Power Check 2005

Systems with Solar-Fabrik AG components

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1 Introduction

For securing the quality of its products, Solar-Fabrik carries out a "check of energy yields". Operators of grid connected photovoltaic systems with modules and inverters manufactured by Solar-Fabrik were asked to report their energy yields. Documents proving the clearing of fed-in energy with the local utility were demanded to secure a high reliability of the reported data. Data provision was done by Solar-Fabrik. Fraunhofer ISE was made responsible for the evaluation of the collected data.

The following evaluations assess the operation of 147 grid coupled PV-systems, which started operation until the end of 2003. Most of the systems are mounted on tilted roofs and exhibit a nominal generator power of up to 5 kWp.

About 75% of the systems have nominal powers between 2 and 5 kWp, which is a typical plant size for single family dwellings. Orientation and tilt angle of the solar generator significantly influence the annual system yield. If the orientation of the generator is between South-East and South-West and if the tilt angle ranges between 20 and 40 degrees, energy losses compared to a system orientated in an optimal way (30 degrees tilt angle and orientation towards South) are less than 3%. Altogether, only 20 of all systems investigated are out of this range.

All but 7 of the evaluated systems are located south of the 49th degree of latitude within the German states Baden-Württemberg and Bavaria.

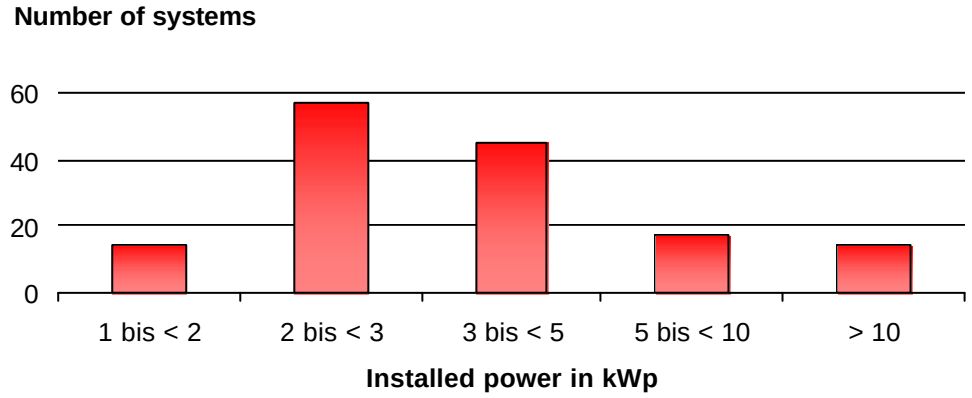

Fig. 1: Distribution of the nominal power of PV systems installed up to the end of 2003.

2 Results

System yield

In 2004, the 147 PV monitored systems produced an average annual yield of 931 kWh/kWp. The distribution in Fig. 2 shows an accumulation of annual yields in the range between 950 and 1000 kWh/kWp. Two-thirds of the systems reach yields above 900 kWh/kWp. Only few of the systems produced yields less than 850 kWh/kWp. This is quite a good result, being 2004 an average year regarding irradiation.

