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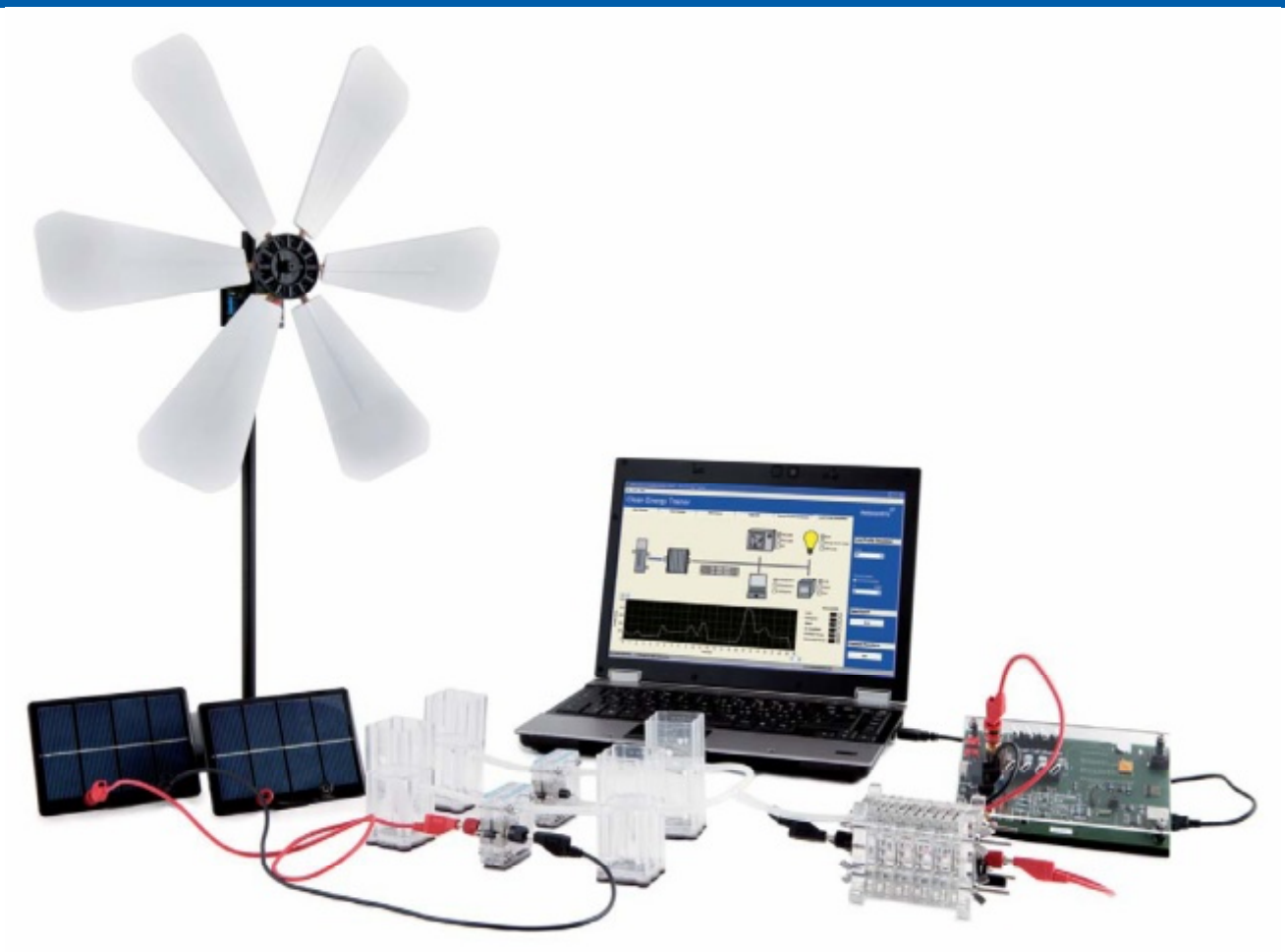
Clean Energy Trainer

Experiment Guide



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Preface

Renewable energies and their importance for safeguarding our way of life have now become a matter of general awareness. Their benefits are indisputable. The utility of hydrogen as a fuel has also gained an increased focus in recent years. This Experiment Guide can help explain renewable energies to your students in an entertaining manner and familiarize them with the interrelationships of renewable energy sources and hydrogen. This manual makes the utility of energy conversion comprehensible and promotes an understanding for practical application.

