

**Supporting Materials for the Use
of the fischertechnik Building set**

PROFI Oeco Power

for Instruction in the Natural Sciences

at the Orientation Level

PREFACE

The summarized supporting materials in this activity booklet for the teacher are the result of a project on the subject of "electricity" as part of the natural phenomena instruction for the sixth grade of the general educational school, which is part of the path to a high school diploma, with a natural science profile.

"Natural phenomena" as a field of study are part of the instruction in the natural sciences in the Baden-Württemberg schools, which later lead to a high school diploma, in the fifth and sixth grade where the students are to obtain an insight into the impressive world of the natural sciences and technology. The new instructional plan expressly lists the topics of "magnetism and electricity" as part of the competencies and the contents of the educational standards for the sixth grade. The corresponding phenomena are to be examined experimentally in the form of student exercises and within the framework of projects.

For this reason, at the school of the creator of the text, it was important that the instruction was to be given to groups with a maximum of 20 to 22 students and in the form of blocked hours of 90 minutes each, which means in the afternoon alternating in a 14-day cycle and outside of the class group, for example, grade 6a + 6b = 3 groups.

Initially as part of this, parts of the physics equipment were used, which proved to be a problem during the course of time, firstly due to the blocking of these materials for any possible concurrent practical physics instruction and secondly due to certain shortcomings considering that this equipment was more intended for experimental instruction for higher grades.

Thus, the idea arose that components could be used from commercially available experiment sets. In this case, fischertechnik was chosen because with the assortment available other topics, for example, from the areas of kinetics, mechanics or statics could be experimentally examined and when making illustrative models can be connected with those from the area of the science of electricity. In particular, the possibility of illustrating and acquiring in-depth understanding of physical aspects through the construction of functional models is in accordance with the intention of the subject of natural phenomena.

Supporting Materials

The building set, which was developed by the fischer plants, "PROFI Oeco Power," allows you to illustrate the use of renewable energies in various forms through several models to children and young people.

The following pages provide information, which comes from initial experience with the use of this building set, for teachers and students and this can also be transferred to other school types and countries.

ORGANIZATION OF THE INSTRUCTION

Methodological and Subject-specific Didactical Information

Some of the most important skills in the instruction on natural science experiments are the proper and careful use of devices and aids. Mutual respect and cooperation are practiced in small groups and in this way the social skills of the students are strengthened. The exchange of experience between groups promotes communications in a way that this is not perceived to be a disturbance factor. As part of this, students can also help others in the handling of problems concerning understanding and give the teacher positive and negative feedback about possible changes.

For the instructional unit, which is to be given with the help of the "PROFI Oeco Power" building set, three to four two-hour periods are to be planned for the third quarter of the school year. This is preceded by the treatment of the term, energy, and the transformation of energy as well as circuits and switches in order to examine the meaning of electricity and this can also be done using the fischertechnik PROFI E-Tec and this was done during the trial phase.

Following the treatment of electrical power and its areas of application, it is useful to study the topic of renewable energies so as to close the circle to a certain degree by examining the alternatives for the better use of original and natural forms of energy through modern technologies.

Waterpower and windpower should already be understood as one of effects of varied insolation: water circulation and wind as the movement to balance the differences between high and low pressure areas. The use of this power in old mills, sawmills and hammer mills and similar facilities can be shown to the students during a visit to an open-air museum such as during a school excursion.

After the students have become familiar with the principles and the importance of electricity and the basic facts about the transformation of energy in various ways, it is then possible to understand the importance of the direct use of solar energy. When this is done, terms such as "solar cells" and "solar collectors" are to be explained including their various functions. The way the latter functions can be discussed briefly at an earlier time in an instructional unit, "fire-light-heat."

Supporting Materials

For the first one, the comparison with the output of green plants from photosynthesis is a possibility in order to bring bioenergy into play as an additional form of regenerative energy. In this connection, certainly and even at this age level, the problem of the availability and the storage of energy can be discussed.

