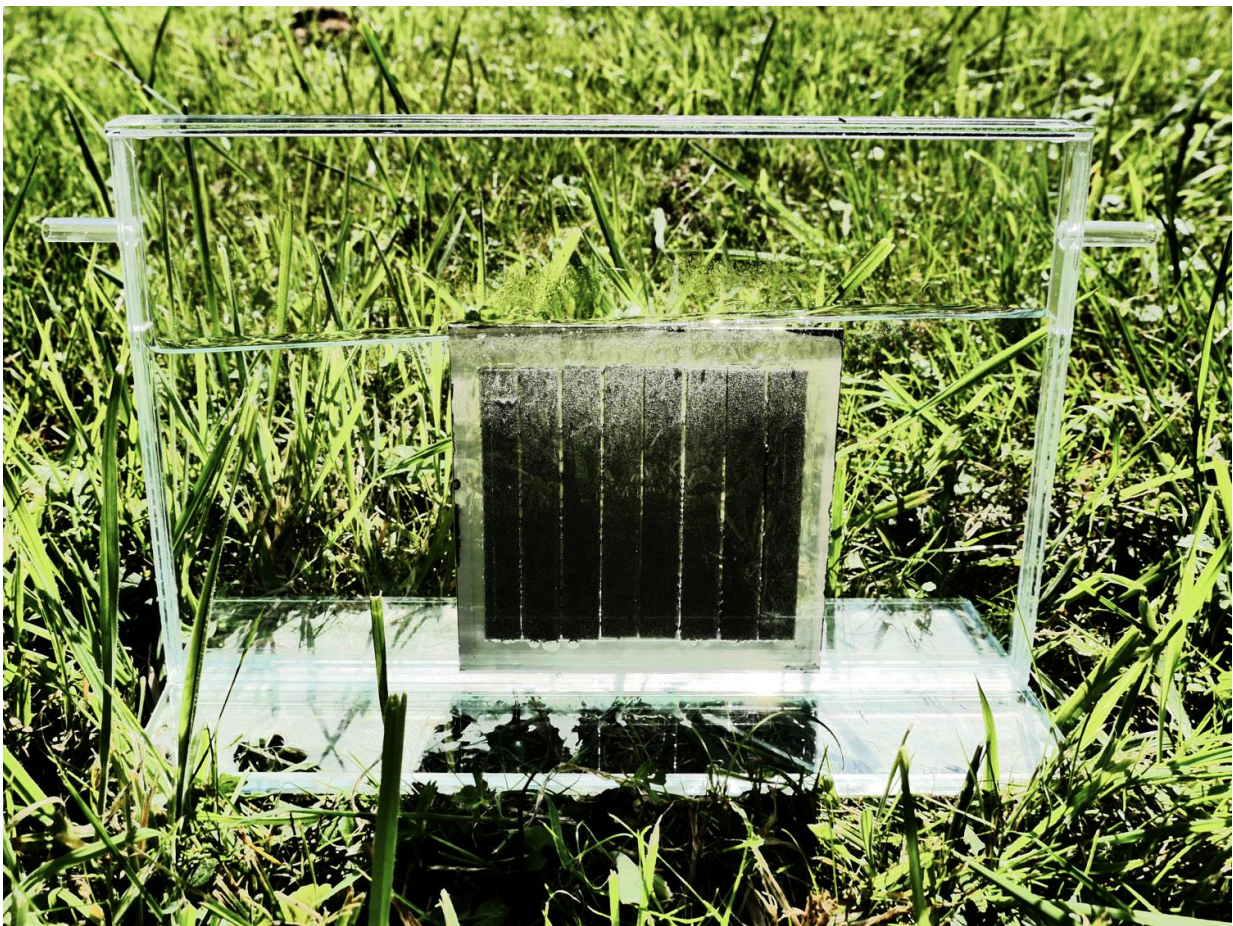


Artificial photosynthesis: Researchers create the first practical design for photoelectrochemical water splitting

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The photosynthesis system of the Jülich solar cell scientists is compact and self-contained, and the flexible design allows for upscaling. The concept can be applied for all thin-film photovoltaic technology and various types of electrolyser. Credit: Forschungszentrum Jülich

Scientists from Forschungszentrum Juelich have developed the first complete and compact design for an artificial photosynthesis facility. This is a decisive step towards applying the technology. The concept is flexible both with respect to the materials used and also the size of the system. The researchers have now published their findings in the journal *Nature Communications*.

