Name of research institute or organization:

Berner Fachhochschule BFH, Labor für Photovoltaik (PV LAB)

Title of project:

Long term study for the efficency of photovoltaic elements in the high mountains

Project leader and team:

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El.-Ing. BSC / MSE BFH Franziska Kuonen Assistant
PD Dr. Eva Schüpbach, Senior Research Consultant

Project description:

1. Introduction

Since the 1980s, the PV LAB at BFH Burgdorf in Switzerland has continuously strengthened its research efforts on the performance measurements of alpine PV-installations. From 2014 - 2015, the existing PV-installation at Jungfraujoch was extended and - in 2016 - the electrical measurement equipment was modernized.

2. Modernization of the electrical measuring instruments

Modernization aimed at ensuring that both PV-installations (from 1993 and 2014), see Figure 1, can be measured by only one suite of equipment. Hence, the internal measuring instruments for current, voltage etc. of the "old" PV-installation (1993) were replaced by new instruments, and all connections to the "old" PV-installation (1993) were rewired to the new cabinet. The loggers were also replaced and their software was updated. This work was completed in April 2016.

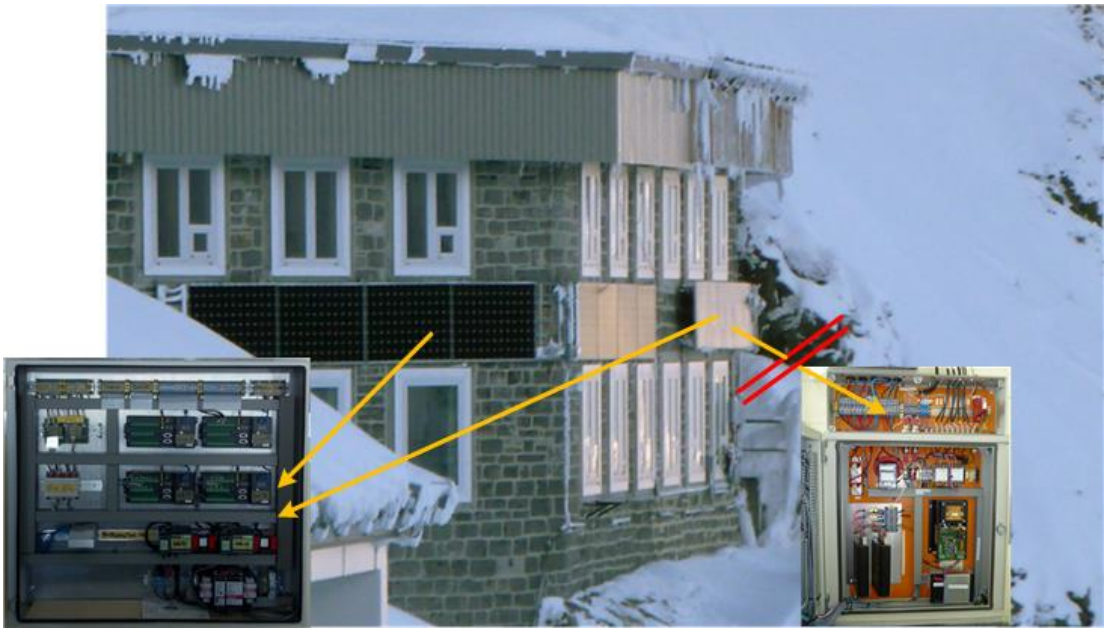

Figure 1. PV-installations at the façades of the research building at Jungfraujoch (installations from 2014 (left) and 1993 (right)) and measurement equipment (located inside the research building at Jungfraujoch). The entire electronics in the old housing was replaced by new components in the new cabinet.

3. Modernization of the public display board in the station of the Jungfraubahn

3.1. Development of new public display board

The modernization and electronic update of the PV-installation at Jungfraujoch does not only serve long-term studies on energy yields as conducted by the PV LAB at BFH. But it was also a requirement for the development of a new public display board in the building of the Jungfraujoch railway station.