This addition and conclusion also assure that the topics of "energy" and "electricity" are examined not only from a purely physical and technical viewpoint, but also from an aspect that applies to several subject areas. At the orientation level, many of these topics will be discussed in the future initially in geography and biology instruction after the children in primary school have obtained initial insights through the subject combination of "people, nature and culture," according to the instructional plan of the state of Baden-Württemberg.

In particular, the subject of renewable energies is related to a series of other areas in other subjects and in addition to geography and biology this also applies to religion and ethics instruction, which deal with problems, which result from the relation of the human being to nature and his environment.

Practical Instructional and Procedural Information

In order to achieve these methodological and subject-specific didactical goals, the strict observance of the order and the instructions is necessary!

Therefore, the consecutive numbers of the building sets are to be entered in a list along with the names of the students using the particular set. An additional list can be used to record the reports about missing or damaged parts. This gives the teacher the opportunity to monitor the completeness and the following of the instructions and thus to evaluate the students. The teacher can make the lists according to the requirements such as the group number, group size and number of available building sets. See the **sample** in the appendix.

Supporting Materials

The students receive information about the use of the building sets for this purpose.



Master copy 1

The instruction to be given is not limited to a room, which is specifically equipped for the natural sciences, and can thus be given in a normal classroom, which also provides greater flexibility when making the hourly schedule.

At the start of each two-hour period, short written tests are given to examine what was learned and the results of this are used to assist in establishing an overall grade. They are so structured that a maximum time of 10 minutes is sufficient for completion by the students and correcting the tests can be done very fast as well. This assures that the teacher can quickly get an overall impression about the success or lack of success and this allows the teacher the opportunity to make additions and corrections during the further course of the instruction.

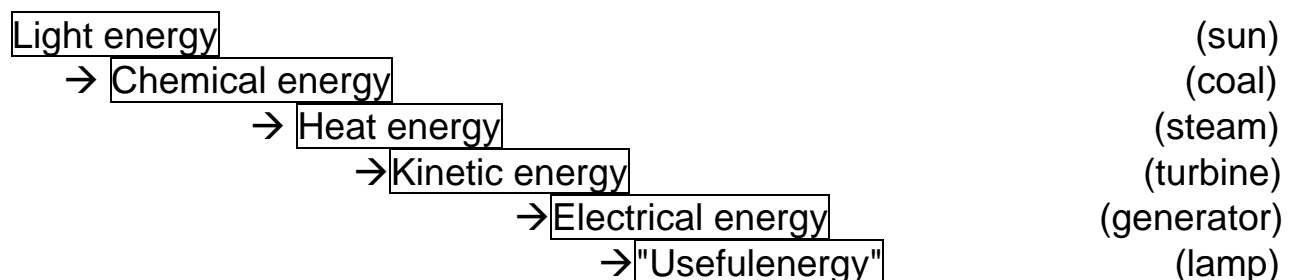
This type of testing is intended to motivate the students to read and examine the construction instructions and the associated information in the activity booklet more intensively. Experiences show that many children tend to just try things out and to give too little attention to the instructions and thus cannot solve the task given to them!

The recording of the knowledge from the construction of the models and entering of the results are done using the **worksheets** (master copies 2 +3) for the students.

REGENERATIVE ENERGY SOURCES

The eight models, which you can build with the help of the instructions from the parts of the building set, are to show you how you can use the regenerative or renewable energies from water, wind and sunlight. You already know that in the final analysis, all energy, which we as human beings use, comes from the sun. The sun is also in a certain sense the driving force for the wind and the movement of water.

The fossil fuels such as coal, oil and natural gas also contain stored solar energy. However, these are not renewable, which means that in a short time we are consuming what nature took a very long time to form. In particular, every transformation of energy results in high losses more or less. For example, when we use electric power, which was produced in a coal-fired power plant, then several transformations of energy were necessary for this:



You can understand it this way that every time that a form of energy is transformed into another form only a part is transformed into usable energy and this part is shown by the length of their joint borders as shown in the table above. Added to this is the loss during transport. Thus, the light energy from your desk lamp is only a very tiny fraction of the solar energy originally needed.

