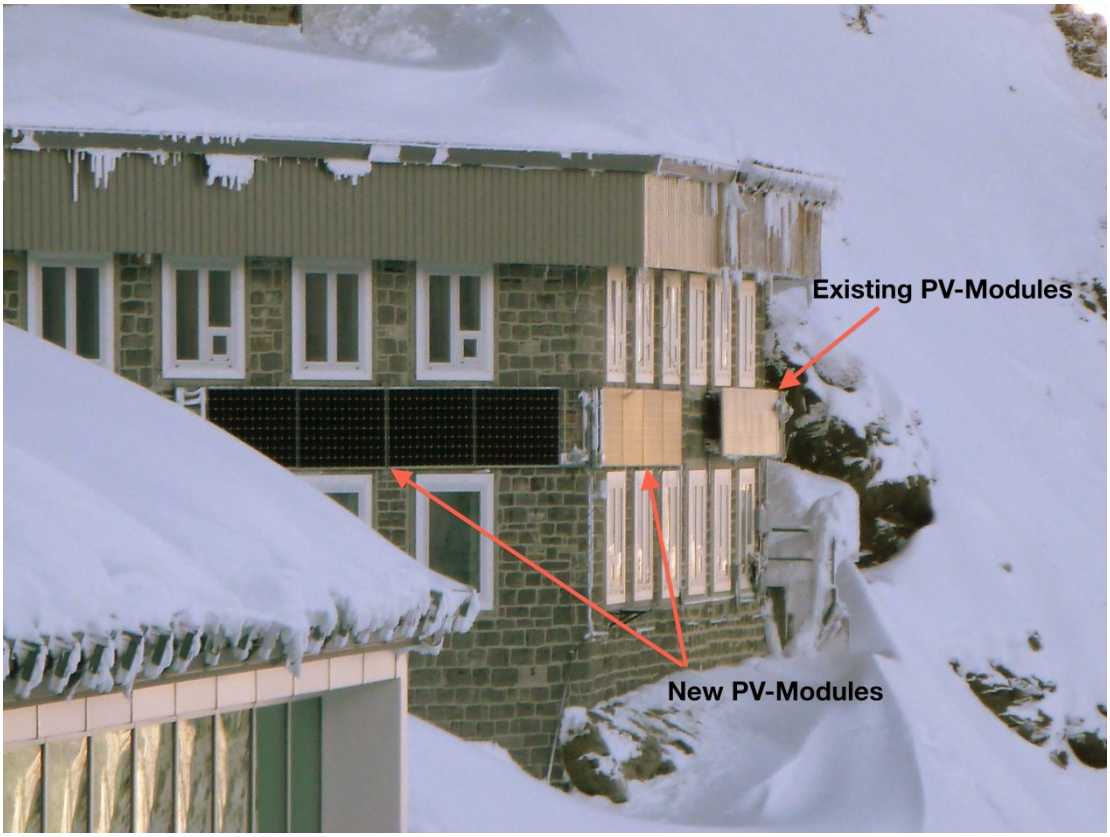

Figure 1. The extension mounted at Jungfraujoch in 2014 with new PV modules on the south and southwest wall (installations on the left) is located near the already existing PV installation from 1993 with 1'152 Wp (installation on the right).

The extension (new PV modules) was mounted on the south and southwest wall of the Jungfraujoch research building (Figure 1) in September and October 2014, close to the already existing PV installation, which allows new insight into alpine PV production through the comparison of photovoltaic technology.

With an area of 13m^2, the new installation in 2014 is only slightly bigger (30%) than the existing PV installation from 1993 with 10m^2. However, because of the increased efficiency (of 21%) of the new PV installation mounted in 2014, the energy yield is expected to amount to 2'760Wp, as compared to the energy yield of 1'152Wp from the PV installation mounted in 1993. In conclusion, the new technology is expected to produce at least 2.4 times the energy yield of the PV-modules from 1993.