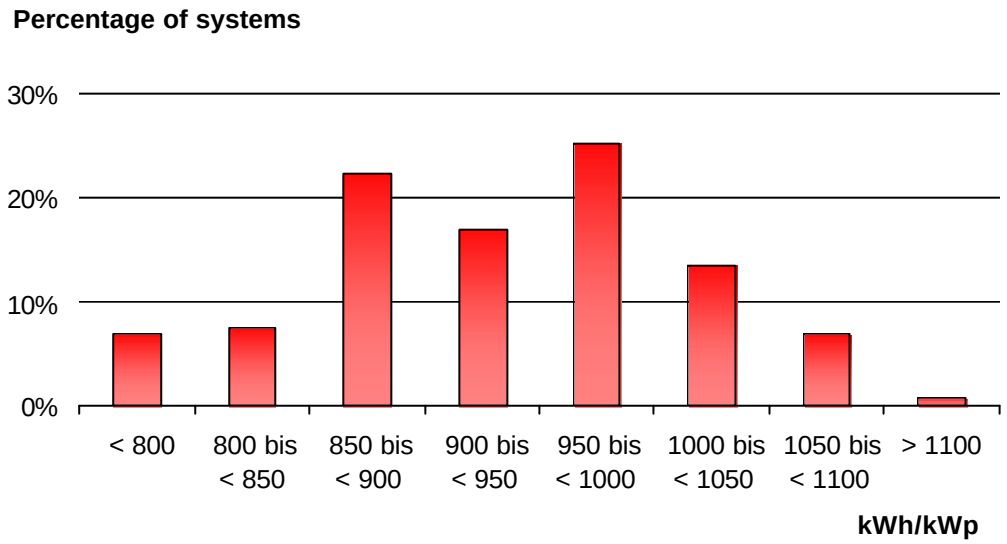

Fig. 2: Distribution of the annual yields for all systems in 2004

The best systems reached yields around 1050 kWh/kWp. Such maximum values can be reached even at South-German locations only, if the following conditions are met:

- the solar generator is not shaded and well ventilated
- orientation and tilt angle of the generator are optimal
- the power of the installed solar modules matches the nominal values specified by the module manufacturer

- the installed inverters have a high efficiency and a good type of electrical control
- the inverters have a high availability
- the system layout and dimensioning is optimal

To evaluate in detail the technical development of the PV systems with Solar-Fabrik components, we investigated the yield of the year 2004 as a function of the construction year of the systems. Fig. 3 shows the average system yield for the different installation years. The graphic clearly shows a significant step-up in system yields for installations starting operation since 2001 and a continuous increase for installations since 2003.

While the yield of systems built before 2001 was significantly below 900 kWh/kWp, PV plants starting in 2003 reached in average energy yields of around 960 kWh/kWp. This equals to an increase of 10%.

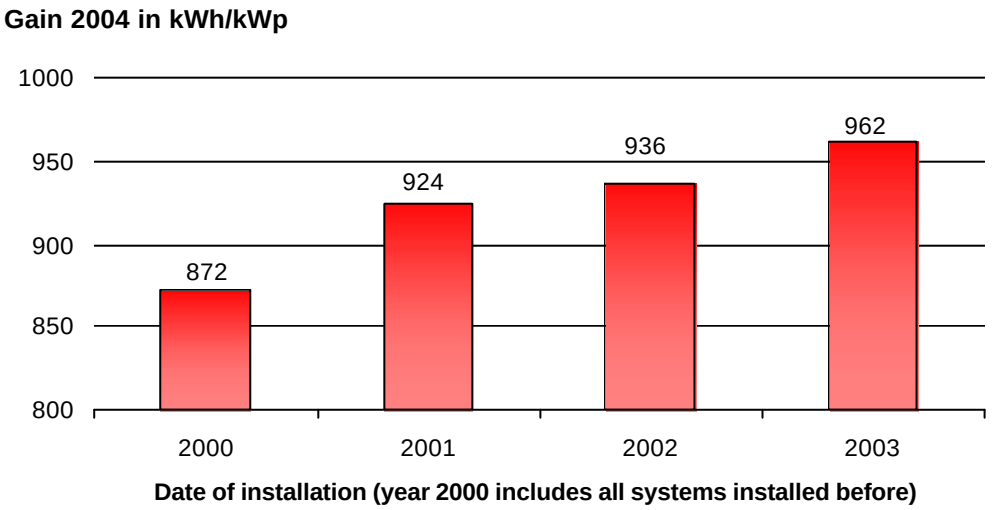

Fig. 3: Development of the system yields for installations with Solar-Fabrik components.