The fossil fuels, meaning the non-renewable energy forms, are becoming more and more expensive and will be exhausted at some point in time.

For some years, attempts have been made to find ways to limit the consumption of fossil suppliers of energy. Coal and oil are also certainly important raw materials, from which various products can be produced. In addition, such limitation would also reduce air pollution.

Technical progress today allows the better use of the energy from wind and flowing water than was possible earlier from windmills and water wheels.

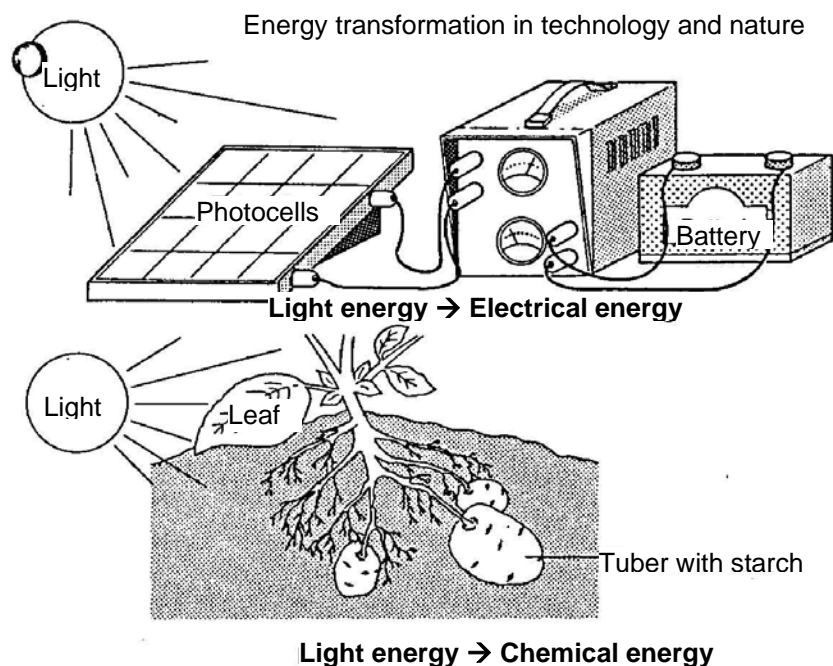
Background Information

This saves long transport distances between the location of the production and the consumption location and thus reduces the losses as well.

The invention and the development of solar cells now allows the direct conversion of solar energy into electrical energy. This has been exploited for some time and this primarily applies to a series of small devices. In the meantime, an increasing number of systems for the generation of electricity are being installed on the roofs of houses. The government promotes such measures through subsidies.

How does such a system work?

You can find the physical and the technical explanation on pages 4 and 5 of the activity booklet in chapter 5.1, "The Solar Cell." We can compare the energy transformation, which takes place in the cell, with the processes in plant leaves.



The figure shows you that in principle the green leaves of plants work like solar cells. In these leaves, the energy from sunlight is absorbed and converted to another form and in this case that is chemical energy, which is then stored as sugar, starch, wood and other organic materials.

When we generate electrical energy with solar cells, we save the detour over other forms of energy, which is associated with many losses.

Background Information

In connection with other renewable energies, this could provide a solution at least to part of our present problem with the sufficient supply of inexpensive and environmentally friendly energy in the hope that further technical improvements will increase the share of such energies.

One of the big hopes of scientists is still that at some time they will succeed in using the electricity, which is produced by solar cells, to produce hydrogen and to store hydrogen as well.

The Use of Waterpower

Human beings began at an early time to exploit the power of flowing water for driving simple machines. Where there is a sharp drop in a stream or a river, the power is greater. Therefore, this form of energy use in the mountains played a greater role than in flat areas. Mills, sawmills and hammer mills were operated in this way.