This public information board (Figure 2) dates back to 1993, when the first photovoltaic test-installations at Jungfraujoch were carried out by the PV LAB at BFH. The board is equipped with two point meters that display the actual electrical energy yield and the actual solar irradiation. Through a copper cable, a 0 mA to 20 mA current signal to each point meter is transmitted; the signals correspond to the measurements of the energy yield produced from photovoltaics. As the point meters do not need any additional power supply, the board is self-sufficient.

Figure 2. The public display board at the Jungfraujoch railway station; the two pointer meters are located in the middle.

As point meters indicate just the momentary values, no information on the temporal evolution of energy yield produced from the sun at Jungfraujoch can be displayed. In order to remedy this gap and display background information on photovoltaic energy production at Jungfraujoch, a solution was sought to visualise the temporal evolution of the energy produced based on the weather and sun's position.

A flat screen was evaluated as it enables the presentation of a transition line past the last 48 hours and thus allows a comparison of energy yield production with the day before. As the screen needs a computer to create an image on it, and both (flat screen and computer) need additional power, a new power supply needed to be provided and installed in a way so that it remains "invisible".

Once the individual components were in place, the electrical interaction had to be tested and the software developed.

In summer 2016, the new board was designed and produced, taking into account graphical aspects to respect the corporate identity designs of the partners.

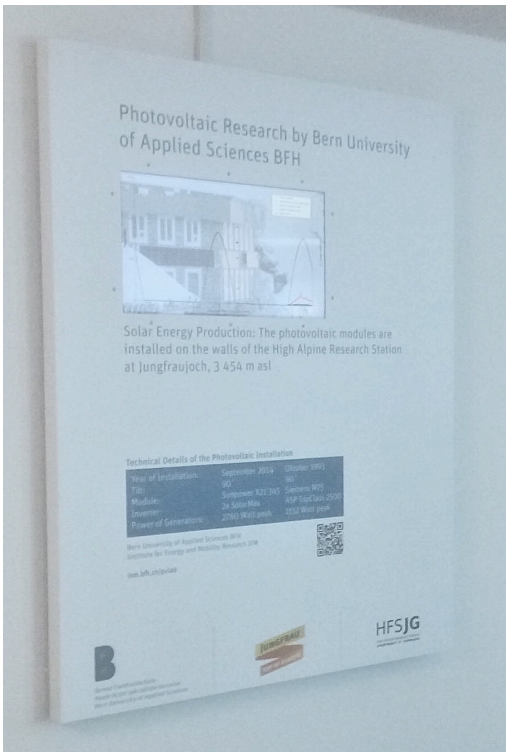

Figure 3. New information board at the Jungfraujoch railway station, equipped with flat screen and an embedded single board computer to create the images.

3.2. Enabling the digital data transfer to the new public display board

When the old board was installed in 1993, a cable of four wires was pulled through a channel running from the research building at Jungfraujoch to the location of the public display board at the railway station of the Jungfraubahn. This cable is about 250 m long and didn't have to meet specific requirements back in 1993 (except for shielding) as it only served to transport a 20 mA direct current signal. However, and in order to allow for a digital data transfer from the measurement equipment (located in the research building) to the new public display board (located at the railway station of the Jungfraubahn), some engineering research work became necessary.

The underlying research concept (Figure 4) was that it should be possible to send some frequency-based signals trough the existing cable (if the frequency is low), as the existing cable consisted of two twisted wire pairs. Otherwise, the old cable had to be replaced by a new cable meeting the requirements for a digital data transfer.

For the examination of the research concept, function tests were carried out using a couple of hundred meters of cable (similar to the one at Jungfraujoch) laid out in the Tiergarten building at BFH Burgdorf and connected to the new public display board to be mounted at Jungfraujoch. As signal converters for the data transmission through the cable, a RS-232 signal to a RS-422 signal and vice versa were chosen. Such a converter at each end of the cable allows it to send data over a distance of 1200 m.

