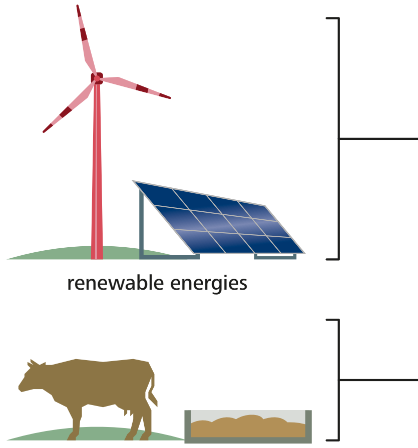


Interim storage for green electricity

“Power-to-Gas” is a key concept when it comes to the storage of alternative energies. Excess energy from solar cells and wind farms is converted into hydrogen. When combined with the greenhouse gas CO_2, methane can be produced that can easily be stored and distributed in the natural gas grid. Empa researchers have now succeeded in further optimizing this process.

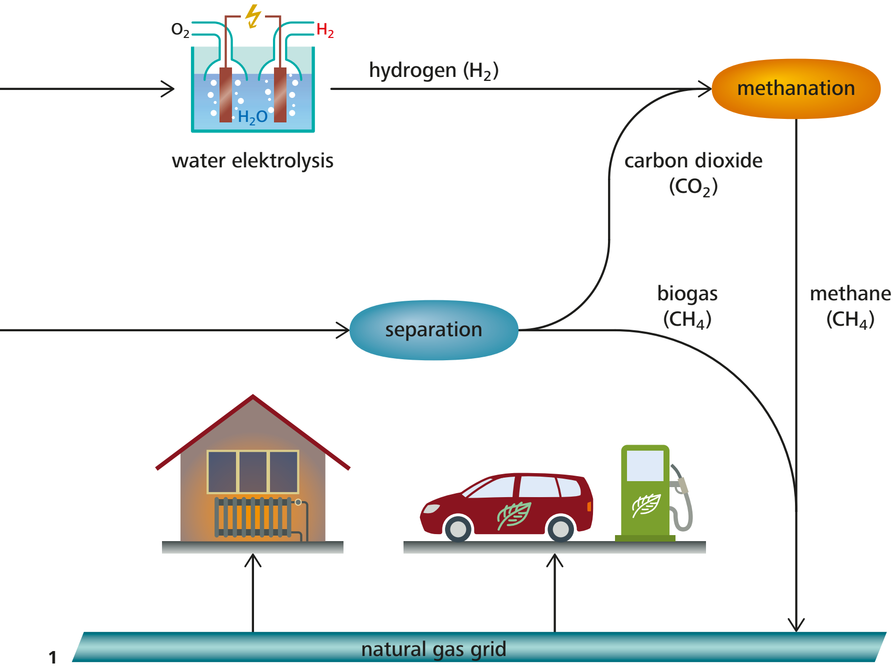
TEXT: Cornelia Zogg /
PICTURES, ILLUSTRATION: Empa

Photovoltaic systems and wind power plants generate large volumes of renewable energy. Depending on the wind and weather conditions there is, however, often a surplus that cannot be used productively. A storage facility for excess energy would help to remedy this situation. Already today excess power can be converted into hydrogen (H_2) by water electrolysis. Hydrogen can serve as an energy reservoir but methane would be an easier option. It is the main component in natural gas and can be produced quasi from “waste products”: besides combustible methane the production of crude biogas also yields large amounts of carbon dioxide (CO_2). Before being discharged into the natural gas grid biogas must first be desulfurized, dried and stripped of CO_2. The separated CO_2 is normally released into the atmosphere; biogas is thus a renewable energy source but also a factor in carbon dioxide emissions that shouldn’t be underestimated.

The methanization process can use the CO_2 from biogas production. With hydrogen from excess green electricity it supplies “clean” methane that can be distributed easily and cheaply in the natural gas grid, and stored over longer periods, too. This means that a quasi ‘fossil’ fuel is produced from renewable energies – the basic principle of “Power-to-Gas”.

Process optimization using zeolites

The Sabatier reaction, which produces combustible methane from hydrogen and CO_2 , is a well-known process. Now researchers in Empa’ laboratory for Hydrogen and Energy have succeeded in further optimizing the process. A catalyst, for instance nickel, is needed to trigger the reaction between CO_2 and hydrogen with as little energy input as possible. On a catalyst surface of this kind, the gas molecules react more readily with one other – the energy input for the reaction is reduced. This is called adsorption catalysis. Empa scientist Andreas Borgschulte and his team have now combined a nanoscale nickel catalyst with a zeolite. Ze-



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1
Hydrogen can be extracted from excess green electricity at certain times of the day (above). It is combined with CO_2 from crude biogas to form methane in a special reactor. A valuable climate-neutral fuel has been made from waste materials and "waste energy".

2
Andreas Borgschulte with the zeolite particles used in the new methanization method.

3
Data from the reactor prototype (on the left), in which methanization takes place, are recorded and analyzed.

Zeolites

Zeolites are already being used in many areas for instance as ion exchangers in water softeners, as dishwasher drying agents and as EDTA substitutes in detergents. Moreover, zeolites are suitable for water decontamination because they store metal ions like the nickel used for methanization. In the nuclear disaster in Fukushima researchers tried to use zeolites to bind radioactive cesium and strontium isotopes from the wastewater flowing into the sea.
Another example of zeolite applications is the self-cooling beer keg – the water-absorbing capacity of zeolite produces evaporative cooling, which keeps the beer cold without electricity.

olites are crystalline alumosilicates with the capacity to absorb water molecules and then release them when heated.

The principle is simple: during the chemical reaction between hydrogen and CO_2 not only methane (CH_4) but also water (H_2O) is formed. The researchers use the zeolite's "hygroscopic" property to remove water. The chemical balance shifts towards methane. The result: a higher yield of pure methane and, by extension, a far more efficient catalytic process. As soon as the zeolite is saturated with water, it can once again be "unloaded" by heating and vaporizing the water and then be used again.

Wanted: project partners

The process does work but for the time being only on a laboratory scale. It's still a long way to commercial use in large-scale plants according to Borgschulte. Right now, the Empa researchers are looking for project partners in order to build a methanization plant on a larger scale and to use it as a pilot project. At the same time, Borgschulte's team is planning to further optimize the process. The next step involves using four or more adsorption catalysts simultaneously. When one is full, saturated with water, the plant automatically switches to the next "dry" catalyst whilst the previous one is devaporized.

One problem encountered with this cyclic method so far is sulfur, which is also formed together with methane and CO_2 in biogas plants. Sulfur compounds can cause irreversible damage to the zeolite. The researchers are working on ways to absorb the sulfur from the crude biogas and keep the zeolite functioning as long as possible.

In future Borgschulte thinks that new, more efficient catalytic materials than nickel are feasible in combination with zeolites. They could further improve the Sabatier process. Then the excess green electricity would no longer be a disposable product. //