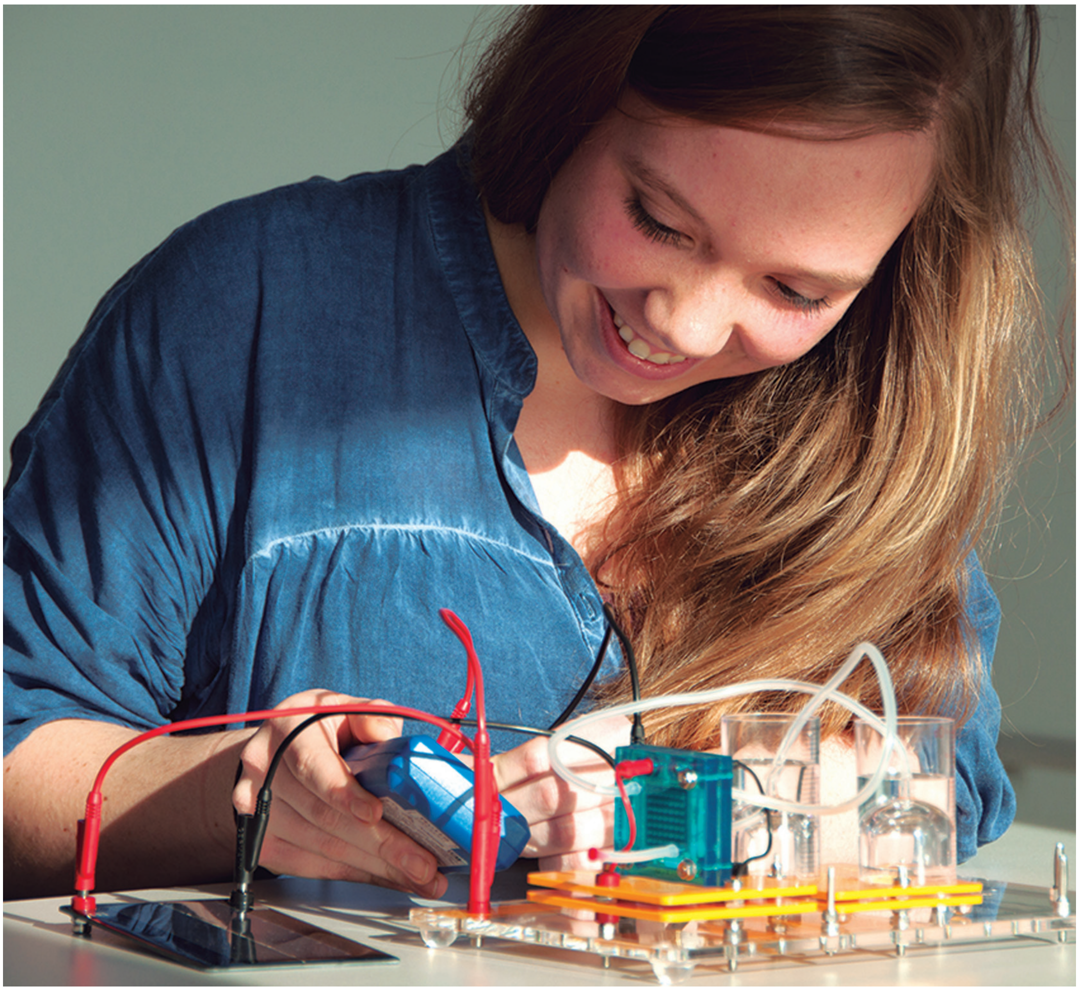
leXsolar-H_2 Professional

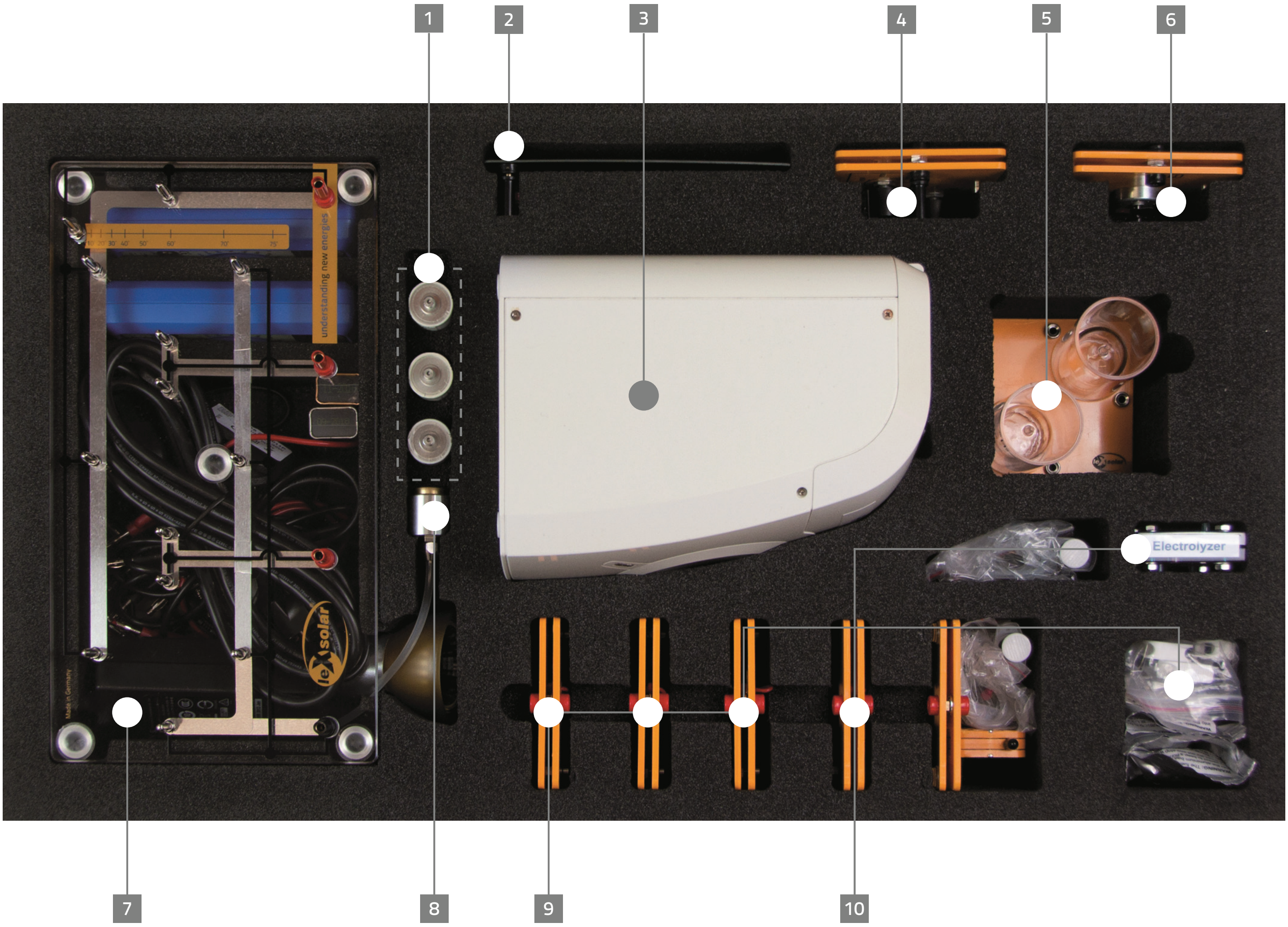


Experiment handbook

www.lexsolar.de/feedback

Layout diagram leXsolar-H_2 Professional
Item-No.1217

Bestückungsplan leXsolar-H_2 Professional
Art.-Nr.1217



1 — 1200-18 H2 Storage + 2xoptional expansions
1200-18 H2 Storage + 2xoptionale Erweiterung

2 — 1100-31 Solar panel 2.5 V, 420 mA
1100-31 Solarmodul 2.5 V, 420 mA

3 — 1200-17 H2 Charger
1200-17 H2 Charger

4 — 1100-23 Potentiometer module
1100-23 Potentiometermodul

5 — 1213-01 Gas storage module
1213-01 Gasspeichermodul

6 — 1100-27 Motor module with
L2-02-017 Yellow propeller
1100-27 Motormodul ohne Getriebe mit
L2-02-017 Luftschraube (Propeller) gelb