Performance Ratio

For an objective evaluation of the system performance and the quality of the PV installations under consideration, respectively, the Performance Ratios (PR) of the systems have been determined using irradiation data, that have been measured by the help of METEOSAT- Satellites. They allow an assessment of the systems independently from the location and the orientation and tilt angle of the solar generator. The Performance Ratio gives the ratio between the energy actually

fed into the grid by the real system to the amount of energy, that could have been produced in maximum by the solar modules at a constant temperature of 25°C in an ideal loss-free system.

Fig. 4 shows, that about one-third of the systems reach a Performance Ratio higher than 80% and only few systems are significantly below 70%. Those systems are without exception installations of the first years. The average for all systems is around 75%. For systems that have been built in 2003, the average is 79%. Here there are only few systems with a Performance Ratio below 75%.

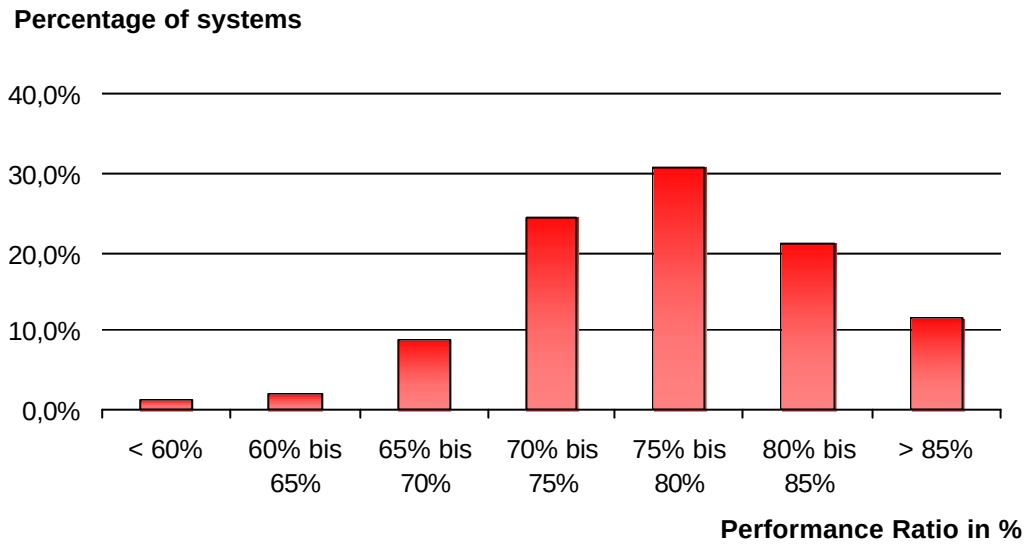

Fig. 4: Distribution of the Performance Ratio for the year 2004

In analogy to the progression of the system yields as shown in Fig. 3, the development of the Performance Ratio for the same period is shown in Fig. 5. The graphic shows the continuous increase of system efficiency.

The following table shows the values for the Top-Ten systems in 2004. Besides the location, the year of construction and the nominal power of the systems, the annual values for solar irradiation on the module surface, the yield and the Performance Ratio are also listed. The accuracy for the value of the solar irradiation is about 6%, which is comparable with the accuracy of common irradiation sensors.