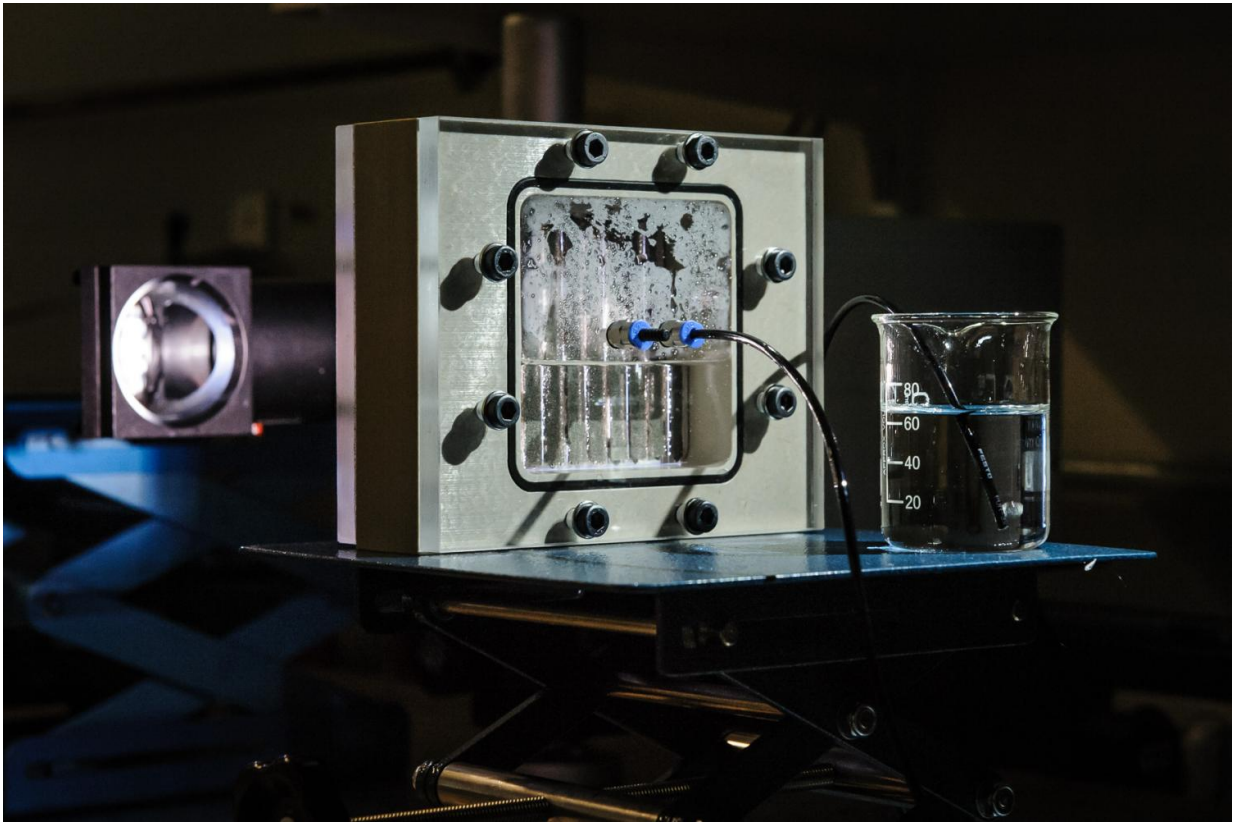
In future, sun and wind will supply the lion's share of our energy. The fluctuating nature of these [renewable energy sources](#) means that current research is focusing more intensively on efficient storage technologies. Like the [energy sources](#) themselves, these technologies should be environmentally friendly and affordable. This trend is particularly apparent in research on direct photoelectrochemical [water splitting](#), that is to say [artificial photosynthesis](#) employing a combination of solar cell and electrolyser. In this way, solar energy can be directly converted into the universal storage medium of hydrogen. This process was first investigated in the 1970s, but has only begun to attract increasing attention in recent years. As yet, research has focused on materials science for new absorber materials and catalysts to further improve efficiency.

Juelich solar cell researchers Jan-Philipp Becker and Bugra Turan, however, are concentrating on an aspect that has so far largely been neglected: a realistic design that can take this technology from the scientists' laboratories and put it into practical applications. "To date, photoelectrochemical water splitting has only ever been tested on a laboratory scale," explains Bugra Turan. "The individual components and materials have been improved, but nobody has actually tried to achieve a real application."

Compact, complete, and expandable

The design created by the two experts from Juelich's Institute of Energy and Climate Research is clearly different from the usual laboratory experiments. Instead of individual components the size of a finger nail that are connected by wires, the researchers have developed a compact, self-contained system - constructed completely of low-cost, readily available materials.

With a surface area of 64 cm², their component still appears relatively small. The trick is in its flexible design. By continuously repeating the basic unit, it will in future even be possible to fabricate systems that are several square metres in size. The basic unit itself consists of several [solar cells](#) connected to each other by a special laser technique. "This series connection means that each unit reaches the voltage of 1.8 volt necessary for hydrogen production," says Jan-Philipp Becker. "This method permits greater efficiency in contrast to the concepts usually applied in [laboratory experiments](#) for scaling up."



Test set-up of the prototype for photoelectrochemical water splitting: The complete system is immersed in an aqueous potassium hydroxide solution. Illumination with a daylight lamp generates a voltage of 1.8 Volt in the solar cells, which is used by the electrolyser (front side, with nickel-foam stripes as anodes and cathodes) to split the water into hydrogen and oxygen. Credit: Tobias Dyck/Forschungszentrum Juelich

Compatible with a wide range of technologies

At the moment, the solar-to-hydrogen efficiency of the prototype is 3.9 %. "That doesn't sound like much," admits Bugra Turan. "But naturally this is only the first draft for a complete facility. There's still plenty of room for improvement." In fact - the scientists add - natural photosynthesis only achieves an efficiency of one per cent. Jan-Philipp

Becker is of the opinion that within a relatively short time the Jülich design could be increased to around 10 % efficiency using conventional solar cell materials. However, there are also other approaches. For instance, perovskites, a novel class of hybrid materials, with which it is already possible to achieve efficiencies of up to 14 %.

"This is one of the big advantages of the new design, which enables the two main components to be optimized separately: the photovoltaic part that produces electricity from solar energy and the electrochemical part that uses this electricity for water splitting." The Jülich researchers have patented this concept, which can be flexibly applied for all types of thin-film photovoltaic technology and for various types of electrolyser. "For the first time, we are working towards a market launch", says Becker. "We have created the basis to make this reality."

More information: Bugra Turan et al, Upscaling of integrated photoelectrochemical water-splitting devices to large areas, *Nature Communications* (2016). [DOI: 10.1038/NCOMMS12681](https://doi.org/10.1038/NCOMMS12681)

Provided by Forschungszentrum Juelich

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