Degradation Measurements of Aged PV Modules

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What is Degradation?

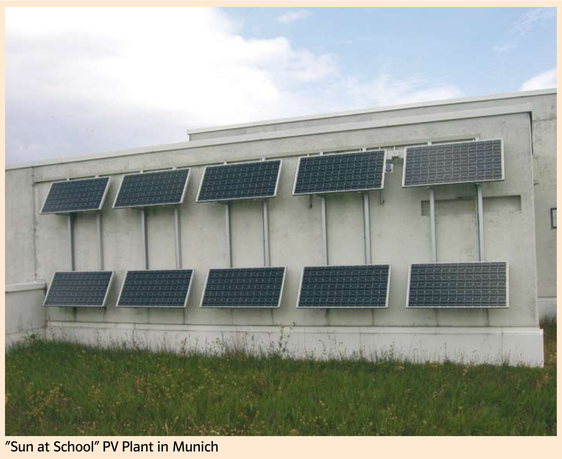
Practically, this is the decrease of output power within the lifetime of a module. Degradation may depend on many parameters, some of them can be pollution of the module's surface or haze of the laminate and delamination or aggravation of the contacts, i.e. by mechanical stress and dampness. Light-induced degradation and thus a decrease of solar cell efficiency under illumination may occur. The reason is a formation of a defect which is correlated to the simultaneous presence of boron and oxygen in the material.

Organisation

Crystalline PV modules – in two groups – with an operation time of about 8 - 12 years have been investigated. The services of two laboratories – called Lab A (measurement uncertainty for the power value: ± 5.0 %) and Lab B (± 3.5 %) – were taken up.

• The first group of modules is coming from the photovoltaic promotion "Sun at School" which is operating PV systems of 1 kW_P in over 900 schools in Germany. Additionally this group contains modules of two larger PV plants. No reference is available for this group.

• The second group of modules is coming from the 1 MW_P PV system Munich Trade Fair Centre. For them a reference – non illuminated modules – is available.


"Sun at School" PV Plant in Munich


"Citizens for Solar Power" PV Plant in Unterföhring near Munich

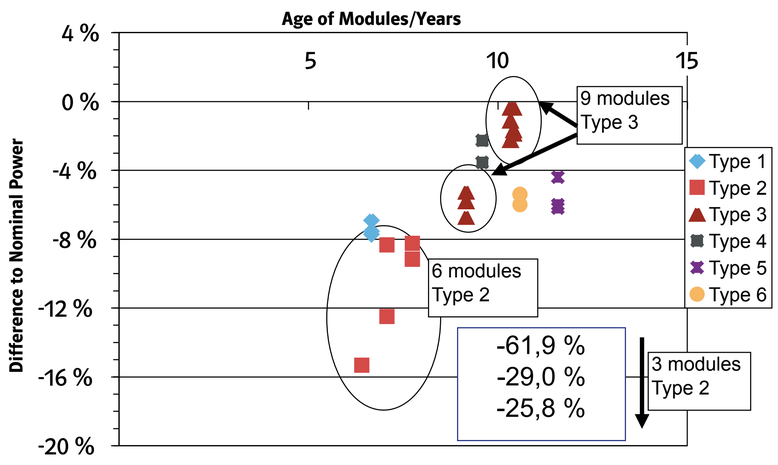

"Sun at School" PV Plant in Gröbenzell near Munich


PV System Munich Trade Fair Centre

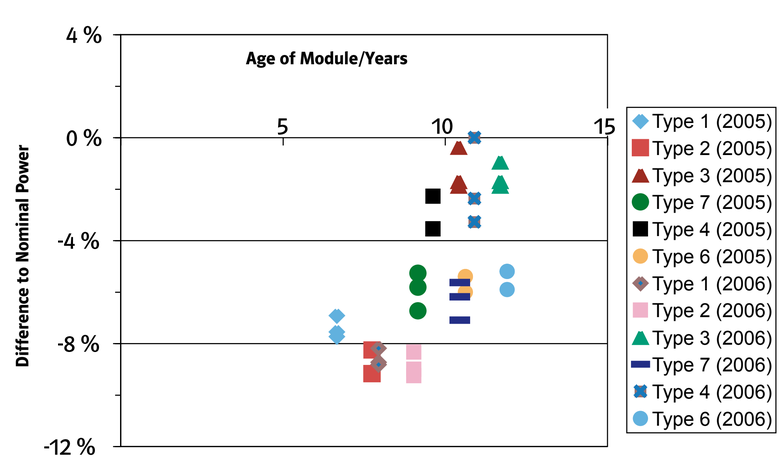
Sun at School + two larger Systems

In the year 2005 in total 30 modules from two manufacturers and of six types have been analyzed by Lab A. 12 of the modules had nominal powers between 50 and 55 W_P, the rest showed values between 100 and 120 W_P.

