Renewable Energy Sources

Author: Marcus Brändle

Recommended Year:	*9th grade*
Time framework	*2 lessons (1 double lesson)*
Thematic block	*Man and Technology*
Objectives and development of competencies	*Goals:* *On the basis of the science the students can categorize and tell the difference between several ways of energy conversion from renewable energy sources.* *Furthermore they are able to independently develop concepts for plants, as they know about the fundamental functioning of the necessary machines/devices for energy conversion.* *By means of experiments the students get to learn about the principle of energy conversation and energy conversion. From these phenomena the students can deduce and distinguish possible ways of proceeding* *Skills:* *The students are in the position to analyze and to judge the different possibilities of energy usage in the competence area "technology".* *The students are familiar with the basic methods of measuring and working to obtain information and to portray them in form of an own practically-oriented solution.*
Interdisciplinary (cross- curricular) relations	• *Scientific way of thinking* • *Problem-solving competence* • *Independent information collecting by literature research* • *Ability to work in a team*

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Theoretical Introduction

Problems with the prevailing generation of primary energy

The continuously rising demand for energy means a massive burden on the environment. Energy conversion from fossil fuels is one of the most common methods of electricity generation. But when it comes to the exploitation only a little part of the released energy can actually be used to generate electricity. A major part gets lost a thermal energy. It might be theoretically realizable to use this waste heat as thermal heat but in practice transporting the heat over long distances is very difficult.

For the same purposes nuclear materials are used in nuclear reactors. Here the problem isn't the pollution emissions but the chemo- and radiotoxic pollution. The accumulation of the nuclear fuels produces waste that can't be converted further on. Therefore it must be stored isolated from the biosphere.

As soon as a the fuel rod has reached its maximum functional life there is also need for a special final storage to isolate the remaining radiation from our living space.

As a possible solution to the environmental and climate problem renewable energy sources become more and more important to the politics and the economy.

Methodical Part for the teacher

Definition of efficiency

The efficiency indicates the ratio between useful energy E_{ab} and supplied energy E_{zu}. It can be seen as non-dimensional and cannot exceed 1 or rather 100%. If this were the case it would be a Perpetuum Mobile, an apparatus that "produces" energy. But "producing" energy is impossible! The only process that can happen is a conversion of energy, which often means a loss of energy (cf. waste heat).

The efficiency can illustrate how efficient a machine converts supplied energy into another energy form. It serves a reference for the profitability of such machines.

It can be calculated according to the formula:

$$\eta = \frac{E_{ab}}{E_{zu}} \tag{1}$$

Schedule for the lessons

Topic: renewable energy sources at a glance

Time [min]	Phases	Lesson Unit	Arrangements and patterns of action	Methodology and didactic commentary	Medias
5-10	Introduction and problematization	• Pictures of various environmentally harmful factors such as coal-fired power stations, coal-mining, nuclear waste disposal site, melting iceberg • **Problem:** the current way of converting fossil or nuclear energy sources into primary energy (mainly electricity) means a massive environmental damage	• Introducing the students to the problem of environmental damage • **Arrangement:** Conversation between teacher and students (STC)	• Showing the problems at the blackboard by means of a mind map	• Projector, computer • Blackboard
3	Transition	• Are there ways to exploit naturally occurring energy sources? • Yes by using various technical methods.	• **Arrangement:** STC	• Fixing the key question at the blackboard	• Blackboard
40	Development	• Distributing the four areas of topics to the groups (depending on the number of students you can assign a topic to multiple groups • On the basis of the given information and by researching on the Internet the	• **Arrangement:** Group work + students' presentations r	• Providing the information sheets and experiment instructions at four different stations • Granting access to the computer room or giving	• Computer room, projector, materials • Laptops

		students develop an overview over the current prevailing renewable energy systems. • The students use their research to prepare a short presentation and a little experiment (see links for the instructions and materials for the experiments) • Necessary components for the experiments can be collected from the teacher (*depending on the selection the worksheets for the groups are passed together with the experiment instructions, the materials are provided at the teacher's lectern.)*		each group a laptop for the research	
20	Consolidation	• The students present their results in five-minutes-presentations by means of an experiment • The groups that haven't worked on this topic note the information on a handout (distributed by the teacher).	• **Arrangement:** students' presentation	• The teacher should draw up a handout on which the students can note the most important information. • The handout must immediately refer to the questions that the students worked on. • The expert groups can answer possible questions concerning the topic (appreciating the work)	• Blank handout
2	Transition	• Not every method of converting can be used for every terrain	• **Arrangement:** STC	• Questions that lead to the difficulty of the terrain	• Blackboard

				conditions • Fixing the problem at the blackboard	
15	Consolidation and application	• Setting a scenario where the students must decide which form of energy conversion is the most appropriate. The scenario can be varied and chosen freely.	• **Arrangement:** single or partner work	• The teacher prepare equal or various task with terrain scenarios. • The students shall suggest solutions on the basis of the already-learned methodology • Sample scenarios can be developed freely or set by a real local terrain	• Tasks with sample scenarios
	Homework	• Completing the work on the scenarios at home			