Curriculum aspects

Among other things, this manual can help to communicate the following aspects:

- Principle of solar cells
- Principle of wind generators
- Chemical reactions
- Electrolysis
- Faraday's laws
- Principle of fuel cells
- Efficiencies
- Dimensioning of various components of renewable energies
- Influences on systems of renewable energies
- Conversion of different energy forms
- Science and technology in a regional, national and global connection.

Here at Heliocentris we hope that your students will gain experience using our product which will provide them with an understanding of energy sources, hydrogen and fuel cells and pique their general interest in the subject of sustainable solar-hydrogen technology.

If only the masculine or feminine form is used in parts of this manual, this is only used for readability and simplicity. Persons of the respective other gender are always included.

1 Lesson Planning

This Experiment Guide includes 13 experiments covering various thematic blocks from renewable energies. Each of the experiments is accompanied by a worksheet with questions about the experiment as well as a corresponding answer sheet.

A fundamental description of the components and the basic action sequence can be found in the Instruction Manual.

Overview

This Experiment Guide contains instruction material covering the subject of renewable energies. This manual is subdivided into the following topics:

- Solar energy
- Wind energy
- Hydrogen and electrolysis
- Fuel cells
- The combination of multiple renewable energy sources

There are two to three experiments and two to three worksheets for each topic. The sample solutions for the experiments and the worksheets can be found on the answer sheet. We recommend the following instructional sequence:

Recommended sequence planning

Activity	Duration [min]	Social form
Development phase Theoretical part	15	Instructor lecture
Consolidation phase 1 Experiment 	20	Group work (3-5 students per group)
Recapitulation 1 Comparison with students 	10	Instructor or student lecture, active participation
Consolidation phase 2 Worksheet 	25	Individual work or in pairs
Recapitulation 2 Comparison with students 	20	Instructor or student lecture, active participation

Table1-1 Sequence planning

With a 45-minute school hour, the sequence can be discontinued after Recapitulation 1 and resumed in the subsequent hour.

At the beginning of each chapter there are didactic explanations for all experiments and a checklist. Prior to the experiment, go through the checklist together with the students. Plan for time at the end of the experimentation to collectively put away the materials.

TIP

Familiarize yourself with the Clean Energy Trainer before you conduct the experiments during the lesson. For this purpose, read the Instruction Manual. Conduct the experiments on your own before using them in the lesson. You become familiar with the experiment and can recognize any potential difficulties which your students may encounter.

TIP

Make sure that each student has a copy of the experiment sheets.

Consider additional tasks for groups which finish with an experiment before others. However, do not hand out the second worksheet to the "stronger" students ahead of time.

The questions on the worksheets may be partly investigated by the students themselves.

The following applies for all experimentation:

- If the USB data monitor is used as an energy source, a different energy source (max. 2 V) can take its place. Comparable consumers can always be used instead if the USB data monitor is used as a consumer.
- There are sample answers on the answer sheets which make no claim to completeness or correctness. They are provided to give possible solutions. If your students arrive at different solutions this does not mean that these answers are not correct – they are only sample solutions.

2 Solar Energy

Experiment 1 - Learning the different features of a solar cell	
Summary	The students become familiar with the typical features of a solar cell in this experiment. In this process, they investigate the influence that the intensity of illumination and the angle of incidence have on the behavior of the measurements of a solar cell.
Worksheet theme	• General questions about solar energy • Questions about the experiment • Comprehension questions and calculations for the power of solar cells
Degree of difficulty	Easy
Advance knowledge	• Electrical circuits
Learning objective	The students expand their knowledge in recognizing that the distance, the angle and the brightness of a source of light influence the power of a solar cell. The students learn the importance of close observation in science and the importance of being able to concisely formulate the observations which were made.
Checklist	• 1 solar module • USB data monitor - USB cable - PC or laptop with installed software • Magnetic bed • 1 lamp (at least 75 W) • 2 cables, 1 black, 1 red • 1 measuring tape • Objects for shading (film, thin paper, etc.)
TIP	Have the students summarize their observations on an additional sheet of paper.