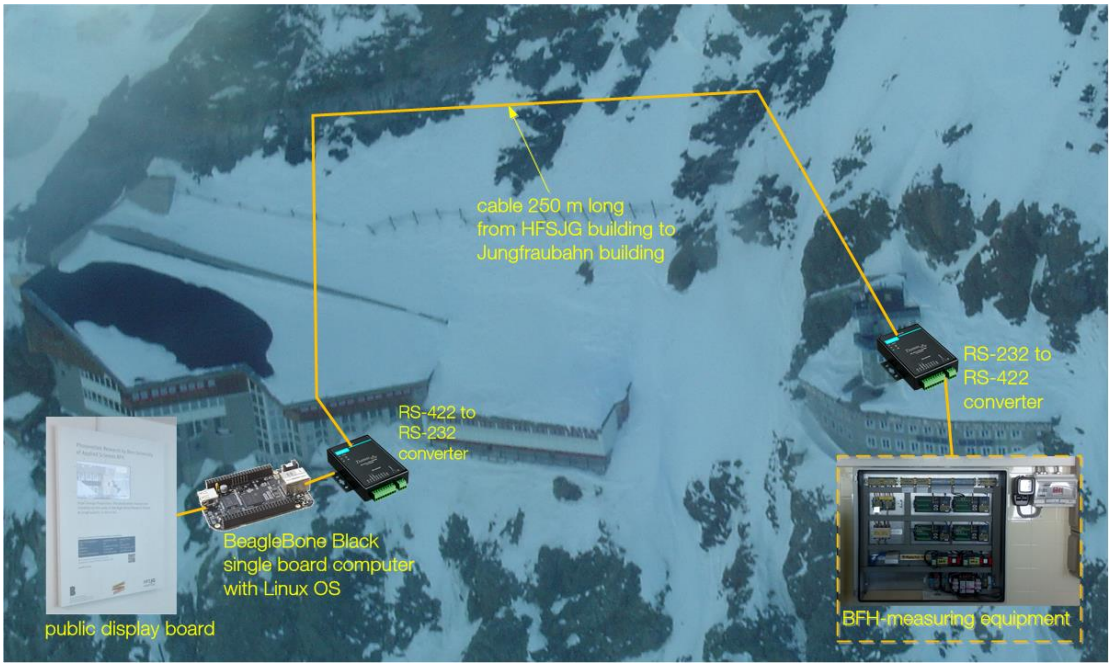

Figure 4. Schematics of the research concept on digital data transmission from the PV-measurement equipment (located in the research station building at Jungfraujoch, right) to the new public display board at the Jungfraujoch railway station (left).

3.3. Monitoring software and micro-computer

An embedded system single board computer is the centre of the data transfer and display concept. The micro-computer is a BeagleBone black that runs on a Linux operating system. The operating system runs a software that was developed by an engineering student at BFH and carries out:

- collection of the data, sent from the data logger of the BFH measurement equipment
- conversion of the data for the display
- sending the data to the screen.

Key words:

Photovoltaic power production at high alpine sites, long-term stability of photovoltaic modules at high alpine sites, digital data transfer in cables from the 1990s

Internet data bases:

[1] http://pvtest.ch
[2] http://www.bfe.admin.ch
[3] http://sccer-furies.epfl.ch/

Collaborating partners/networks:

Studiengesellschaft Mont Soleil Les Brenet
University of Bern

Scientific publications and public outreach in 2016:

Conference papers

[2] Kuonen, F., D. Gfeller, T. Schott, E. Schüpbach, H. Heck, U. Muntwyler, Calculation- and Visualisation-tool (CVT) for partial shading of photovoltaic systems, 32nd EU PVSEC, Munich, Germany, June 20-24, 2016.

[1] Muntwyler, U., E. Schuepbach, Electric vehicles powered with PV electricity as a new driver for photovoltaics, 32nd EU PVSEC, Munich, Germany, June 20-24, 2016.

[3] Muntwyler, U., T. Schott, E. Schüpbach, F. Kuonen, Neue hochalpine PV-Installation auf dem Jungfraujoch in der Langzeitmessung der BFH, Poster Contribution, 14. Nationale PV-Tagung, Bern, Switzerland, February 22-23, 2016.

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