Internet links

Theoretical Principles

Watter, Holger (2015). *Regenerative Energiesysteme (4. überarbeitete und erweiterte Auflage).* Wiesbaden: Springer Vieweg.

Experiments on Photovoltaics

https://elearning.izt.de/pluginfile.php/1589/mod_page/content/1/Materialien/Photovoltaik.pdf (30.03.2016 16:44)

Experiments on Solarthermics

https://elearning.izt.de/pluginfile.php/1589/mod_page/content/1/Materialien/Solarthermie.pdf (30.03.2016 16:40)

Experiments on Water Power

https://elearning.izt.de/pluginfile.php/1589/mod_page/content/1/Materialien/Wasser.pdf (30.03.2016 16:43)

Experiments on Wind Energy

https://elearning.izt.de/pluginfile.php/1589/mod_page/content/1/Materialien/Windenergie.pdf (30.03.2016 16:46)

Accompanying Materials for the Teacher

Theoretical Background to the learning circle

Photovoltaics

Photovoltaics is used to transform the energy of the solar radiation into electric energy. The sun serves as an efficient energy supplier. Its energy reaches the earth by electromagnetic rays and by visible radiation in the form of light. A solar cell is able to transform this radiation into electric energy. This functional principle is based on the semiconductor technology. Here the photoelectric effect is utilized. Silicon is one of the materials that are most frequently used for photovoltaics.

There are several external factors that have an impact on how efficiently the solar cell works, such as the position of the solar cell relative to the sun as well as the current weather situation. If there is a cloud cover there is a higher amount of diffuse light and the gain is much lower compared to direct radiation.

Solarthermics

The sun serves as an efficient energy supplier. Its energy reaches the earth by electromagnetic rays and by visible radiation in the form of light. One method of profiting from the sun is converting this energy into electric energy another one is the solarthermics.

The basic principle at this is the conversion of radiant energy into heat. Each body is able to either absorb radiation, to reflect or to let it pass through. An ideal black body absorbs all the radiation that strikes its surface; an ideal white body reflects it completely.

For the solarthermics you need a material, which absorbs as much radiation as possible and then emits it in the form of long-wave thermal radiation. Currently ideal black bodies don’t exist yet, but nanotechnology makes very high levels of absorption possible.

Thermic solar panels are used to heat up industrial water and usually serve as addition to the central heating system.

The problem is the seasonal divergence: in summer there is high radiation intensity and the solar panel works efficiently. But the warmed water can be used only for a few purposes (showering, doing the dishes), as there is no need to heat the house. In winter the radiation intensity is limited by the weather and the angle of incidence of the sun as well as by potential icing or a snow cover of the panels. But it makes the most sense especially in winter to support the heating system. Consequently besides an efficient collector there is also need for a storage that is as efficient as possible so the warmed water can be saved for colder days.

Wind Energy

Wind power stations convert wind power into electric potential energy. Thereby wind power drives a machine that converts it into electrical potential energy by means of the inductive effects. The generator uses the reversed principle of action of an electric motor, which can covert electric potential energy into kinetic energy.

The choice of location and the dimensioning of the size play a leading role when it comes to wind power stations. Concerning the size it should be noted that the power increases in quadratic proportion to the diameter of the rotor. That means there is a fourfold power for twice the size. That means a big wind turbine is advantageous. Concerning the choice of location the deciding factor is that the power increases by the cube of the wind force. This means double the wind speed leads to an eight times greater power. The other way round means that half the wind force leads only to one eighth of the power. The locations should ensure a certain level of wind-safety. Therefore offshore wind power stations are very efficient as they can tap into the land/onshore circulation and consequently have a certain wind-safety as a basis.

The height of the wind power station is also very important. The higher the region the lower the wind breaking terrain effects, which leads to constant and strong winds.