Experiment 2 - Determining the power characteristic curve of a solar cell	
Summary	In this experiment the students investigate when the solar module can give off its maximum power. Using measurements of current and voltage, they create characteristic curves for varying light irradiation and recognize the maximum power of the solar cell.
Worksheet theme	• General questions about the solar cell • Questions about the experiment • Comprehension questions about characteristic curves and the power of a solar cell
Degree of difficulty	Medium
Prior knowledge	• Creation of a current/voltage characteristic curve • Creation of an power characteristic curve • Calculating electrical power • Electrical circuits
Learning objective	The students expand their knowledge when recognizing that there is a range of values in which the solar cell provides its maximum power. The students expand their knowledge in determining the MPP (Maximum Power Point) of a solar cell.
Checklist	• 1 solar module • USB data monitor - USB cable - PC or laptop with installed software • Magnetic bed • 2 cables, 1 black, 1 red • 1 lamp (at least 75 W) • 1 measuring tape • 1 color transparent film
TIP	In this experiment you assign different groups with different tasks. For example, Group 1 draws the characteristic curves for varying light intensity, Group 2 draws the characteristic curve for solar modules connected in a series or parallel, Group 3 draws the characteristic curve for different angles and Group 4 draws for different distances.

Experiment 1

How do the measurements behave depending on the angle of irradiation?

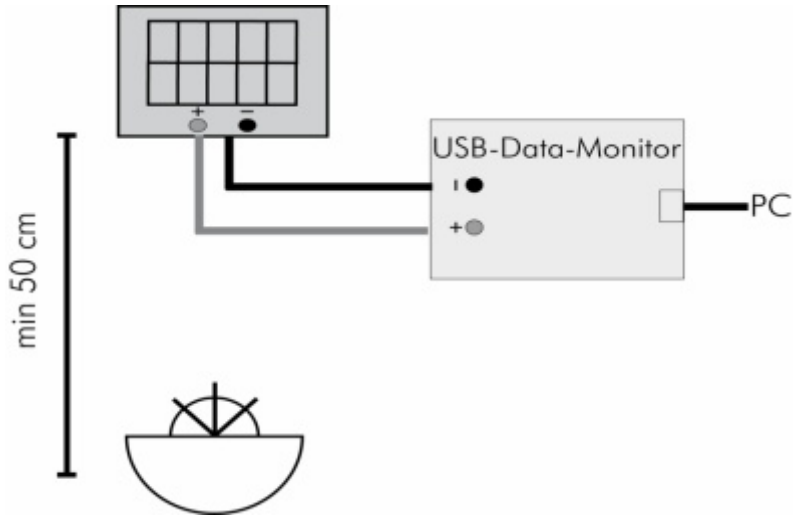

Fig.2-1 Experiment 1 setup

1. Set up experiment as shown in Fig.2-1.
2. Adjust the distance of the lamp to the solar cell to 50 cm. The angle of irradiation should be approx. 90°.
3. Start the software and select the *SOLAR MODULE* tab.
4. Switch the operation mode to *MANUAL MODE*.
5. Switch on the lamp.
6. Change the angle of the solar module by hand.
   The distance to the solar module must always be the same. Make sure that the magnet base always remains in the same position.
7. Observe the measurements and make not of the observations.

How do the measurements behave depending on the intensity of illumination?

1. Set up experiment as shown in Fig.2-1.
2. Adjust the distance of the lamp to the solar cell to 50 cm. The angle of irradiation should be approx. 90°.
3. Hold various objects (films, sheets) between the lamp and solar module and observe the measurements and make note of observations.