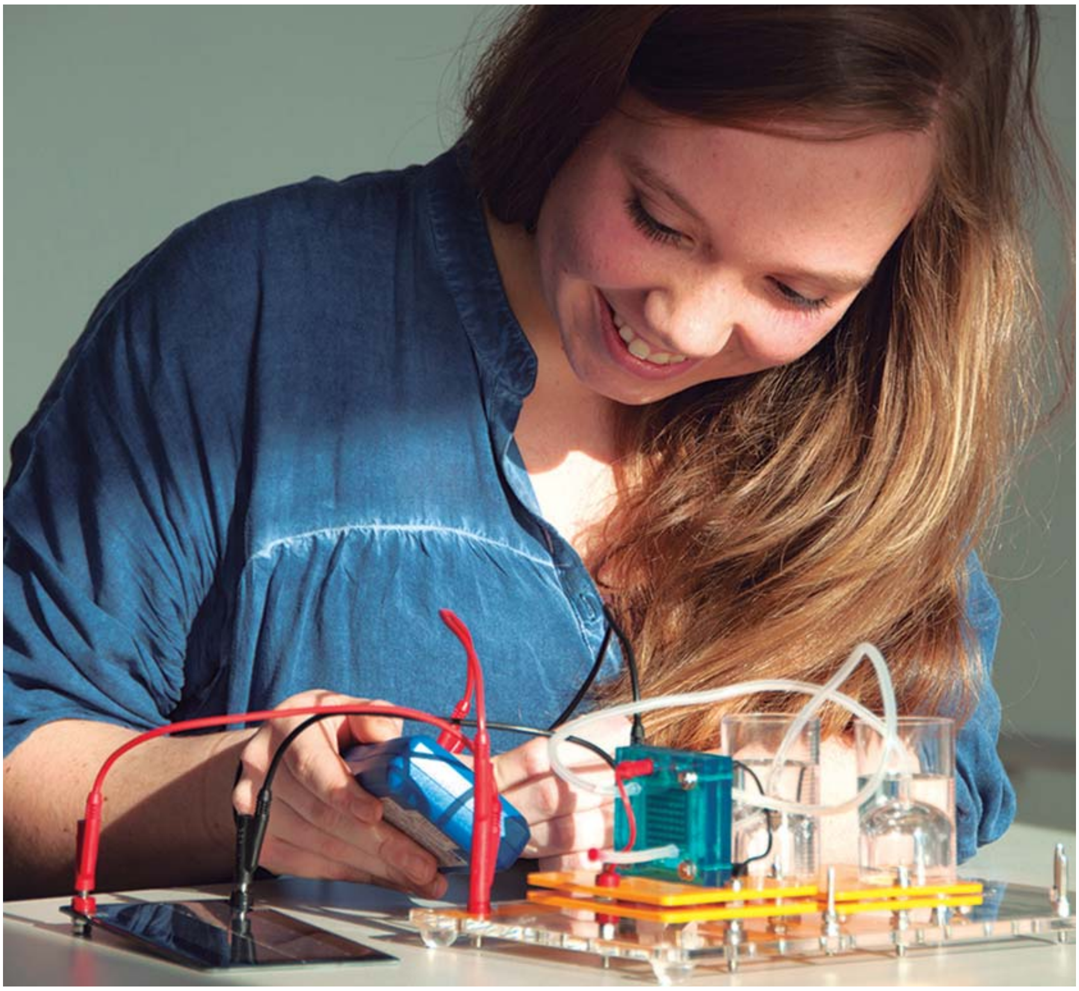
leXsolar-H_2 Ready-to-go



Teacher's Manual

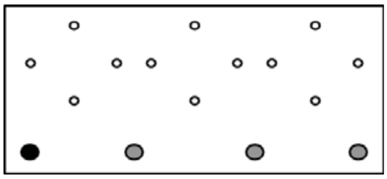
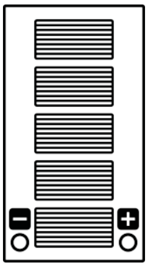
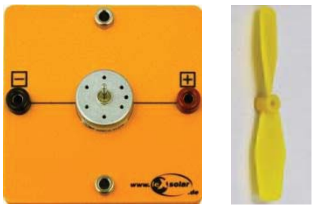
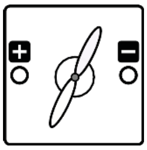
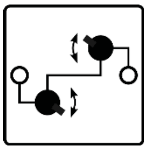
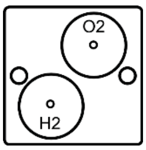
leXsolar-H_2 Ready-to-go