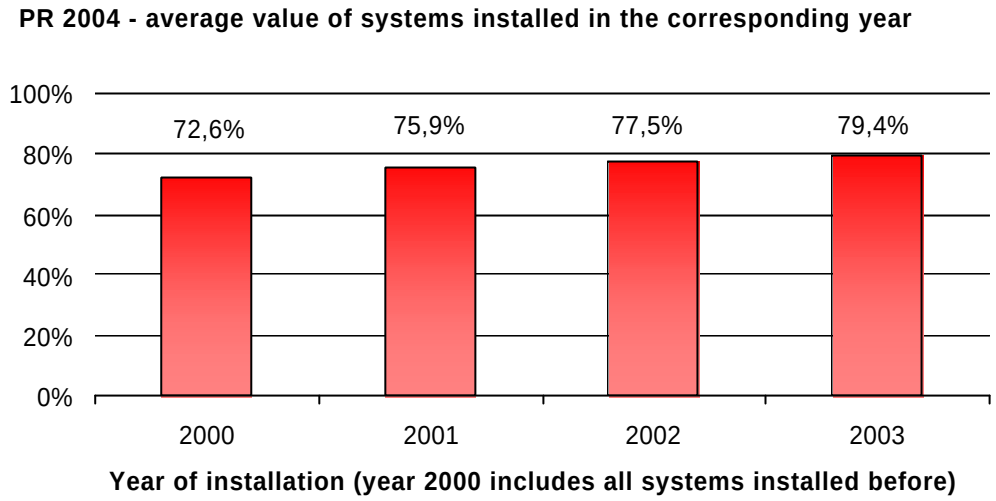

Fig. 5: Development of the Performance Ratio during the last 4 years

The annual total amounts of the solar irradiation for all of the systems under investigation are very near the average value of 1210 kWh/m². The top irradiation value with more than 1302 kWh/m² was measured at Vogtsburg in the "Kaiserstuhl" mountain near Freiburg. Installations on locations with postal code (PLZ) 8… on average receive 5% higher irradiation compared to systems at locations with postal codes 7… .

For the best systems, the Performance Ratio is between 84 and 87 % with the highest yields in the range between 1050 to 1100 kWh/kWp. Even for Southern German locations these are top values.

PLZ	Location	Start of operation	Power [kWp]	Irradiation [kWh/m²]	Yield [kWh/kWp]	PR [%]
86692	Münster	Dec 03	2,40	1257	1100	87,5%
88267	Vogt	Jul 03	4,69	1257	1090	86,7%
71735	Eberdingen	Oct 01	2,30	1257	1082	86,0%
84048	Mainburg	Oct 03	4,90	1243	1075	86,5%
84048	Mainburg	Oct 01	5,06	1243	1068	85,9%
85604	Zorneding	Dec 02	2,40	1206	1060	88,0%
86720	Nördlingen	Dec 01	2,00	1229	1053	85,6%
73199	Kirchzarten	May 03	4,49	1199	1052	87,7%
72181	Starzach	Dec 01	2,00	1254	1044	83,2%
79111	Freiburg	Jun 03	2,86	1217	1043	85,7%

Table 1: The Top-Ten high yield installations in 2004

3 Conclusion

An average annual yield of 931 kWh/kWp for the 147 systems under investigation is an excellent result. The number of installations with a yield higher than 950 kWh/kWp (46%) and the relatively small number of systems with yields less than 850 kWh/kWp (14%) are remarkable. Also noticeable is the average Performance Ratio of 75%, with almost half of the systems reaching values higher than 80% as well.

The quality of the recently built systems is impressive. Systems operating since 2003 achieved an average system yield of 960 kWh/kWp and a Performance Ratio of almost 80%. The best installations achieve a Performance Ratio of around 85%, which is a top value for roof-mounted PV systems in the lower power range.

Such results are only possible with the use of high-quality modules and inverters, a good system design, professional installation and an almost failure-free operation.

4 Glossary

System yield:

The kilowatt hours (kWh) fed into the grid by the photovoltaic system are measured by calibrated energy meters and are finally reimbursed by the corresponding utility. By dividing the calculated annual generation by the nominal power of the system (peak-power of the solar generator in kWp) one can calculate the specific system yield in kWh per kWp. This value strongly depends on the exactness of the module manufacturer in classifying the power of the modules (peak power in kWp).

Performance Ratio (PR):

PR = Energy yield / (Annual irradiation on the module surface • Module efficiency under „Standard Testing Conditions“). The Performance Ratio is a measure mostly independent from the plant location, which characterizes the system quality. Only very good systems reach values above 80%.