While the existing installation from 1993 uses one grid-connected inverter of 2.5kW output power to push the PV-energy in the 230V grid, the new installation mounted in 2014 uses two inverters of 3kW output power each (Figure 2). Every inverter is connected to one of the 3 phases of the 230V/400V three-phase electric power grid.

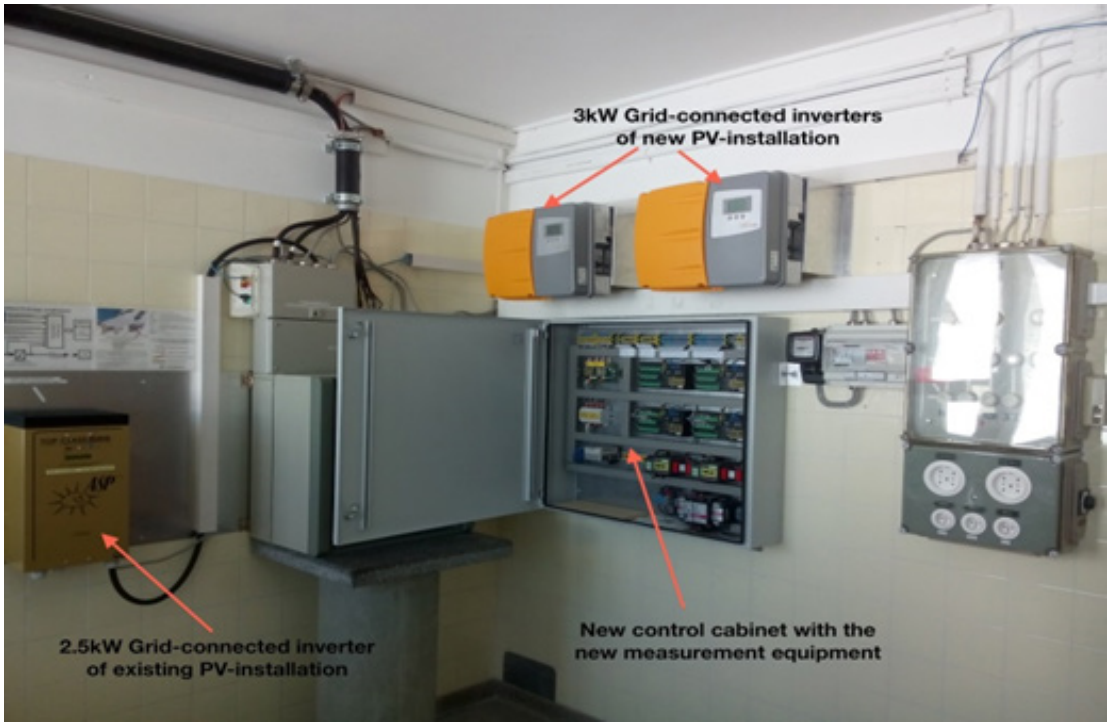

Figure 2. The two new grid-connected inverters and the new measuring equipment.

2. Conference and Workshop

The Photovoltaic Laboratory (PV LAB; www.pvtest.ch) at Bern University of Applied Sciences (BFH) in Burgdorf, Switzerland, has been working on energy yields from alpine PV installations for more than 20 years. To celebrate the opening of the new PV installation at Jungfraujoch, a workshop on electricity production with alpine PV installations was hence organised on 3-4 October 2014 that assembled international experts in the field and attracted media coverage. The workshop results confirmed that cold temperatury (specifically in winter) cause the solarcells of the modules to work more efficiently and produce bigger energy yields. This effect is aided by the reflection of the solar radiation by the glacier and permanent snow surrounding the PV installation at Jungfraujoch, offering additional convertible sunlight to the solarcells.

Figure 3. Workshop on "Hochalpine PV-Anlagen zur Energiewende" at BFH Burgdorf, Switzerland.

Figure 4. Dr. Heinrich Häberlin.

Prof. emer. Dr. Heinrich Häberlin (Figure 4) evidenced that the earnings of electricity over a year are about 45% - 75% higher at Jungfraujoch than measured at a PV installation at lower elevation in the Swiss basin.