So that waterpower was available in sufficient quantities during dryer times, flowing water was blocked by the construction of dams. In this way, in many cases, additional energy was obtained because the water fell on the waterwheel from a greater height.

The transfer of this usable energy to the location of the consumption was, however, very limited because due to friction a lot was lost.

Only when the waterpower was used to produce electricity was it possible to transport the energy to distant locations. In a hydro-electric power station, kinetic energy is transformed into electrical energy, which can then be distributed easily through power lines.

Due to technical improvements of the turbines, the utilization coefficient of modern power plants is significantly higher than for older systems.

Background Information

The Use of Windpower

Just as the mountainous areas used the natural energy source of the flowing water earlier so the other areas used the power from wind. This was particularly true for those areas where the wind blew almost consistently, such as on seacoasts. In the Netherlands, windmills were used not only for the grinding of grain, but also primarily for the pumping of water out of the drainage ditches to reclaim land.

In later years, this form of energy use was almost forgotten because these were replaced by machines, which were operated with coal, oil or gas. Above all, no electricity was or could be produced in this manner.

In the awareness that these energy suppliers will become more scarce and that there are environmental consequences from such use, these old and natural forms of the use of energy have attracted attention in the past years.

Technical improvements have also allowed these to expand to other areas. Modern windpower systems can, in connection with other alternative forms, supply entire municipalities with electrical energy today.

The Direct Use of Solar Energy

The most modern form of the use of regenerative energy is possible since the invention of solar cells and their further development. This transforms energy from sunlight directly into electricity.

Another possibility is the heating of water with the help of solar energy in sun collectors in order to save fuels. With this, the heat can be stored in well insulated storage containers for a limited time.

Unfortunately, still today, it is not possible to store the electrical energy, which is produced by solar cells, in great quantities and for a longer period of time.

However, in our Eco-Power building set, we have a small component, with which this is at least partly possible, the Goldcap.

Instructions for the use of the building set

1. A unit in the building set consists of three stackable boxes with a cover, which is used as a working surface.
2. The boxes are divided into compartments of various sizes and show a overview of the contents of the compartment on the floor of the compartment.
3. Each workgroup, which consists of two students, always uses the same boxes, which have numbers on them. These and the names of the users are entered in a list.
4. It is not permitted to change the distribution and to exchange parts between different sets!
5. When building a circuit or a model, only take the required parts from the compartments. This information is given for the individual work steps in the instruction manual.
6. When a part is no longer needed, then it is to be put back into the correct compartment immediately.
7. You are only to do what the teacher has assigned as a task and what stands in the work instructions!
8. Get into the habit of never pulling on cables because this can uncover parts, which are carrying electricity.

For example, this can be life endangering in the case of household appliances and damaged cables can cause a fire!

WATERPOWER

When you build the models, hammer drivers and water turbine, you will find that initially the functioning is the same namely the use of the power of flowing water.

Describe, how the energy is transformed.

What possibilities are there to transport this energy from waterpower to more distant locations?

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Why can you call waterpower a **renewable energy**?

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What disadvantages do the windpower systems have, where kinetic energy from the wind is transformed into electrical energy?

Why were there only windmills earlier in areas with flat land and on the coast?

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Name	Class	Sheet No.
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SOLAR ENERGY

Many people are placing big hopes in the increased use of solar energy. You can see sun collectors on the rooves of many houses and these collectors heat water from the effects of the sun and thus heating energy is saved.

Another possibility is to produce electricity from solar energy. Complete the following sentence.

_____ transform solar energy into electricity.

You certainly know some small devices in your daily life, which are operated with this, because they need little electrical energy.

Hold your model in different directions towards the sun or another strong light source like a lamp. What do you find?

The motor has the highest speed when the solar cell is pointed at the sun so that _____

How would you build a house if you want to install a photovoltaic system on the roof of this house for the production of electricity?

Make a small sketch!

Name	Class	Sheet No.

Solar Energy

When you have finished building the "oil pump" model, you can examine how the effect of the solar cells can be increased in order to produce a certain amount of power to operate a machine.

