Energy
National Research Programmes 70 and 71

Project

Simulation of PV systems

Computers contribute to the conception of a new generation of solar cells

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A new generation of solar cells is about to break through. Innovative materials and advanced designs promise to provide a high level of efficiency and various options at a low cost. Computer-aided simulations should help to exploit the potential offered by the new technologies.

The weather and the quality of sunlight must be taken into account in order to realistically calculate the energy yield of new solar cells. *Source:* Shutterstock/Swissdrone

At a glance

- Computer models explain the physical characteristics of a new generation of solar cells and help to optimise them.
- The simulation performed under realistic environmental conditions reveals the potential that lies in the new solar-cell technology.
- Computer tools can play a key role in the development of the new solar cells up until they reach market maturity.

Energy Strategy 2050 wants to cover around 20 % of future electricity needs with solar energy. The chances of success are good. This is because a new generation of solar cells is about to get out of the starting blocks. The cells are based on the material of the future, namely perovskite, which is cost-efficient, easy to process and able to absorb light very efficiently. The so-called tandem cells achieve especially high levels of efficiency – they are built from two layers, with each utilising a different part of the light spectrum.

The new solar cells are, however, still facing their biggest challenge – making the leap from the laboratory to productive operations. The decisive factor is how high the energy yield of the installed systems will be in real use. This not only depends on the solar cell, but also how the solar modules function under realistic environmental conditions.

Researchers at the Zurich University of Applied Sciences (ZHAW, Winterthur) have used computers to investigate this complex issue. In cooperation with the laboratories of the Swiss Federal Laboratories for Materials Testing and Research (Empa) and the EPFL Lausanne, they developed a toolbox of numerical models that can simulate all stages of electricity generation from sunlight – from the physics of individual solar cells to the electricity yield of an installed module comprising tandem cells.

Understanding the fundamentals of solar cells

Understanding this process chain begins with the interaction of the light with the material and it was here that the researchers placed their focus. Using the existing components, they developed a computer model of the perovskite cell that simulated optical and electrical processes together for the first time. This enabled them to explain behaviour that until this point had not been fully understood: the perovskite cell provides different amounts of electricity under the same conditions depending on whether the applied voltage starts from above or below the cell – a phenomenon known as hysteresis. With their simulation, the researchers showed that this hysteresis can be explained by the movement of charged particles, so-called ions. They can form at room temperature from elements of the perovskite, for example iodine. These moving charges shield the electric field inside the building component.

A further model from the toolbox of the ZHAW researchers describes a tandem cell for which the perovskite cell is attached to the surface of a silicon cell as an extra layer. The perovskite cell filters the short-wave light on the blue-violet side of the spectrum, while the silicon cell situated beneath it specialises in the long-wave red to infrared light – a division of labour that allows for greater efficiency rates than is possible to achieve with a simple solar cell.

Using this model, the researchers played through various configurations and optimised the capacity of the cell in each case – a process that would be very time-consuming in a laboratory with real solar cells. The researchers then looked for the most favourable distribution of the light spectrum between the upper and lower part of the tandem cell. To this end, they tested perovskites that filter light at different wavelengths. This allowed them to show that the level of efficiency can theoretically be raised to up to 31 %.

Simulation reveals potential

Equipped with the model of a perfected tandem cell, the researchers could now get down to their main task – the simulation of the new technology in real operations. To this end, they used data on sunlight, ambient temperature and wind – environmental factors on which the electricity production of a solar module is dependent. The spectral distribution of the sunlight also had to be calculated. This is because it exhibits different red and blue components over the course of the day as well as over the year. In particular, this impacts the output of a tandem cell which converts red and blue light in separate cells. As the weaker cell determines the electricity flow through the entire tandem cell, balanced irradiation is required for an optimal output. Using their model, the researchers were able to calculate how great the loss of output is due to the colour deviations of the sunlight – it amounts to just 1.27 % of the annual electricity yield.

Make tools usable for everyone

At the same time as the development of the computer models, the experimental development of the perovskite technology was also advanced further. Indeed, a giant leap forward was made here – and without the support of the simulation tools. However, a number of hurdles still need to be overcome before a perovskite cell reaches market maturity as the new technology is as yet not durable enough for practical use. The computer models could prove to be indispensable here. Until now, only specialists have been able to use the programs. However, with a more user-friendly user interface, they would be available for broader use. The toolbox is not only interesting for research groups and technology firms. Architecture companies or authorities could also benefit from them – for example, by being able to calculate electricity production on building facades in advance.

Produkte aus diesem Projekt

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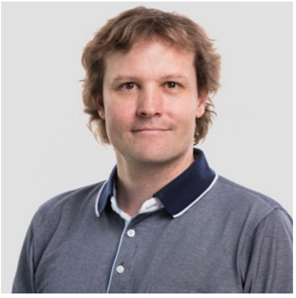

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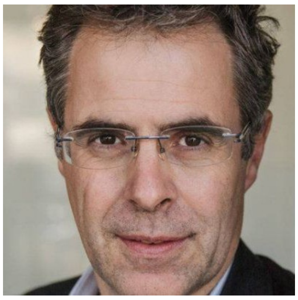

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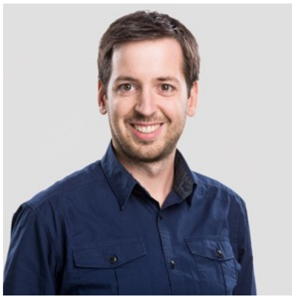

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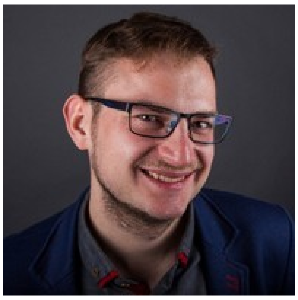

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