Figures 5 and 6 show two graphs with normalized mean seasonal variations of energy earnings. Figure 5 is a typical earning in the Swiss basin, while Figure 6 shows the earning of Jungfraujoch. The higher earning of energy in the Alps is predominant in the winter season.

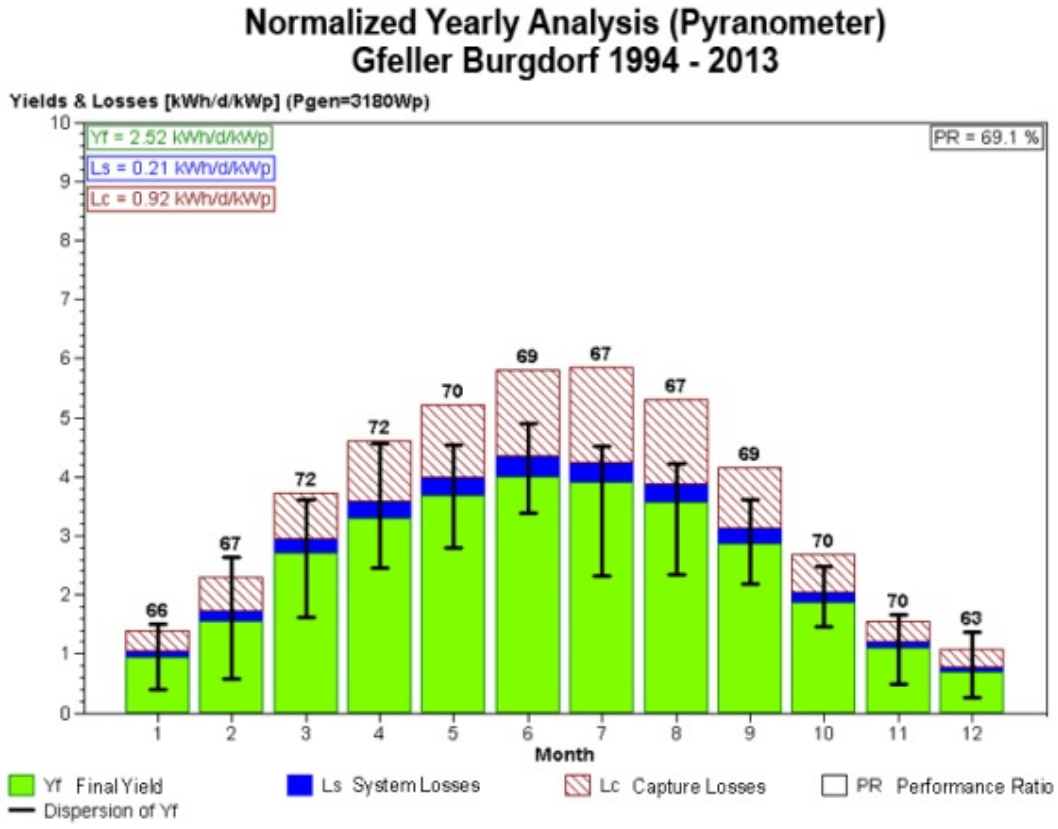

Figure 5. Typical energy production with a photovoltaic power plant in the Swiss basin (big earnings in the summer, low earnings in the winter).