A second round of measurements has been carried out in 2006. The diagram below indicates the results for the modules measured in 2005 and in 2006 by Lab A.



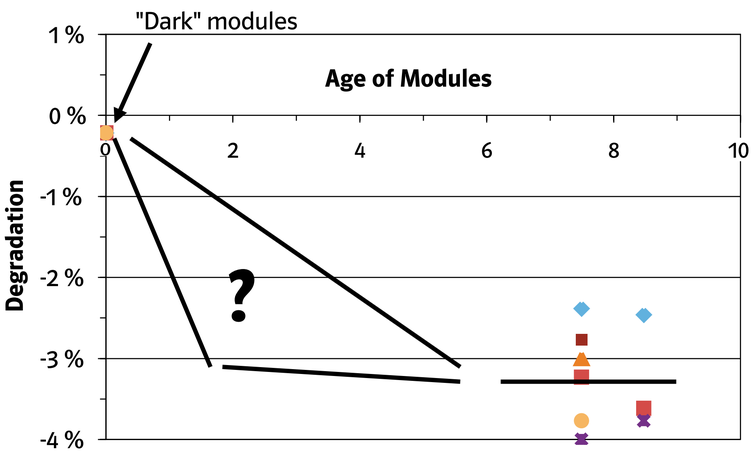
The various modules are indicated as Type 1 to Type 6, they come from two manufacturers. The degradation results for one type always lie together. However the values spread over a wide range, from nearly 0 % to more than - 60 %. The modules with more than - 25 % have been replaced in the meantime; they were out of faulty production.



It can be stated again, that after long years of operation no module reaches its nominal power. This effect may come from degradation, but as well from the fact, that the original nominal power at the time the module was installed was considerably smaller than the value on the label.

Munich Trade Fair Centre

12 modules from this 1 MW_P PV system were sent to Lab A in May 2005, 6 of them had been in operation since 1997, 6 of the modules were spare modules which have been in a dark store since the beginning of the operation. Some more measurements were carried out one year later in May 2006.

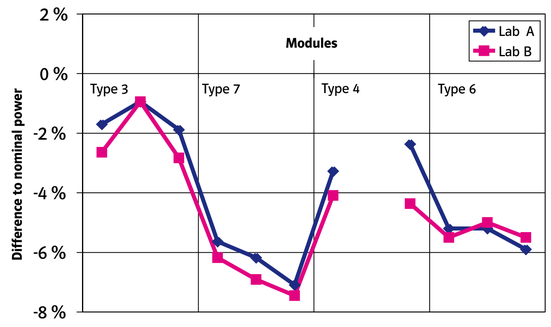


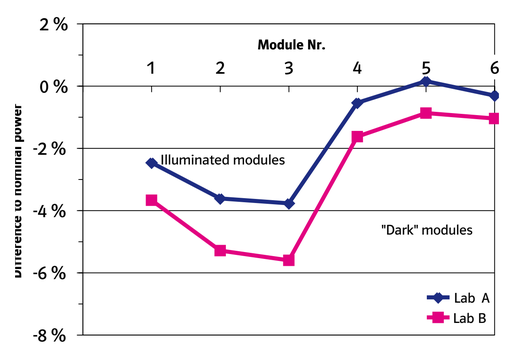
One of the most important results is that the "dark", non illuminated modules, directly coming from the store, showed nearly the nominal power. The exact mean value of all measurements carried out in 2005 and 2006 is 129.7 W for a 130 W_P module. Thus the nominal power may serve as reference. After nearly 8 resp. 9 years of operation degradation values of 2.4 up to 4.0 % have been measured. It can be seen, that certain degradation exists. However, no statement can be made about the development of the curve.

Checking Accuracy

11 modules out of the group "Sun at School" have also been measured in Lab A and Lab B. The upper right diagram indicates the results.

Additionally 6 modules of the same type – coming from the Munich Trade Fair Centre – have been measured in Lab A and Lab B; they refer to the lower right diagram.





It can be seen that the results of both labs follow the same trend. However the results of Lab B are systematically below those of Lab A. Normally the differences are smaller than 1 %, in one case 2 % are obtained.

Conclusion

It can be stated, that after long years of operation no module – out of the group "Sun at School" – reaches its nominal power. No reference is available, thus this effect can come from degradation, but as well from the fact, that the original output power (STC) at the time the module was installed was considerably smaller than the value of the nominal power on the label.

For the modules of the Munich Trade Fair Centre a reference is available, non illuminated modules, which show nearly the value of the nominal power. After 8 resp. 9 years of operation the illuminated modules show degradation values of 2.4 up to 4.0 % .

Some modules have been measured in two laboratories. A comparison shows that the results of Lab B are about 1 - 2 % below those of Lab A, the trends are the same.

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