Predicting the life expectancy of solar modules

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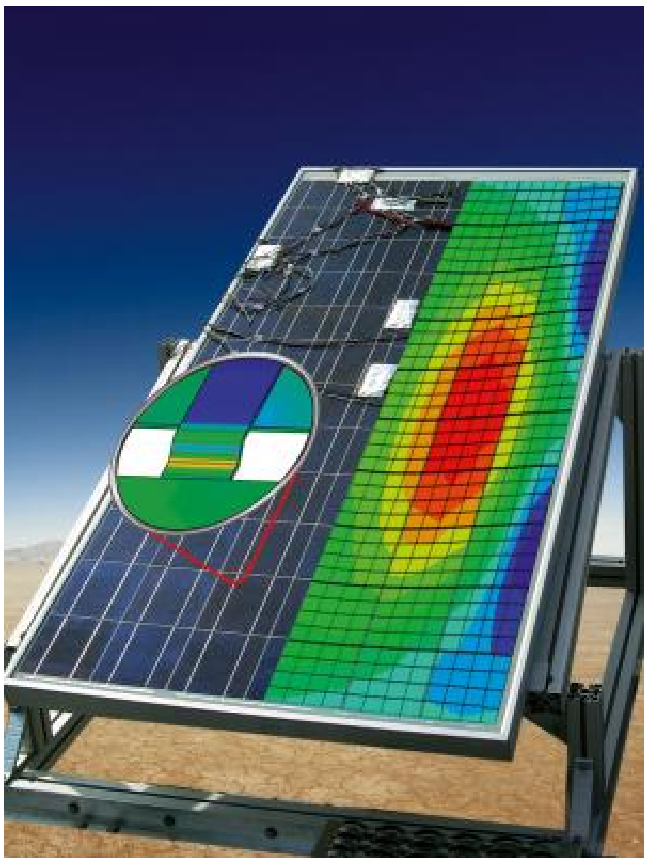

Sensors measure the elongations that arise in solar modules. Their operating life can be calculated from this data. Credit: © Fraunhofer IWM

Solar modules are exposed to many environmental influences that cause material to fatigue over the years. Researchers have developed a procedure to calculate effects of these influences over the long term.

This allows reliable lifespan predictions.

People who invest in their own solar panels for the roof would like as a rule to profit from them over the long term – but how long will this technology actually last for? While most manufacturers guarantee a lifetime of up to 25 years to their customers, the manufacturers themselves cannot make reliable predictions about the expected operating life. The modules must fulfill certain standards, of course, to be approved for operation. This involves exposing them in various trials to high temperatures and high mechanical loading. "However, the results only predict something about the robustness of a brand-new sample with respect to extreme, short-term loading. In contrast, agerelated effects that only appear over the course of time, such as material fatigue, are pertinent for the actual operating life," explains Alexander Fromm from the Fraunhofer Institute for Mechanics of Materials IWM in Freiburg.

The scientist is part of a project called Reliability of Photovoltaic Modules II, funded by Germany's Federal Environment Ministry (BMU), and is working on a new procedure for predicting the operating life of solar cell modules. "Using a dual approach, we combine actual measurements with a numeric simulation," according to Fromm. To this end, Fromm is initially investigating how mechanical loading affects units in field tests. This is because snow loads, temperature fluctuations, and wind gusts create mechanical stresses and associated strain and elongation in the modules. This leads to material fatigue in the long term. Both the plastic embedding material and the cell connectors in particular – thin strips of copper that connect the solar cells to one another – are susceptible. "It is like continually bending a paper clip back and forth. At some point, it breaks," explains Fromm.

Even light winds cause module oscillations

To be able to grasp the effect of these influences on the material, the researchers equipped a complete solar module with sensors that use changes in resistance to measure strains and elongations of the construction components. In turn, this allows the mechanical stresses in the material to be calculated. Fromm and his team determined from the data evaluation that even light wind suffices to cause oscillations in the module. The higher the ambient temperature, the more pronounced these oscillations become. Moreover, the resonant frequency increases over time as the plastic material gets stiffer and more brittle, due to UV radiation. "The pivotal question now is how these influences affect the operating life of the components over the long term. Our simulations come into play at this point," according to Fromm.

For this purpose, a detailed 3D simulation of the solar module has been worked out. Based on the measurements from the field tests, numerical calculations can be used to derive long term effects of the environmental influences on the module components and what kind of mechanical stresses develop. "Using the simulation, we have learned for example that the brittleness caused by UV radiation plays a much greater role in material fatigue than has been assumed thus far," says Fromm. To be able to predict the operating life of a module, the researchers combine the measurement values from the field test with known specific tensile strengths of the corresponding materials. These numbers predict the load at which the material is expected to break or separate.

No ready-made, large scale industrial test

The procedure can be implemented immediately. However, to produce optimal and reliable prognoses, the developers require highly detailed specific material data and information about the geometry of the module that is to be tested. "Our procedure does not offer a ready-made, large scale industrial test, but instead is individually tuned for each customer," explains Fromm. Using their calculations, the researchers are then able not only to make predictions about the expected operating life but also to depict potential improvements with regard to geometry and material as well as to predict the effects of various materials on the mechanical stresses in the module.

Provided by Fraunhofer-Gesellschaft

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