From a certain wind speed of ca. 20m/s the wind power station must be turned off to prevent it from damages. Up to this point the rotors can regulate the power by their position so that only the maximum power capacity of the generator is reached (overheat protect). As soon as the wind speed exceeds this point the blades must be moved out of the wind as a regulation on its own isn't enough any more to protect the generator from overheating. Additionally the high wind speeds mean a huge strain on the material. The failure of the materials harbors a high potential of hazards especially on onshore wind power stations.

Water Power

Water power can be exploited in many ways. Depending on the local conditions the types of power stations vary. The basic principle of the power stations can be explained through the example of a storage power station.

A storage power station has an (artificial) reservoir. This is a property that distinguishes it from the other water power stations. For energy generation the potential energy of falling water is used, this means a certain drop height is a necessary condition. At the lower end of the downpipes a turbine is driven, which is connected to a generator. Generally you can achieve enormous power also at lower speeds as water has thousand times the density of water. But this process has a detrimental effect on the materials, as water promotes the erosion and corrosion of the substances. Additionally the higher viscosity of water means alternating stresses and therefore a true challenge for the material.

Various types of power stations provide varying fields of application. A run-of-river electric power station makes the provision of the base load energy possible by its uninterrupted operation.

The tidal and wave power stations can also be classified into the category of base load supply as these natural effects also run continuously.

Storage power stations serve as an energy storage system. They store water at an elevated location. If needed they can convert the potential energy. When there is no need of electric energy or there is an "overproduction" the water can be pumped back to the elevated position. So the electric energy can be "stored" in the form of potential energy.

Experiments on Photovoltaics – Example of a high budget version

Running an electric motor by means of a solar cell

Materials required

- Solar cells
- Electric motors
- Propellers or similar as a resistance for the e-motor o
- Lighting source e.g. halogen reading lamp with dimmer
- Set square to measure the angles

Performing

The students put together their construction kit and investigate the speed of the propellers depending on different illumination angles as well as different lighting intensities.

Saving the results

The speed of the propellers depends on the illumination and the lighting intensity. There exists a connection between incoming energy (light) and released energy (electricity/voltage). Good students discern that from a certain point of lighting intensity there is reached the maximum that means that the propeller can't rotate faster.

Experiments on Photovoltaics – example of a low budget version

Solar Car

Materials required

- Construction Kit of a solar car (obtainable in electrical stores/on the internet)
- Lighting source e.g. halogen reading lamp or fluorescent tube with dimmer
- Stopwatch
- Large set square to measure the angles

Performing

The car is set up on the teacher's lectern, as an additional effect a start and a finish line could be determined.

Now the solar cell of the car is illuminated by various light intensities and from different angles. Then it must be time how long it takes the car to cross the finish line. The results are noted in a table together with the accompanying illumination angles (set square) and lighting intensities (position of the dimmer switch). A fluorescent tube is practical as is makes a continuous lightning over a certain distances possible. This makes the experiment more exact.

Saving the results

The students discern that the car is the fastest under a high-intensity lighting and with an orthogonal angle of incidence. This means that most energy is converted when there is the optimal angle of incidence and the optimal lighting intensity.

Further Experiments

Further experiments can be found in the given link.

Experiments on Solarthermics

A collection of experiments on solarthermics can be found in the appropriate link.

Experiments on Water Power

A collection of experiments on water power can be found in the appropriate link.

Experiments on Wind Energy

A collection of experiments on wind energy can be found in the appropriate link.

Accompanying Materials for the group work

Group: Photovoltaics

Platz für Illustrationen

Theoretical Introduction

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There are several external factors that have an impact on how efficiently the solar cell works, such as the position of the solar cell relative to the sun as well as the current weather situation. If there is a cloud cover there is a higher amount of diffuse light and the gain is much lower compared to direct radiation.

Tasks

1. Inform yourself on the Internet about the **semiconductor technology** and about the **photo effect.** Portray the functional principle and the connection between the two terms in key points.
2. Find out why silicon is suitable for the semiconductor technology.
3. Define the term **efficiency**.
4. Search the Internet for the efficiency of a photovoltaic module.
5. Compare the efficiency of a coal-fired power station to the efficiency of a solar cell. What do you observe?
6. Prepare a short presentation together with the other members of your group. The presentation should provide a good overview of the topic. You can take the solutions of the tasks 1-6 as guidance for the contents. Prepare an experiment that explains the functional principle.