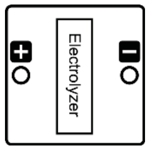
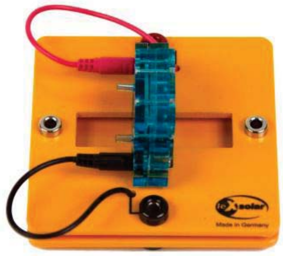
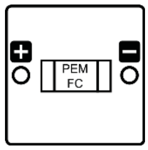
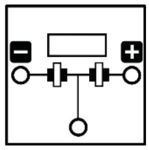
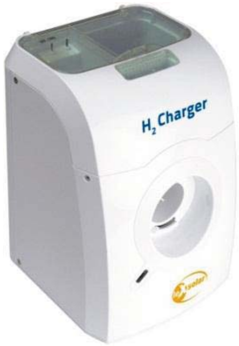
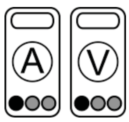
Teacher's manual

I Introduction

II Experiments

1 Designation of components

Standard equipment of leXsolar-H_2 Ready-to-go		
Designation	**Component**	**Symbol in the Experimental Setup**
	leXsolar main board	
	Solar module (2.5V, 420mA)	
	Motor module without gear	
	Potentiometer module	
	Gas storage module	

	Electrolyzer module	
	PEM fuel cell module	
	Ethanol fuel cell module	
	H_2-Charger	
	H_2-Storage	
	Voltmeters / ammeters and cables	

	Lamp	

2 Handling suggestions

When conducting experiments with the leXsolar-H_2 Ready-to-go, some advice concerning the handling of the components and devices should be considered.

2.1 Operation of the electrolyzer

Specifications:

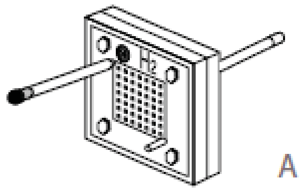
- Input voltage: 1.8 V ~ 3 V (D.C.)
- Input current: 0.7 A
- Hydrogen production rate: 7 ml per minute at 1 A
- Oxygen production rate: 3,5 ml per minute at 1 A

Important handling guidelines:

- Whenever not in use, the electrolyzer should be stored in an air-tight plastic bag, to keep it from drying out.
- Positive and negative pin of the electrolyzer must always be connected to correctly to the voltage source, to avoid damages to the electrolyzer.
- The electrolyzer must only be used with moistened membranes. The distilled water must be filled in on the O_2-side and should be allowed to soak for about 3 minutes. Connecting the dry electrolyzer to the voltage source can lead to irreparable damages.

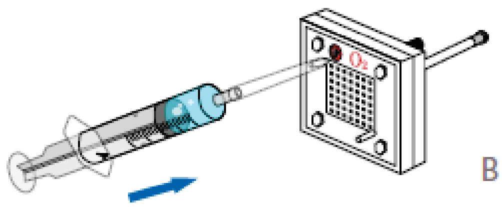
User instructions:

1. The electrolyzer should be placed on a flat surface. The short piece of tube must be connected to the upper port on the H_2-side (black port) and be sealed with the black pin (see A).



A

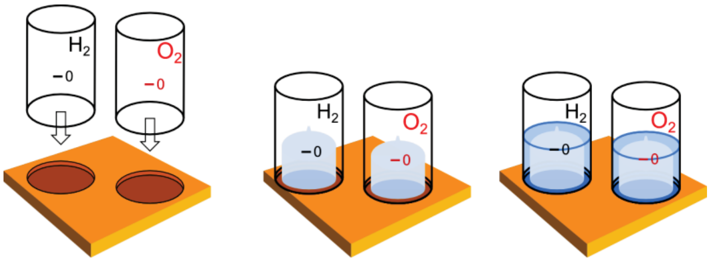
2. The syringe must be filled with distilled water and another short piece of tube should be fitted to it. The other end of the tube must be connected to the upper port on the O_2-side (red port) (see B).



B

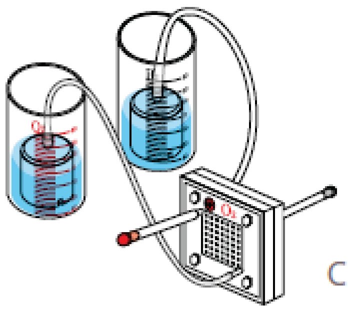
Now, using the syringe, the water should slowly be pumped into the electrolyzer until it leaks out of the lower port. The syringe can now be pulled off the tube, which can be sealed with the red pin. At this point the electrolyzer should sit for 3 minutes.

