Content package for interactive whiteboards: Electricity from renewable energy sources

This guideline will provide an overview of the content and didactic context of the media in the media package entitled “Electricity from renewable energy sources.”

1 Introduction to teaching this topic

1.1 Motivation for the topic

The topic of renewable energies has been in schools for a long time. “Magnetism and electricity” and “Responsible use of electricity” are included in the curriculum for local history and personal, social and health education (PSHE) in third grade and fall under the main “Environment” topic. Although the “Electricity from renewable energy sources” content package can be handled as a separate topic in third or fourth grade, it makes sense to integrate it into the curriculum topics mentioned above and to work through them in the following order:

- Recognizing the importance of electricity in everyday life (electrical devices and appliances)
- Investigating how electricity works (heat, motion, light)
- Knowing how electricity travels from the power plant to your home
- Renewable energies
- Building an electrical circuit
- Differentiating conductors and nonconductors
- Recognizing the dangers of electricity
- Knowing ways to save electricity

1.2 Media selection

The content package for interactive whiteboards entitled “Electricity from renewable energy sources” contains 28 individual media.

- 7 photos and photo collages of energy sources and types of power plants
- 4 schematic diagrams of various types of power plants, some animated
- Charts with data on the availability of energy sources, carbon dioxide emissions from electric power generation, and the electricity mix in 2050
- Graphics that can be labeled interactively on the structure of a wind power plant
- 1 simulation of a solar cell
- 1 information sheet providing an overview of energy sources and power plants
- 2 interactive matching exercises, one for evaluating the advantages and disadvantages of the energy sources and one for labeling the most important components of a wind turbine
- Experimentation instructions, plus related information for the teacher
- 1 multiple-choice test
- Guideline for the teacher providing basic knowledge on the topic of “renewable energies”

1.3 Background information for teachers

The media files in the “Electricity from renewable energy sources” content package for interactive whiteboards can be used individually and completely independently of each other by limiting the study to a particular subject. However, the lesson will certainly be livelier when the media are used in context. The direct applicability of the material to the lives of the students creates an opportunity

to spark students' interest in specific technical details. To accomplish this, we recommend working through the topic in the following steps:

- Introduction: What are renewable energies?
- What renewable energy sources are there?
  (water, wind, sun)
- What are the advantages and disadvantages of renewable energies?
  (remaining years of use, exhaust emissions from power plants)

2 Introduction: What are renewable energies?

To renew literally means "to make like new." A renewable energy source is a source which "regenerates itself" on its own, so to speak. This gives rise to the term "renewable energies." The basic principle behind the use of renewable energies is the fact that energy is tapped from processes that take place continuously in our environment, such as solar radiation, and is then used in technology, especially electric power generation. In this process, resources are not used to a greater extent than energy continues to flow and "renew" them.
The term "renewable energy sources" was coined in contrast to fossil and nuclear energy sources, which will be used up by people in a foreseeable period of time. This media package examines the renewable energies sun, water, and wind.

The media files from the media package that could be used in developing this chapter and as an introduction to the chapters building on this one are as follows.
An image shows the three renewable energy sources: water, wind, and sun. This image should be used as a prompt to help the students recall previous experiences and lead to the topic:

Medium  "Renewable energy sources"

This information sheet is an initial introduction to the topic that explains the types of energy sources – renewable, fossil, and nuclear – and provides descriptions of the respective power plants where electricity is generated from the energy sources:

Medium  "An overview of energy sources"

The following guideline helps the teacher prepare the content:

Medium  "Renewable energies"

3 What renewable energy sources are there?

The energy sources are covered in order, based on their significance in the history of culture and technology – hydropower, wind power, and solar energy.
Group work lends itself to working through the three topics in class. Each of the three (or six) groups will become an expert on one energy source. The students will work with (interactive) graphics to find out how their respective power plant generates electric power and then build an experimental model, which they can use to introduce "their" energy source to the class in presentations.