7 — 1100-19 Base unit large
1100-19 Grundeinheit groß

8 — L2-06-132 Valve for H2 Storage
L2-06-132 Ventil für H2 Storage

9 — 3x1218-02 PEM-Fuel cell module
3x1218-02 PEM-Brennstoffzellenmodul

10 — 1218-03 Electrolyzer module 2.0
1218-03 Elektrolyseurmodul 2.0

Version number
Versionsnummer

II-01.24_L3-03-195_04.05.2017

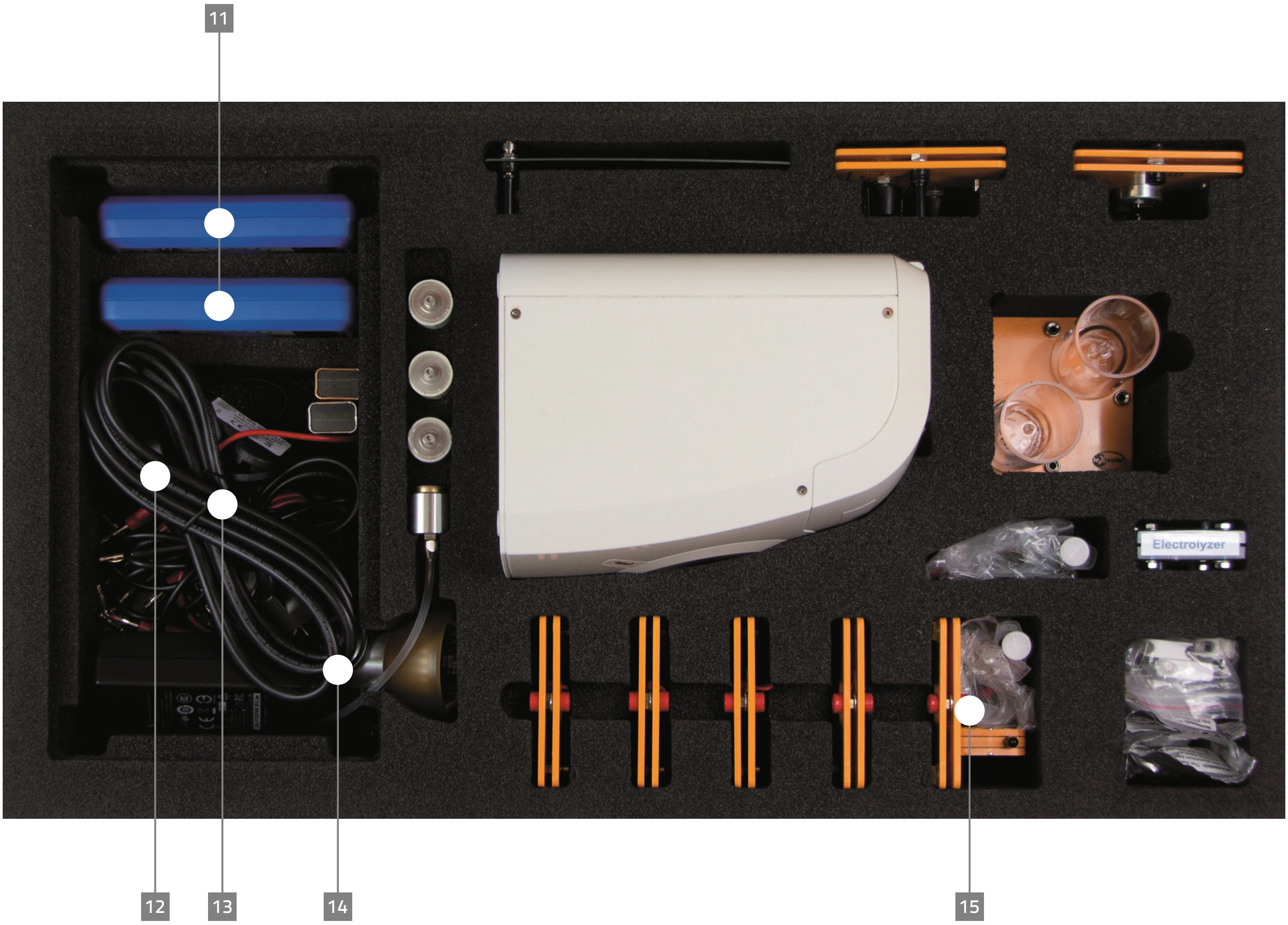
CE RoHS 2

Layout diagram leXsolar-H_2 Professional

Item-No.1217

Bestückungsplan leXsolar-H_2 Professional

Art.-Nr.1217



11	2xL2-06-011 Digital multimeter 2xL2-06-011 Digitalmultimeter
12	2xL2-04-066/067 Test lead black/red 25 cm 2xL2-04-066/067 Messleitung schwarz/rot 25 cm
13	L2-06-059/060 Test lead black/red 50 cm L2-06-059/060 Messleitung schwarz/rot 50 cm
14	L2-04-022 Lamp with table clamp L2-04-022 Lampe mit Tischklemme
15	1700-01 Ethanol fuel cell module 1700-01 Ethanol-Brennstoffzellenmodul

