

More than 6 Years of Operation Experience with a 1 MW Photovoltaic Power Plant - Highlights and "Weak Points" -

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Overview

General

The photovoltaic rooftop plant mounted on the roofs surfaces of the six northern halls of the New Munich Trade Fair Centre is one of the world's largest. Key elements of the plant are below:

- 7,812 frameless solar modules ($V_{MPP} = 20.4 \text{ V}$; $I_{MPP} = 6.35 \text{ A}$) each with 84 monocrystalline silicon cells and an output of 130 watt which is equivalent to 1,016 kW_p in total.
- There is a total roof surface of 66,000 m^2 on the six halls available. Solar modules are mounted on 38,100 m^2 of this area.
- The inverter consists of three units with an output of 330 kVA each in master-slave-mode of operation.
- The solar electricity is being fed into the 20 kV grid of the Trade Fair Centre.

In November 1997 the Solar Roof was connected to the grid, thus more than 6 years of experience are now available.

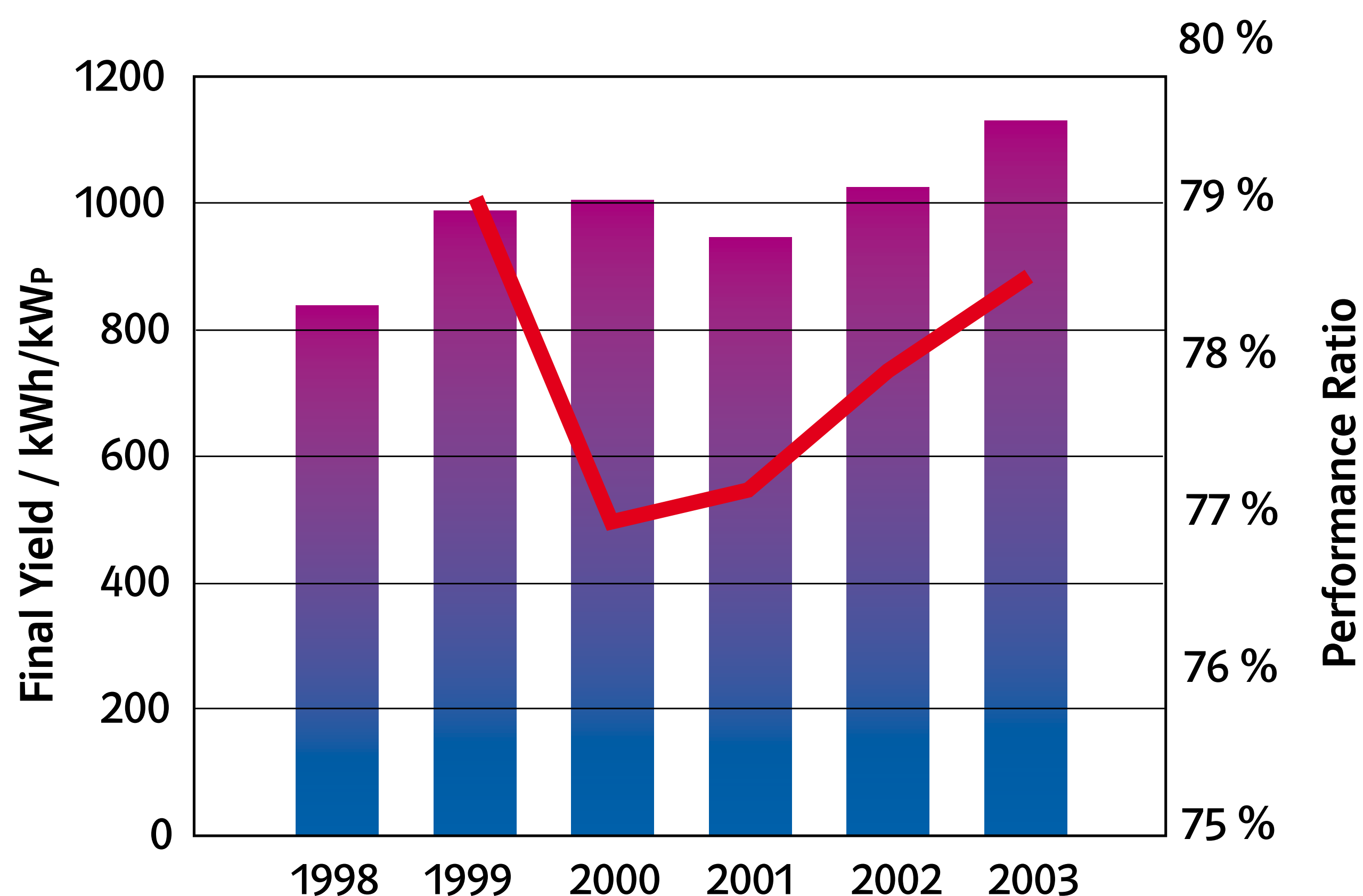


Details

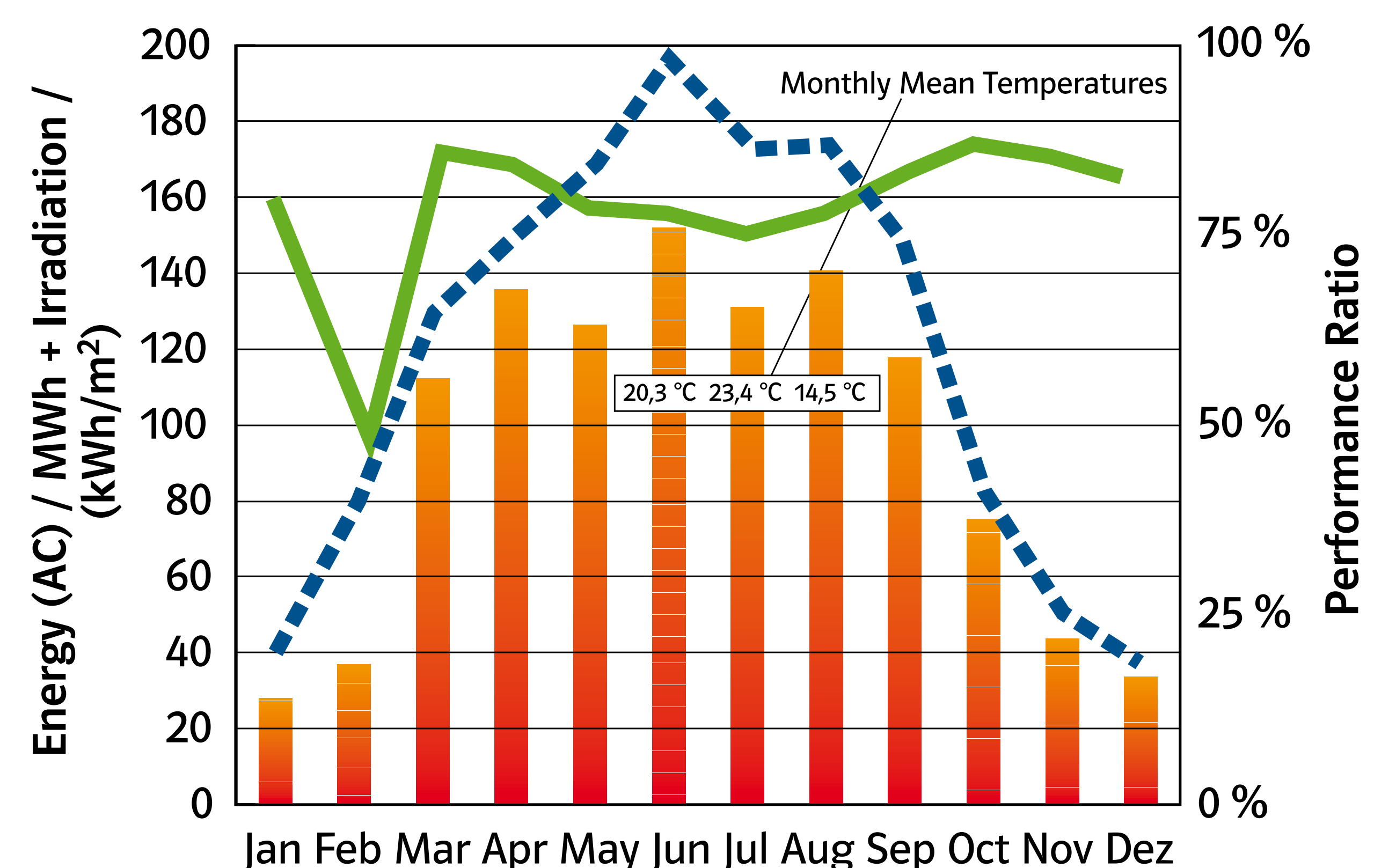
- In each case 21 modules are connected to 372 strings, 6 strings are connected together in a terminal box.
- The cables out of 5 or 6 of these terminal boxes are connected together in another box, equivalent to one "Sub" PV generator.
- There are 12 "Sub" PV generators.
- The electric energy from these 12 PV generators is fed to the centrally located and air-conditioned converter room.
- The DC cables with copper conductors show lengths up to 500 m and cross sections up to 400 mm^2 , with cross sections adapted to the length, which means that the ratio of length and cross section is approximately constant. Touchproof connectors for field cabling are used.
- DC breakers are applied to disconnect the converter and the PV generators.

Highlights: Best Yields and Performance

Since 1998, the system shows best Final Yields and Performance Ratios. In 2003 - with high irradiation and temperature values - the operation results are excellent. The annual energy production reaches the top value 1,131 MWh.



