

Name of research institute or organization:

Berner Fachhochschule, Hochschule für Technik und Informatik (HTI), Photovoltaik-Labor

Title of project:

Long-term energy yield and reliability of a high alpine PV (photovoltaic) plant at Jungfrauoch (3454 m)

Project leader and team

Prof. Dr. Heinrich Häberlin, project leader
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Project description:

PV plant Jungfrauoch (1.152 kWp, 3454 meters above sea level) was planned and realised by HTI Burgdorf during summer and fall 1993. At the time of its erection it was (and perhaps it still is) the highest grid connected PV plant in the World.

Purpose and Goals of the project:

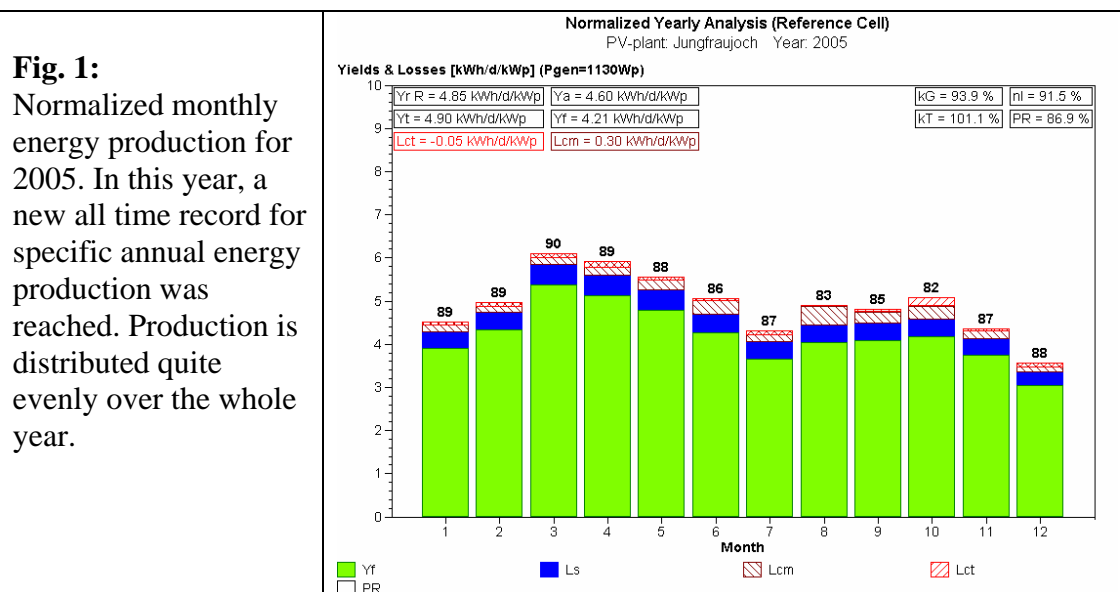
- **Test of PV components:** Operation in high altitudes is a very hard stress for all components due to extremely high irradiance peaks of more than 1.7 kW/m², heavy storms and thunderstorms, and large temperature differences. PV components surviving in such a harsh environment should perform more reliably under normal operating conditions.
- **Long-term operating experience:** Experimental demonstration that high PV energy yields for high alpine PV plants that can be not only be simulated, but can actually be obtained in practical operation over many years.
- **Intensive analytical monitoring** with redundant sensors to ensure maximum reliability in order to get long-term data about energy yield and reliability.
- **Maximum availability of energy production and monitoring data (AMD ≈ 100%).**

In 2005, the PV plant on Jungfrauoch (rated peak power 1.152kWp, effective peak power 1.13 kWp, 3454 m above sea level), has established a new all-time record for normalised annual energy production. Despite a line interruption of one day (23.8.2005) due to flooding in the valley, in 2005 **1537 kWh/kWp** were produced with a winter energy fraction of 48.5%. Thus the old record dating from 1997 (1504 kWh/kWp) was trespassed considerably. Without the line interruption, in 2005 the production would have been even 1540 kWh/kWp. This record production was due to the highest annual in-plane irradiation since 1994 and at the same time very low snow coverage of the two PV arrays over the whole year.

In the average of 1993 to 2005, PV plant Jungfrauoch has produced 1407 kWh/kWp with a winter energy fraction of 46.3%.

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average 1994-2005
Y_f (kWh/kWp/a)	1272	1404	1454	1504	1452	1330	1372	1325	1400	1467	1376	1537	1407
$PR = Y_f/Y_r$ in %	81.8	84.1	84.7	85.3	87.0	84.8	84.6	78.6	85.2	84.9	86.2	86.9	84.2

Table 1: Annual energy production (referred to effective STC-power) and performance ratio PR from 1994 – 2005. Twelve-year average values are also indicated.



A detailed description of the plant, measurement results of earlier years and definitions used can be found in earlier annual reports (2000, 2002, 2003, 2004) and in several publications under www.pvtest.ch (many publications can be downloaded). Diagrams similar to fig. 1 for the years 1994 – 2004 can be downloaded under www.pvtest.ch > PV monitoring data.

Key words:

Grid-connected PV plants, energy yield, high alpine

Internet data bases:

<http://www.pvtest.ch>

Scientific publications and public outreach 2005:

As in 2003 the 10th anniversary of the plant was reached, several contributions were written in 2004 discussing the results of the first 10 years of operation (see annual report 2004). As a consequence, in 2005 there were no specific publications about PV plant Jungfraujoch after only one more year.

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