CE RoHS 2

leXsolar-H_2 Professional

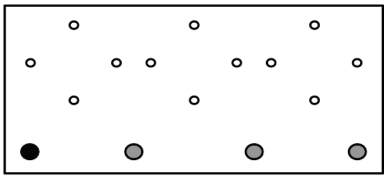
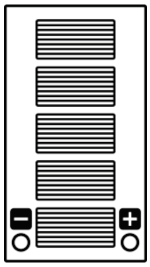
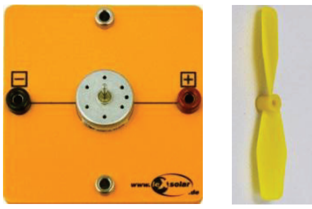
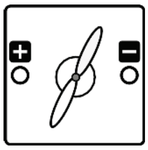
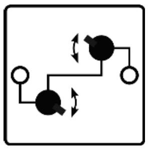
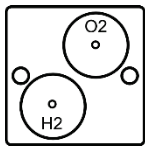
Experiment handbook

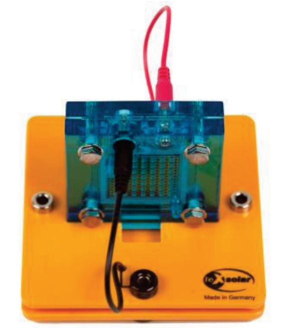
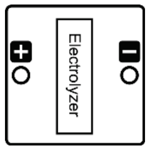
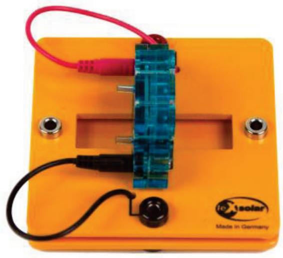
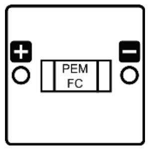
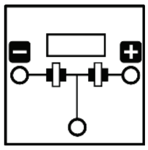
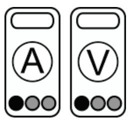
I Introduction

II Experiments

L3-03-199_21.04.2017

1 Designation of components

Standard equipment of leXsolar-H_2 Professional		
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	

2 Handling suggestions

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

2.1 Operation of the electrolyzer

Specifications:

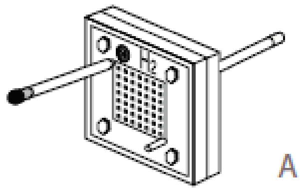
- Input voltage: 1.8 V ~ 3 V (D.C.)
- Input current: 0.7 A
- Hydrogen production rate: 7 ml per minute at 1 A
- Oxygen production rate: 3,5 ml per minute at 1 A

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.

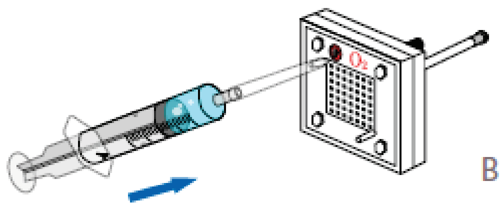
User instructions:

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

Handling suggestion

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:

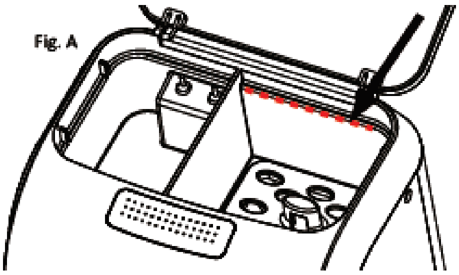
- The H_2-Charger must not be disassembled.
- Both the H_2-Charger and the H_2-Storage must be kept away from heat or flames.
- The H_2-Charger should be operated in an upright position.
- Operations should be done in a well-vented room.
- All electric connections should be kept away from water.

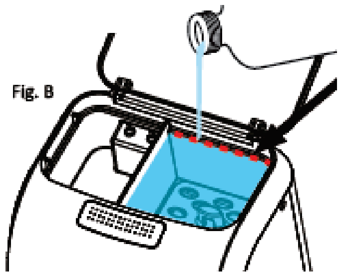
Status light:

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).





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.