First, build the model for this purpose according to the instructions and let the model run. Here, both solar cells are connected in a series. Then, remove the plug from one of the solar cells. What do you find?

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What would happen if you would connect a third and fourth solar cell in the series?

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Do you know, why even today there are no normal cars or other vehicles that are operated solely with solar energy?

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Name	Class	Sheet No.
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Solar Energy

For the model, "rotating swing," the solar cells are connected in a different way.

Compare the rotational movements of the oil pump and the rotating swing with the same brightness. Perhaps you and your partner can work together with the group beside you so that you can build both of your models at the same time and put them in operation.

Write down the differences.

	Oil pump	Rotating swing
Rotational speed		
Required brightness		

Name	Class	Sheet No.
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Solar Energy

The two models, "crane," and the "solar cell update" show you a different circuit principle.

Think about what function the solar cells have when they make the motor run in different directions.

How would you build the crane model without solar cells, for example, with PROFI E-Tec?

Make a circuit sketch.

What advantages does a solar cell update have? In what cases can this be done easily? Is this suitable for a photovoltaic system on the roof of a house?

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Name	Class	Sheet No.

STORAGE OF ELECTRICAL ENERGY

When you have finished building the solar vehicle perhaps you will find that it stops when it reaches a shady location or in a curve when the sun rays do not hit the solar cells precisely.

How could you solve this problem?

You would have to store the energy from the sun!

Batteries do this. The PROFI-Oeco-Power building set contains such an energy storage unit. It is the Goldcap.

Find out about this component on page 8 of the activity booklet.

When you try out how long your vehicle will move when you connect the motor to the Goldcap then you will find that the result is not really great.

Measure the time until your vehicle stops, which means that the Goldcap doesn't supply enough energy.

Your vehicle travels for _____ minutes with a Goldcap charge.

Then charge the Goldcap using both solar cells connected in a series for this exact amount of time.

Then connect the Goldcap to the motor again and test it once again.

Your vehicle now travels for _____ minutes.

Now, think again about what vehicles or devices could use the solar energy in connection with appropriate energy storage units.

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Name	Class	Sheet No.
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Evaluation Sheet Profi Oeco Power

For the first use of these building sets for natural phenomena instruction at our school, you should submit an evaluation based on your experience. After the evaluation of these sheets, the results are to be used to make changes and improvements.

Put an X in the column that most closely agrees with your opinion.

	Very good	Good	Satisfactory	Sufficient	Defects Unsat.
Ease of understanding of the construction instructions in the pictures (figures for the building of the functional models)					
Text explanations in the supplement (ease of understanding the additional explanations)					
System of order in the sets (structure, overview, ways to check)					
Handling the components (size, stability and so forth)					
Certainty of the safe functioning of the models (first time, without additional help)					
Time required for the work (completion of the individual models is possible in 60 minutes)					
Working together with partner (suitable for working together)					

Now put an X beside those models, which you built, and if it worked.

Model	Worked	Didn't work
Hammer drivers		
Water turbine		
Windpower system		
Oil pump		
Rotating swing		
Crane		
Solar cell update		
Solar vehicle		

Name	Class	Sheet No.

School

Natural Phenomena Grade 6

List of deficiencies for fischertechnik building set, PROFI Oeco Power

Two-hour period		1	2	3	4	5	6
Set No.							
1	A						
	B						
2	A						
	B						
3	A						
	B						
4	A						
	B						
5	A						
	B						
6	A						
	B						
7	A						
	B						
8	A						
	B						
9	A						
	B						
10	A						
	B						
11	A						
	B						
12	A						
	B						

Name	Class	Sheet No.

Assignment of the Building Sets

School.....
Natural Phenomena Grade 6

Assignment of building sets fischertechnik PROFI Oeco Power

No.	Group 1		Group 2		Group 3	
	Name	Name	Name	Name	Name	Name
01						
02						
03						
04						
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12						

Name	Class	Sheet No.