8.5 Hydrogen and fuel cell

Basic information and collecting ideas 	Renewable energies are generated by strong winds or bright sunshine. However, energy also needs to be provided when there is little wind or no sunshine. The ability to store renewable energies is critical using renewable energies, in view of both personal mobility and power grid operators. Storing electrical energy in the form of hydrogen – and converting it back to electrical energy in fuel cells – is one of the technologies already in place but not yet completely developed for large-scale operation. **Additional information** This experiment takes time for additional preparations, as you may need to first set up the electrolytic cells. In the Additional information section you will find instructions on how to set up an electrolytic cell. Note that the hydrolyse requires a minimum of 2.5 V; you need to apply at least a voltage of 2.5 for the experiment to work. If your students are doing this experiment, the following safety measures apply: ▪ Students must wear safety goggles. Point out that students must immediately rinse their eyes or skin if sodium carbonate or soda solutions splashes on them. ▪ Working with a flame can result in burns or fires. Before a lighter is used the first time, check to ensure that it is working properly and adjust the flame height. Collect the soda solution; it can be reused. The electrical energy produced by wind or solar power plants can be stored in the form of hydrogen resulting from the electrolysis of water. This hydrogen is then available as an energy source for fuel cells or combustion cells. The experiment shows the principle of hydrogen technology. Your students should have some prior knowledge of electrolysis.
Observing and documenting 	The collecting containers depict the volume ratio of gases produced in the electrodes: two parts hydrogen to one part oxygen. If the graphite electrodes are surrounded with a sufficient amount of hydrogen and oxygen, the cell will function temporarily as a fuel cell: Hydrogen and oxygen are converted back to water and electrical energy and an attached motor rotates.

Analysing and reflecting 	By adding electrical energy to a saturated soda solution, you produce hydrogen and oxygen. The dissolved sodium carbonate (soda) serves as the electrolyte. The soda is not consumed in the process. The following reactions take place at the electrodes: Negative pole (cathode): $4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$ Positive pole (anode): $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ Overall reaction: $2H_2O + \text{Energy} \rightarrow 2H_2 + O_2$ The gases produced can be verified through simple tests: hydrogen with the oxyhydrogen test and oxygen with the glowing wooden stick test. The following reactions take place at the electrodes: Negative pole (anode): $2H_2 + 4OH^- \rightarrow 4H_2O + 4e^-$ Positive pole (cathode): $O_2 + 2H_2O + 4e^- \rightarrow 4OH$ Overall reaction: $2H_2 + O_2 \rightarrow 2H_2O + \text{Energy}$ Electrical energy is stored as chemical energy (hydrogen and oxygen) in the electrolytic cell. The hydrogen could be used to generate power. Alternatively, the hydrogen could be converted back to electricity, e.g. in fuel cells. The oxygen can be used in various ways, e.g. as a chemical reagent in sewage plants. However, the oxygen can also be released to the air.

Space for notes