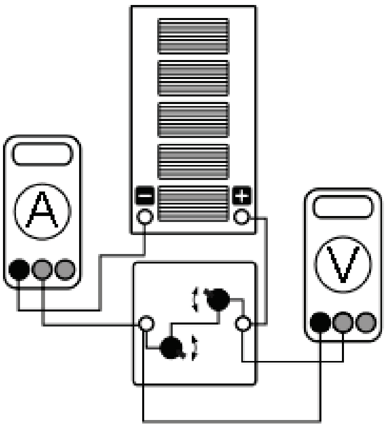
The association of each experiment with a specific grade varies with each curriculum. For some experiments there are variations accommodating different age groups. The more phenomenological experiments are better suited for younger students. Whereas experiments containing power measurements are recommended 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

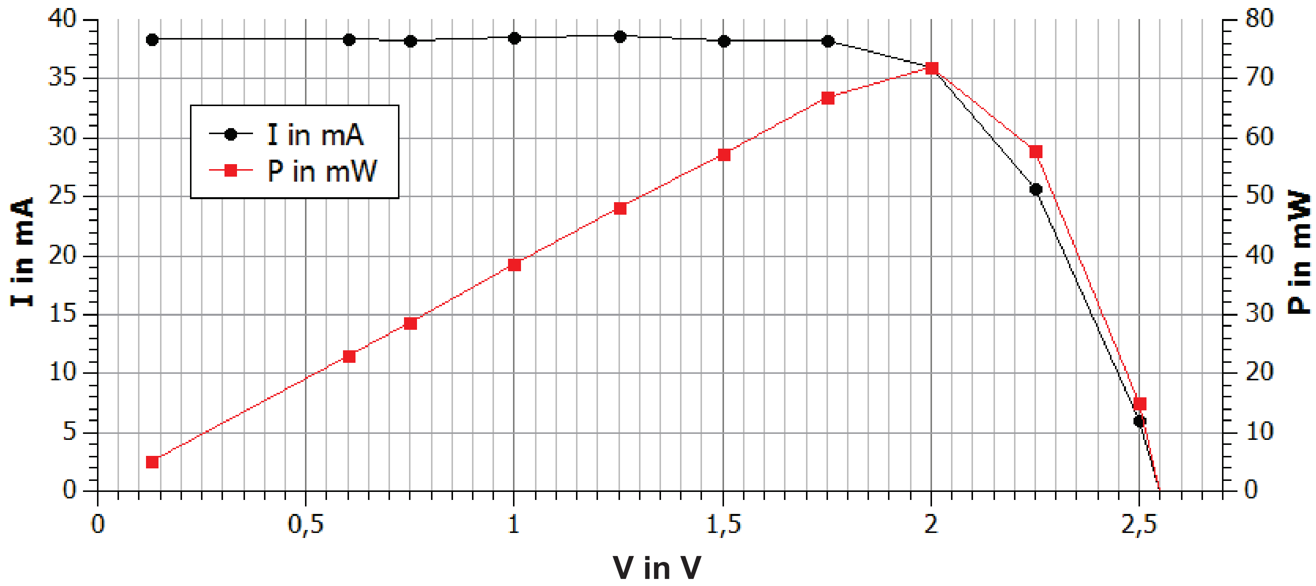
1. I-V curve of a solar module

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.

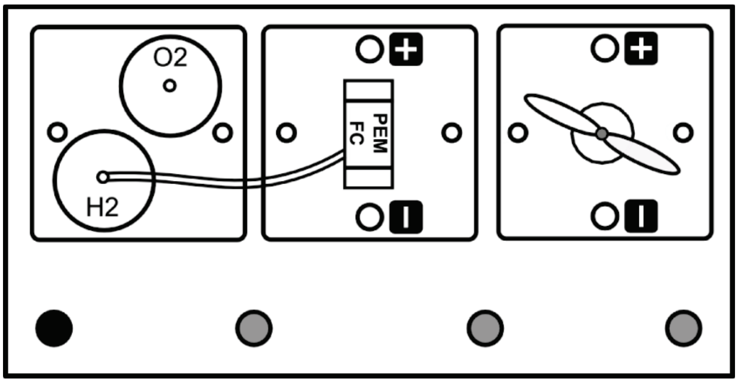
The power of the solar module strongly increases with the voltage and peaks at around 2 V. This particular point is called the “MPP – Maximum Power Point”. Solar cells should be operated at that point to achieve maximum power efficiency.