3.1 Hydropower

Hydropower, or water energy, is the term used to describe the energy of flowing water that is converted to mechanical or electrical energy via turbines and the generators connected to them.
Over 4,300 years ago, people in Mesopotamia (present-day Iraq) and other places were already using hydropower in the form of scoop wheels for irrigation. Hydropower is also a form of solar energy stored in nature. After all, it ultimately comes from the cycle of evaporation and precipitation brought about by the sun. Here, we are just considering the mechanical “hydropower” used directly as an energy source.
A graphic presents the importance of water as an energy source and serves as an introduction:

Medium  “Water as an energy source”

A graphic shows a historical waterwheel and its high-tech refinements – Francis, Pelton, and Kaplan turbines:

Medium  “From the waterwheel to the turbine”

Several graphics (some with animation) illustrate the operating principles of run-of-river, wave, tidal, and storage power plants:

Media  “Tidal power plant”
 “Run-of-river power plant”
 “Storage power plant”
 “Wave power plant”

In an experiment, the students will learn how a waterwheel generates electric power:

Medium  “Hydropower experiment”
(student instructions and teacher information)

3.2 Wind power

People have been using wind energy to drive windmills for around 1,200 years.
When Earth’s surface is heated by radiation, the layers of air above it are heated, which lifts the air and causes it to flow upward. At the same time, air flows back in horizontally from less heated areas, this cross flow is described as wind. The kinetic energy of the linear air movement of the wind can now be converted to rotational movement via wind turbines. In 2016, Europe’s wind turbines alone had a total capacity of around 155,350 MW (source: Statista).
A photo can be used as an introduction to the topic of wind power:

Medium  “Offshore wind farm”

The structure of a wind power plant for large-scale electric power generation is described and illustrated by means of two graphics that can be labeled interactively:

Media
- “Wind power plant (general view)”
- “Wind power plant (interior view)”

In an experiment, the students can build their own wind turbine as an illustration.

Medium
- “Wind power experiment”
  (student instructions and teacher information)

For further study and practice in using the technical vocabulary, the students can name the most important components of a wind power plant in a labeling task.

Medium
- “Structure of a wind power plant”

3.3 Solar energy – Solar thermal energy and photovoltaics

Since “light” is defined in physics and biophysics as the “visible portion of the electromagnetic spectrum,” solar radiation should be distinguished as solar heat and as sunlight. Another reason is the fact that a distinction is made between heat and light in physics, chemistry, and energy conversion technology.
Way back in the Stone Age, before fire was discovered, cavemen used the heat of the sun stored in rocks to protect against the cold in the night or during cold weather. The potential of solar thermal energy is great: If all heating of rooms and water in all households in a country in a temperate zone, like Germany, were converted to solar thermal energy, the total carbon dioxide emissions there could be cut by up to 20 percent and the energy consumption of each household could be cut by up to 70 percent!
Photovoltaics refers to the direct conversion of sunlight to electrical energy using solar cells. Direct conversion is a fascinating possibility, at first glance, since photovoltaics could theoretically achieve efficiency of almost 100 percent. In Germany, for example, with the current level of efficiency of solar cells, approximately 1 percent of the land surface would suffice to supply the entire demand for electrical energy for industry and all private households. Ten percent of the surface would suffice for Germany’s total energy requirement. This means that photovoltaic electric power could then also meet the entire demand for thermal energy (process heat in industry, heating, cooking, and hot water in households) and the entire transport energy requirement (electric cars!). However, this is only a theoretical calculation that aims to show the massive potential of photovoltaics even in countries with a temperate climate. But the idea is not as utopian as it may sound, if we bear in mind what huge surfaces are available just in the form of roofs, building facades, and windows. Technically, solutions that could be implemented immediately today are available for all three applications.

Two photos and a simulation show the two techniques for using solar energy – solar thermal energy and photovoltaics – and serve as an introduction to the topic:

Media
- “Parabolic trough power plant”
- “Solar electric power plant on open space (“solar field,” “solar park”)”
- “Solar cell – Basic principle”

In two experiments, the students will become familiar with the two techniques for using solar energy:

Medium
- “Solar energy experiments” (student instructions and teacher information)

4 What are the advantages and disadvantages of renewable energies?

One advantage of renewable energies that is often cited, in addition to their inexhaustibility, is the fact that they are distributed evenly across the globe. In contrast to fossil and nuclear energy sources such as coal, oil, natural gas, and uranium, this seems to be true. But when we look more closely, we see, for example, that hydropower and wind are also not available to the same extent around the globe. And sunshine cannot be used economically as solar thermal energy in many regions either, at least not for generating electric power. So this advantage is a relative one at best! However, the use of renewable energies can offer a clear advantage for the respective national economy, since it reduces dependency on energy imports. For example, in 2005, the degree of dependency on imported petroleum in the European Union (EU) was around 80 percent, and in the United States around 66 percent (sources: EU Green Paper on Energy Security and the German Foreign Office).