3. Now, the water barrels should be filled with distilled water up to their respective markings.



4. Each gas storage tank should be pinned onto the ring mount at the bottom of each water barrel, so that the grooves on the bottom of the gas tanks are aligned with the grooves of the ring mounts. Excess water can be removed using the syringe.

5. At this point, the gas storage tanks can be connected to the lower ports of the electrolyzer using the long pieces of tube. The black port of the H_2-side must be connected to the H_2- storage tank and the same goes for the red O_2-side and the O_2 tank (see C).



C

6. The electrolyzer can now be placed onto the module plate and be connected to it using the respective cables (red for O_2, black for H_2).

7. Now, the unit can be connected to the solar module or an external voltage source to start the electrolytic process.

<u>NOTE</u>: If the hydrogen gas shall later be used for a fuel cell experiment, it is recommended to put a clamp on the tube connecting the H_2-side of the electrolyzer with the H_2 tank. It can be closed after the gas production, so that the hydrogen can be stored in its tank for later experiments.

2.2 Operation of the PEM fuel cell

Specifications:

- Output power: 270 mW
- Output voltage: 0,6 V (DC)
- Output current: 0,45 A

Important handling guidelines:

- Whenever not in use, the fuel cell should be stored in an air-tight plastic bag, to keep it from drying out.

User instructions:

1. To operate the fuel cell, hydrogen gas is needed. This can be obtained from the H_2-Storage or from the H_2 tank from a previous experiment.

2. If the hydrogen is taken from the gas tank, the tube must be clamped to avoid hydrogen gas to leak.

3. The tube of the H_2 tank must be connected to the lower port of the fuel cell. The O_2 supply for this model is ensured by the ambient air.

4. The upper port of the fuel cell must be sealed, using a short piece of tube and a pin.

5. The fuel cell can now be placed onto the module plate and be connected to it using the respective cables (red for O_2, black for H_2).

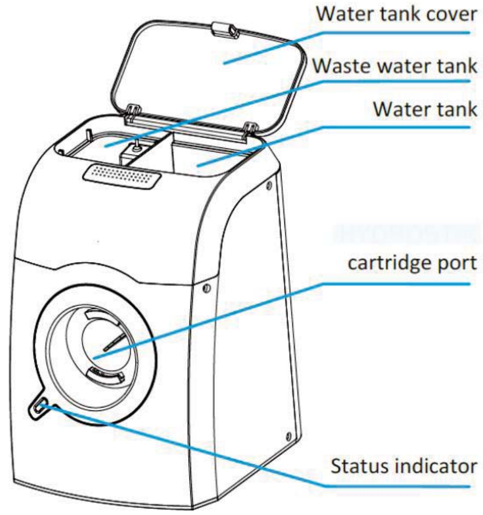
6. Now, the unit can be connected to an electrical load. (Mind the polarity!).

7. By opening the tube clamp the experiment can be started.

NOTE: For quantitative experiments like taking a characteristic curve, we recommend flushing the fuel cell with hydrogen gas by initiation the gas supply (opening the tube clamp on the tank or opening the valve on the H_2 storage) and removing the pin on the short tube for only 1-2 seconds.

2.3 Operation of the H_2-Charger and H_2-Storage

Designation of the parts:



Specifications H_2-Charger:

- Power: 23 W
- Input voltage: 10 V-19 V (DC)
- Use: De-ionized or distilled water (10-40°C)
- Water consumption: ca. 20 ml/h
- Hydrogen pressure: 0-3 MPa
- Hydrogen production rate: ca. 3 l/h
- Hydrogen purity: 99.99%
- Refill time per cartridge: about 4 h

Specifications H_2-Storage:

- Capacity: 10 l hydrogen
- Storage material: AB5 metal hydride
- Load pressure: 3 MPa
- Working temperature: 0-55°C

Important handling guidelines:

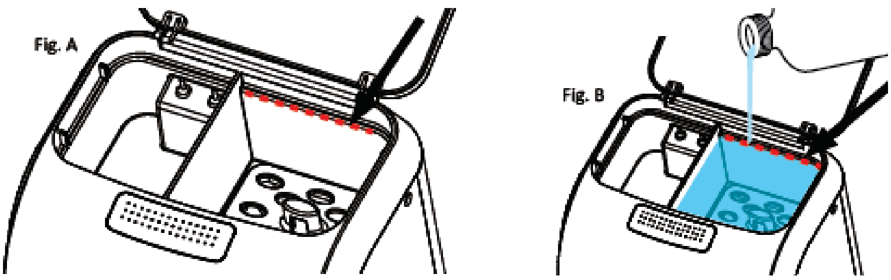
- The H_2-Charger must not be disassembled.
- Both the H_2-Charger and the H_2-Storage must be kept away from heat or flames.
- The H_2-Charger should be operated in an upright position.
- Operations should be done in a well-vented room.
- All electric connections should be kept away from water.