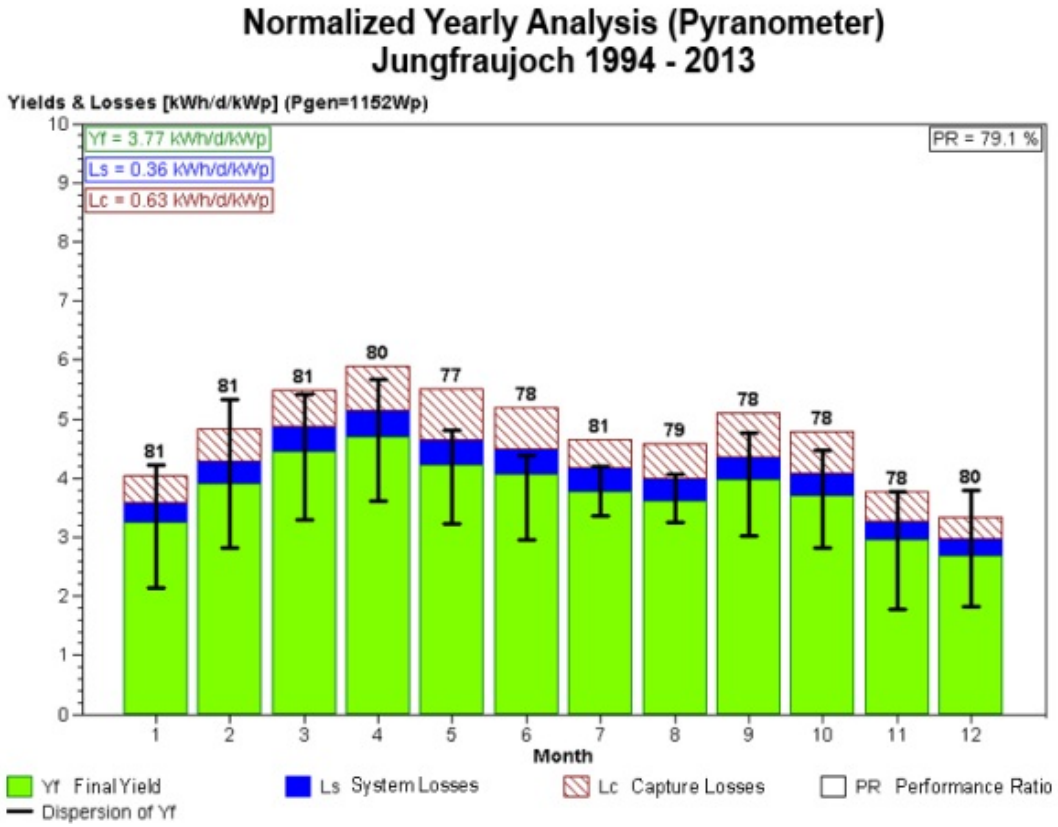

Figure 6. Distribution of energy produced with the photovoltaic power plant at Jungfraujoch evidencing a smaller seasonal variation than at PV installations in the Swiss basin (shown in Figure 5).

After 2014, research on the above mentioned issues is carried further in the framework of the SCCER FURIES, a new Swiss Competence Center for Energy Research (http://sccer-furies.epfl.ch/).

Key words:

Photovoltaics, energy yields, seasonality, winter production, alpine PV installations, long-term stability, technology

Internet data bases:

http://pvtest.ch

Collaborating partners/networks:

Studiengesellschaft Mont Soleil Les Brenet, University of Bern, SCCER-FURIES, Sputnik Engineering, GVB

Scientific publications and public outreach 2014:

Conference Papers

Häberlin, H., M. Jost, PV-Anlage Jungfraujoch: 20 Jahre störungsfreier Betrieb mit Spitzen-Energieerträgen und kaum Degradation, 12. Nationale Photovoltaik-Tagung 2014, Lausanne, Switzerland, April 10-11, 2014.

Schuepbach, E., U. Muntwyler, M. Jost, T. Schott, Long-Term Performance of Swiss Photovoltaic (PV) Installations, 29th European Photovoltaic Solar Energy Conference and Exhibition, Amsterdam, The Netherlands, September 22-26, 2014.

Magazine and Newspapers articles

"Positive Bilanz der netzgekoppelten PV-Anlage auf dem Jungfraujoch nach 20 Jahren Betrieb - Störungsfreier Betrieb und kaum Degradation", Elektrotechnik, **5,** 2014.
http://pvtest.ch/fileadmin/user_upload/lab1/pv/publikationen/14_ET_20Jahre_PV-Anlage_Jungfraujoch.pdf

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