3.1 Properties of a PEM fuel cell

Goals

Power a motor with a PEM fuel cell.

Setup



Equipment needed

- leXsolar main board
- PEM fuel cell
- Tubes
- Motor module
- Gas storage (full), alternatively H_2-Storage

Procedure

1. Set up the experiment in accordance with the drawing. The gas storage has to be filled prior to the experiment. You can find notes on how to set up and use the electrolyzer in chapter "Operation of the electrolyzer" on page 8. Alternatively, you can use an H_2-Storage container.
2. Watch the motor and the H_2-consumption. Write down your observations.
3. Remove the tubes from the fuel cell and watch what happens.

Evaluation

When the fuel cell is supplied with hydrogen, the motor starts running. The fuel cell is producing energy

Gas in the storage tank is slowly being used up. When the tubes are removed from the fuel cell, the

motor decelerates and finally stops completely.

Evaluation

1. Which type of energy conversion is happening during the experiment?
2. Why is there only a hydrogen nozzle on the fuel cell, when we need both oxygen and hydrogen to produce energy?
3. Where does the gas from the storage tank go?

Evaluation

1.

The fuel cell consumes the previously produced gases and produces energy, which can be used to run a motor. During this process chemical energy is converted into electrical energy. The generator inside the motor module converts this electrical energy into kinetic energy.

2.

Air consists of 21% oxygen but virtually no hydrogen. To facilitate the reaction, both oxygen and hydrogen are necessary, while the ambient oxygen content is already sufficient.

3.

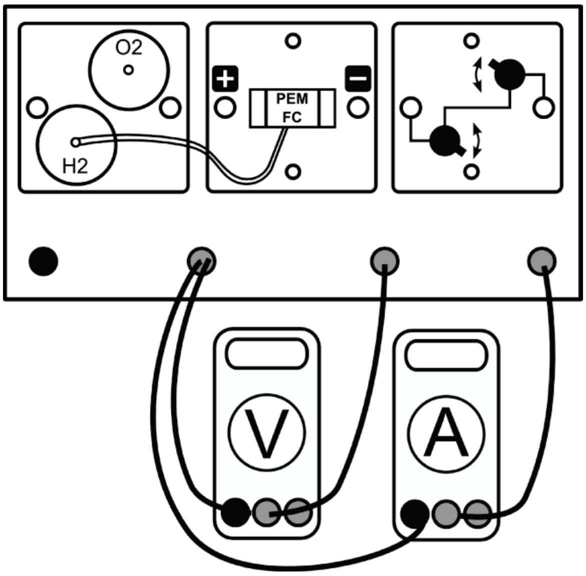
Hydrogen and oxygen are combined to produce liquid water, which is significantly lower in volume, which gives the impression that the gas disappears.

3.2 I-V-curve of a PEM fuel cell

Goals

Take the I-V-curve of a PEM fuel cell.

Setup



Equipment needed

- leXsolar main board
- PEM fuel cell module
- Potentiometer module
- Voltmeter
- Ammeter
- Cables
- Tubes
- Distilled water
- Gas storage (full), alternatively H_2-Storage

Procedure

1. Set up the experiment in accordance with the drawing. The gas storage has to be filled prior to the experiment. You can find notes on how to set up and use the electrolyzer in chapter "Operation of the electrolyzer" on page 8. Alternatively, you can use an H_2-Storage container.
2. Set the potentiometer to the highest resistance by tuning both knobs to their respective maximum.
3. Quickly flush the fuel cell with hydrogen. You can find hints on how to do this on page 10.
4. Determine and set sensible voltage values and measure the resulting current. For this, first adjust the 1kΩ resistor and then the 100Ω resistor for better control.
5. Enter your measurements into the table.