Status light:

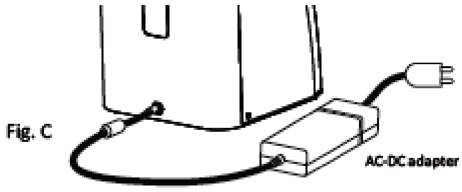
green	red	System status
on		H_2-Storage full
1 second on, 1 second off		Filling of H_2-Storage is halted
	on	H_2-Storage is being filled
	1 second on, 1 second off	Add water or empty the waste water container

Usage instructions:

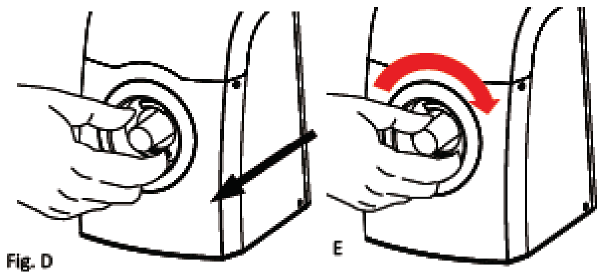
1. Firstly, fill distilled or deionized water up to the mark (see red line and arrow in the figure).



2. Connect the power adaptor to the H_2-Charger. The status light should flash green.



3. Insert the H_2-Storage into the opening on the front side of the H_2-Charger. For this, the stick should be turned clockwise until it locks in place. Don't apply too much force!



4. While the status light is flashing red, the H_2-Storage is being filled. Only when the status light flashes green, the cartridge is completely filled. The stick may now be removed by turning it counter clockwise.

5. Now remove the power adaptor and empty the water tank, in case the H_2-Charger will not be used within the following week. If further cartridges must be filled, revisit this procedure, starting at point 3.

<u>NOTE:</u> Distinct noises (gargling and whistling) are normal during the charging process and are being produced by the self-cleaning of the device.

I. Sample solution of the experiments

The filled out forms of the students' notebook depict the expected experimental results and show possible answers to the questions asked in the evaluation. Those answers are to be understood as guidelines. Every teacher should decide for themselves which answers to expect from their students.

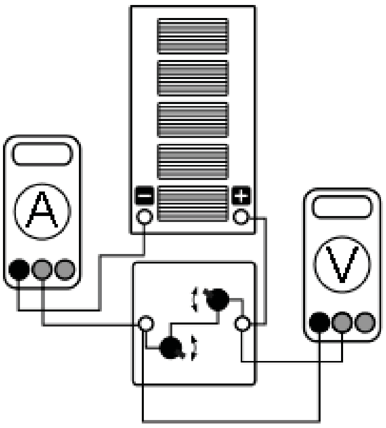
The association of each experiment with a specific grade varies with each curriculum. For some experiments there are variations accommodating different age groups. The more phenomenological experiments are better suited for younger students. Whereas experiments containing power measurements are recommended for older students, since fundamental knowledge in physics and mathematics are required. All manuals are provided as a Microsoft Word document, so they can be altered at your own discretion.

1. I-V curve of a solar module

Goals

Take the I-V curve of a solar module and interpret ist behavior.

Setup



Equipment needed

- Solar module
- Lamp
- Cables
- Ammeter
- Voltmeter
- Potentiometer module

Procedure

1. Set up the experiment in accordance with the drawing.
2. Place the lamp in front of the solar module (distance ca. 30 cm) and switch on the lamp.
3. Set sensible values for the voltage and measure the resulting current. For this, first adjust the 1kΩ resistor and then the 100Ω resistor for better control.
4. Enter your measurements into the table.