Final Yields (bars) and Performance Ratio (line) since 1998, lower Final Yields 1998 due to start-up.



Monthly produced energy values (bars), irradiation (dotted line) and Performance Ratio PR (full line) in 2003. Due to high temperatures energy production decreases in July. In February PR falls below 50%, because of snow on the modules.

"Weak Points"

There are only a few so called "Weak Points":

- The converter failed a few times because of problems with the power transistors.
- In the year 2002 there was an insulation fault in one string, a cable was pulled out, the reason is unknown.
- At the beginning, all the DC breakers showed malfunctions, they were replaced.
- The air-condition devices in the converter room sometimes caused failures. The energy required for cooling (a few percent) is too high, however new installations do not require any air-condition.

Additionally there were a few faults which may occur in every photovoltaic system and thus are no "weak points". Thus in 2000 four modules were damaged by storms, the terminal and connection boxes remained intact. In 2002 the current of one string was too small because of a damaged clamp. Fairly often the server failed, it was replaced.



Conclusion

After more than 6 years of operation, the facts are:

- Nowadays the system is operating at a very good performance. All the problems described have been solved.
- None of the electric parameters shows any degradation effects, the efficiencies of the modules and converter remained at the same level. The insulation resistance of the modules still indicates good values of 80-200 kV.
- In 2002 a second MW photovoltaic rooftop plant was mounted on the roof surfaces of the six southern halls of the New Munich Trade Fair Centre, applying the experiences from the described PV system. The operation shows good Yields and Performances too.
- It should be noted, that the "Bavarian Association for the Promotion of Solar Energy" uses the financial yields to sponsor solar projects.