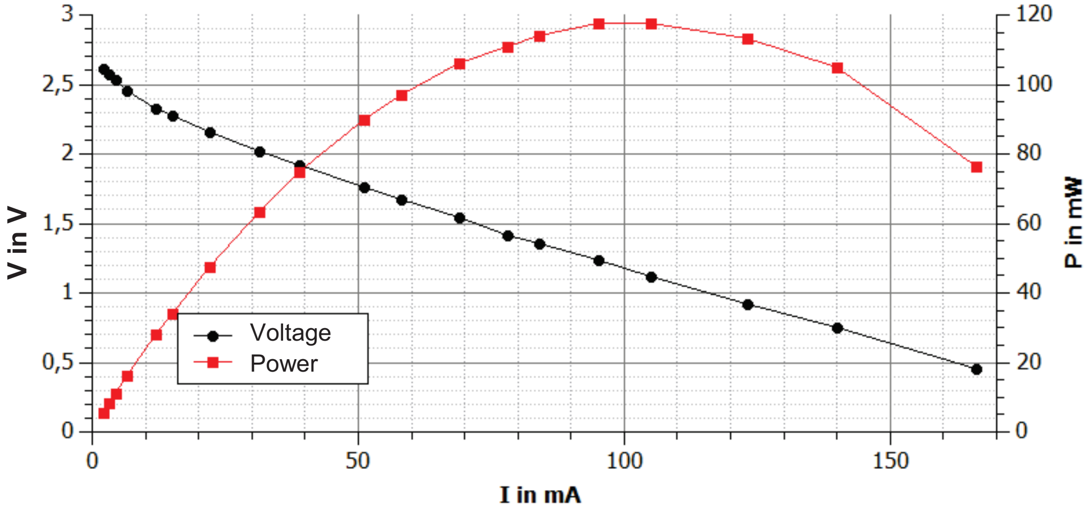
Measurements

V in V	I in mA	P in mW
0.9	0	0
0.75	7.5	5.63
0.7	11.2	7.84
0.65	16.7	10.86
0.6	23.2	13.92
0.5	39.2	19.6
0.43	48.9	21.03

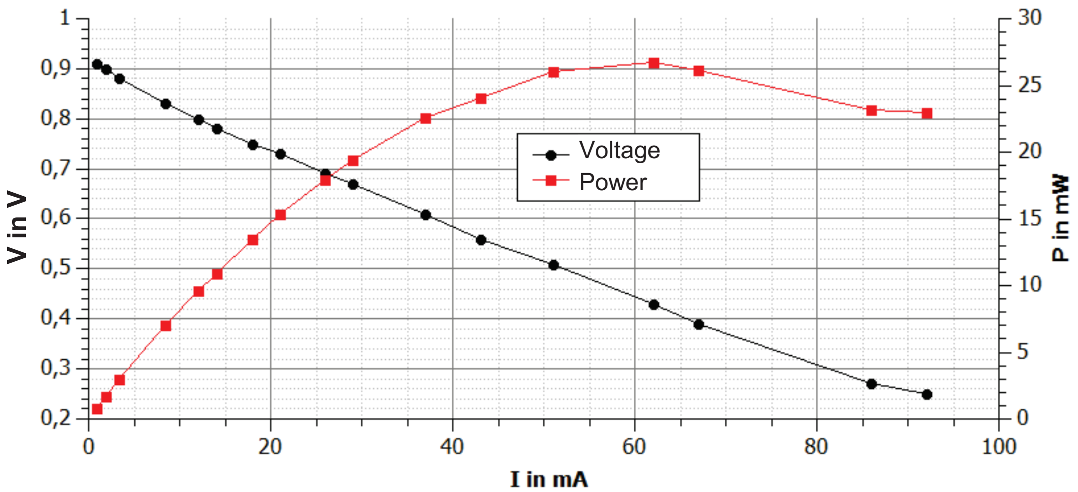
3.4 Series and parallel circuits of PEM fuel cells

Diagrams

a) Series circuit



b) Parallel circuit



Evaluation

3.

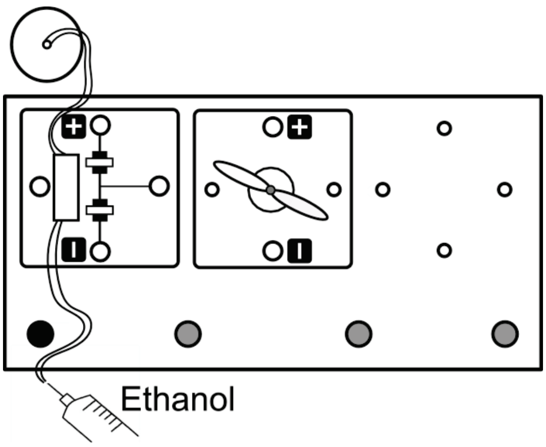
The first part of the I-V-curve strongly decreases, especially for the series circuit. After that the curve progresses more shallowly. The highest possible voltage of this PEM fuel cell amounts to 0.9 V in parallel and to 2.6 V in series connection. The power of the fuel cell increases with current and reaches a maximum. For the parallel circuit this is situated at around 60 mA and for the series circuit at around 100 mA. In general, both the achievable voltage and power of the fuel cell are higher for the series circuit.