Measurements

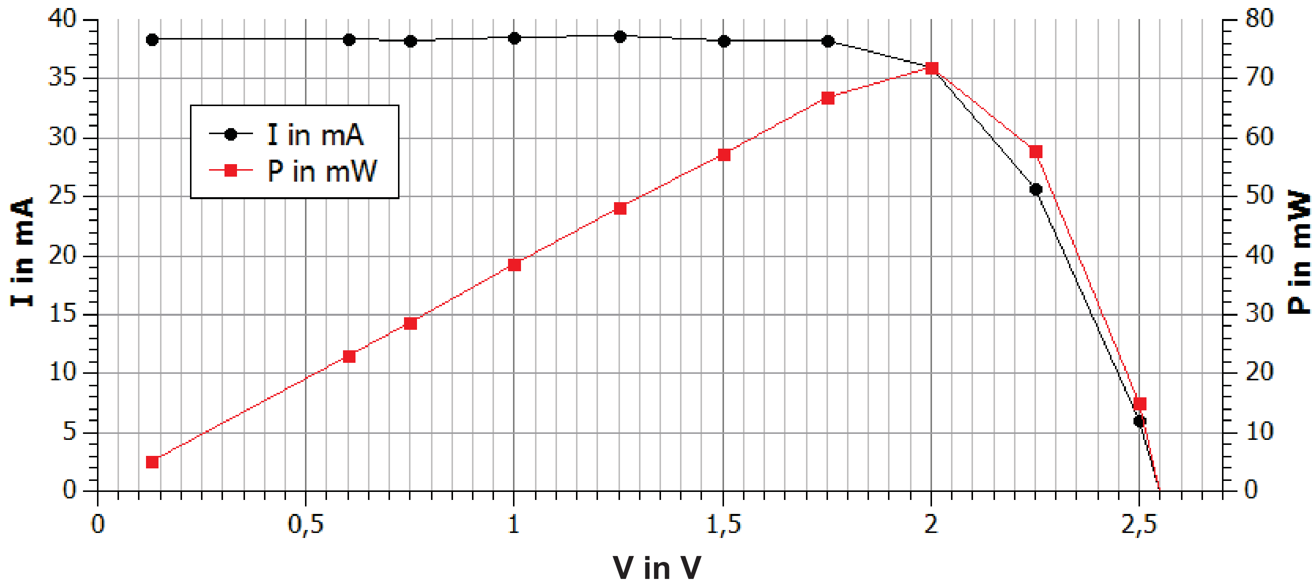
V in V	I in mA	P in mW
0.13	38.4	4.99
0.60	38.4	23.04
0.75	38.3	28.73
1.00	38.5	38.50
1.25	38.6	48.25
1.50	38.2	57.30
1.75	38.2	66.85
2.00	36.0	72.00
2.25	25.7	57.83
2.50	6.0	15
2.55	0	0

Evaluation

1. Calculate the power for every pair of voltage and current values and enter your results into the table.
2. Plot the respective value in the given diagram.
3. Describe the behavior of the current and the power in dependence of the voltage.

Diagrams

2.



3.

The I-V curve matches that of a single solar cell. In the first segment the current remains nearly constant with increasing voltage. Starting at a voltage of about 1.7 V the current decreases rapidly.

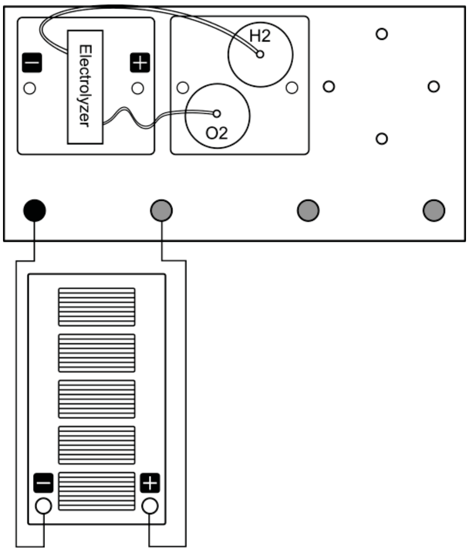
The power of the solar module strongly increases with the voltage and peaks at around 2 V. This particular point is called the "MPP – Maximum Power Point". Solar cells should be operated at that point to achieve maximum power efficiency.

2.1 Properties of an electrolyzer

Goals

Investigate the ability of the electrolyzer to split water.

Setup



Equipment needed

- leXsolar main board
- Electrolyzer module
- Gas storage module
- Tubes
- Solar module
- Lamp
- Cables
- Distilled water

Procedure

1. Assemble the electrolyzer module and the gas storage module in accordance with the drawing. Place the lamp in front of the solar module (distance ca. 30 cm).
   You can find notes on how to set up and use the electrolyzer in chapter "Operation of the electrolyzer" on page 8.
2. Switch on the lamp.
3. Watch what happens inside the gas storage tanks.
4. Note the filling level after 15 minutes.

Observation

Produced amount of H_2: 6ml

Produced amount of O_2: 3ml

Evaluation

1. What is the composition of water? Use the measured amounts of gas in for your explanation.

Water is composed of two parts hydrogen and one part oxygen.

Therefore, twice the amount of hydrogen than oxygen is produced.

$2H_2O \longrightarrow 2H_2 + O_2$