One of the disadvantages of renewable energies that is often mentioned is their low “power density.” This is true to a certain extent since the sunlight from millions of years ago is now being used, as it were, in an accumulated, concentrated form as oil, natural gas, or carbon. In order to generate 3.5 MWh of electrical energy, for example, a coal-fired power plant needs around 1 ton of coal, but a photovoltaic power plant covering at least one hectare in Central Europe needs one average sunny day. But on the other hand, the economic use of, for example, the fossil energy source coal or the nuclear energy source uranium requires very large, centralized power plants. In contrast, wind and photovoltaic systems can also be used economically in relatively small, decentralized plants. For example, if the facades of large office buildings and factories were also used, nearly the entire energy requirement of a Central European country could be met with photovoltaic power alone. With a non-subsidized electricity production price starting at 7 eurocents/kWh, photovoltaic power is now (2016) less expensive than gas turbine power. Onshore wind power from new, optimally placed wind turbines has already become the cheapest power source, at 4.5 eurocents/kWh. The fluctuating availability of renewable energy sources such as water, wind, and sun in comparison with traditional energy sources such as coal, oil, gas, and uranium is also a disadvantage. These irregularities in power generation must be compensated for by expanding the power supply grid and building energy stores.

4.1 Remaining years of use of energy sources

An optimistic estimate from 2005 indicates that, according to International Energy Agency (IEA) figures, worldwide stores of non-renewable energy sources will last around 190 years for coal, around 40 years for oil, around 60 years for natural gas, and around 100 years for uranium. According to studies conducted by the IEA in 2007, however, world energy consumption is set to rise again by around 60 percent by the year 2030 – a fact which had not been taken into account. Skeptics therefore assume that the above resources will not last anywhere close to this, especially since it is uncertain whether it will actually be economically viable to exploit deposits that have not yet been used. This is because when the technical efforts to obtain fossil energy sources increase, the costs and thus consumer prices also rise. Whether industries and end consumers can pay the prices, though, is questionable. For example, an economic crisis already occurred in 2007 due to increased prices for steel and coal, but it was hardly noticed because of the subsequent financial crisis.
A chart shows how long fossil and nuclear energy sources will still be available compared with renewable energy sources:

Medium  “How long will our energy sources last?”

In 2014, around 22 percent of the worldwide consumption of primary energy sources was already covered by renewable sources. Of this, biomass still accounts for the largest share of renewable energy. However, in 2005, the proportion of electric power generated using renewable hydropower was actually 16 percent worldwide. The consumption of fossil and renewable energy sources is divided very differently across industry, transportation, and private households. For instance, in 2001 oil accounted for 28 percent of total energy consumption in the United States, but the share for transportation was 70 percent.
A chart illustrates the energy sources that will be used in the future for electricity:

Medium  “Where will our electricity come from in 2050?”

4.2 Exhaust emissions from power plants

The emission of greenhouse gases – like carbon dioxide from the combustion of fossil energy sources – must be reduced as fast as possible because with each increase in temperature, the need for energy for cooling (air-conditioning and refrigerators for food) increases. The rapid development of renewable energies and thus the replacement of fossil energy sources can play a crucial role in this.
A comparison of the carbon dioxide emissions from power plants using fossil or renewable energy sources will clearly illustrate the advantage of renewable energies. However, with nuclear power, the problem of disposing of radioactive waste is not taken into account!

Medium  “Carbon dioxide emissions from power plants”

4.3 An overview of advantages and disadvantages of energy sources

The energy sources uranium, water, wind, sun, and coal are matched with their respective advantages and disadvantages in an interactive exercise. This provides an overview of the various energy sources, and a comparison can be made:

Medium  “Advantages and disadvantages of energy sources”

5 Conclusion and further study

The learned material can be reinforced and reviewed in a fun way with the interactive multiple-choice test, which has eight questions on the topic of renewable energy.

Medium  “Renewable energies”