4.1 Working principles of an ethanol fuel cell

Goals

Investigate the working principles of an ethanol fuel cell.

Setup



Equipment needed

- leXsolar main board
- Ethanol fuel cell
- Motor module
- Tubes
- Beaker
- Syringe
- Ethanol

Procedure

1. Set up the experiment in accordance with the drawing.
2. Use the tubes and the syringe to fill the fuel cell with ethanol. Write down your observations.
3. When the motor has started to turn, clutch the syringe tightly in your hand in order to warm up the ethanol. Press the remaining ethanol into the fuel cell. Write down your observations.

Evaluation

1. What can you smell at the fuel cell?
2. Which reactions do occur? Explain the working principle of this reaction

Observations

The motor slowly starts turning. When the ethanol warms up, after some delay time, the motor's speed starts to increase .

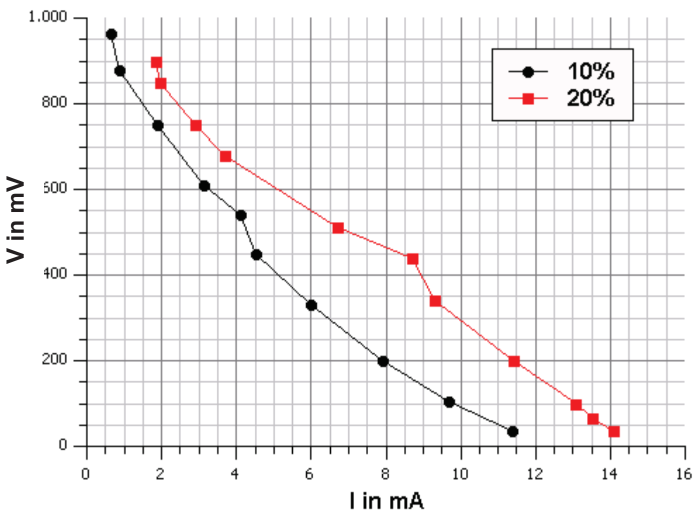
There appears to be a temperature dependence of the fuel cell's power output.

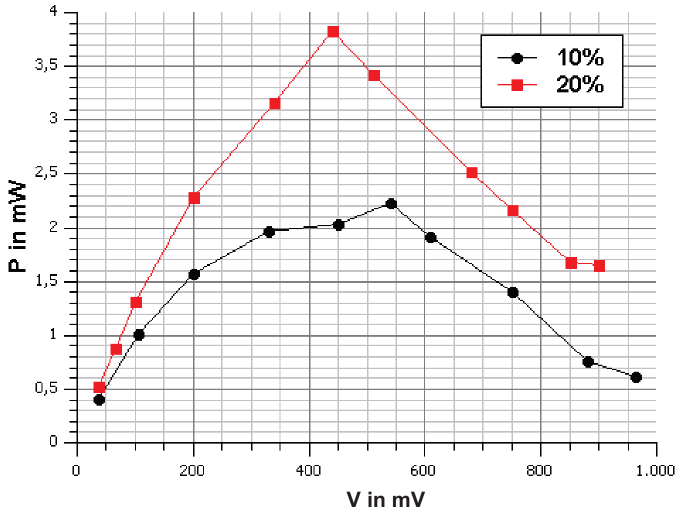
4.4 Concentration dependence of an ethanol fuel cell

Evaluation

1. Calculate the cell's power output for each value and enter your results into the table.
2. Plot your measurements as well as the results of your calculations in the diagrams.
3. How can the curves be interpreted?

Diagrams





Evaluation

3.

It is obvious, that the power increases with a higher ethanol concentration. This is due to the fact that at a higher concentration more ethanol molecules are present, which enables a higher electron flow.

The position of the power maximum, however, does not seem to shift (ca. 450 V). This is important for the technical application of the fuel cell.

Looking at the same voltage value, the 20% solution shows a higher current than the 10% solution. This is due to the fact, that the current is defined as number of charge carriers per area unit per unit of time. For a higher ethanol concentration, there are more electrons available, therefore the current increases.

leXsolar GmbH
Strehlener Straße 12-14
01069 Dresden / Germany

Telefon: +49 (0) 351 - 47 96 56 0
Fax: +49 (0) 351 - 47 96 56 - 111
E-Mail: info@lexsolar.de
Web: www.lexsolar.de