Space for Illustrations

Theoretical Introduction

The sun serves as an efficient energy supplier. Its energy reaches the earth by electromagnetic rays and by visible radiation in the form of light. One method of profiting from the sun is converting this energy into electric energy another one is the solarthermics.

The basic principle at this is the conversion of radiant energy into heat. Each body is able to either absorb radiation, to reflect or to let it pass through. An ideal black body absorbs all the radiation that strikes its surface; an ideal white body reflects it completely.

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Thermic solar panels are used to heat up industrial water and usually serve as addition to the central heating system.

The problem is the seasonal divergence: in summer there is high radiation intensity and the solar panel works efficiently. But the warmed water can be used only for a few purposes (showering, doing the dishes), as there is no need to heat the house. In winter the radiation intensity is limited by the weather and the angle of incidence of the sun as well as by potential icing or a snow cover of the panels. But it makes the most sense especially in winter to support the heating system. Consequently besides an efficient collector there is also need for a storage that is as efficient as possible so the warmed water can be saved for colder days.

Tasks

1. Inform yourself on the Internet about **absorption** and **reflection**. Note down the definition of the two terms in short key words.
2. Explain how short-wave radiation can be converted into long-wave radiation.
3. The text mentions the use of solar panels to heat up industrial water. Explain the functional principle of heat exchange by means of a sketch.
4. Work out the criteria that make the solar panel as efficient as possible and note the key points.
5. Define the term **efficiency**. Search the Internet to find out the average **optical** efficiency of a solar panel.
6. Prepare a short presentation together with the other members of your group. The presentation should provide a good overview of the topic. You can take the solutions of the tasks 1-6 as guidance for the contents. Prepare an experiment that explains the functional principle.

Space for Illustrations

Theoretical Introduction

Wind power stations convert wind power into electric potential energy. Thereby wind power drives a machine that converts it into electrical potential energy by means of the inductive effects. The generator uses the reversed principle of action of an electric motor, which can covert electric potential energy into kinetic energy.

The choice of location and the dimensioning of the size play a leading role when it comes to wind power stations. Concerning the size it should be noted that the power increases in quadratic proportion to the diameter of the rotor. That means there is a fourfold power for twice the size. That means a big wind turbine is advantageous. Concerning the choice of location the deciding factor is that the power increases by the cube of the wind force. This means double the wind speed leads to an eight times greater power. The other way round means that half the wind force leads only to one eighth of the power. The locations should ensure a certain level of wind-safety. Therefore offshore wind power stations are very efficient as they can tap into the land/onshore circulation and consequently have a certain wind-safety as a basis.

The height of the wind power station is also very important. The higher the region the lower the wind breaking terrain effects, which leads to constant and strong winds.

From a certain wind speed of ca. 20m/s the wind power station must be turned off to prevent it from damages. Up to this point the rotors can regulate the power by their position so that only the maximum power capacity of the generator is reached (overheat protect). As soon as the wind speed exceeds this point the blades must be moved out of the wind as a regulation on its own isn't enough any more to protect the generator from overheating. Additionally the high wind speeds mean a huge strain on the material. The failure of the materials harbors a high potential of hazards especially on onshore wind power stations.

Tasks

1. Inform yourself on the Internet about the functioning and the construction of a generator.
2. Research and note down the key points of the conditions for the choice of a suitable location with regard to **wind-safety** and **terrain effects**.
3. Explain how the wind turbine protects the generator from overheating and the material from failure.
4. What dangers can occur if the material fails? Write down some of them and work out suitable prevention strategies.
5. Define the term **efficiency.** Search the Internet for the efficiency of a modern wind power station.
6. Prepare a short presentation together with the other members of your group. The presentation should provide a good overview of the topic. You can take the solutions of the tasks 1-6 as guidance for the contents. Prepare an experiment that explains the functional principle.

Space for Illustrations

Theoretical Introduction

Water power can be exploited in many ways. Depending on the local conditions the types of power stations vary. The basic principle of the power stations can be explained through the example of a storage power station.

A storage power station has an (artificial) reservoir. This is a property that distinguishes it from the other water power stations. For energy generation the potential energy of falling water is used, this means a certain drop height is a necessary condition. At the lower end of the downpipes a turbine is driven, which is connected to a generator. Generally you can achieve enormous power also at lower speeds as water has thousand times the density of water. But this process has a detrimental effect on the materials, as water promotes the erosion and corrosion of the substances. Additionally the higher viscosity of water means alternating stresses and therefore a true challenge for the material.

Various types of power stations provide varying fields of application. A run-of-river electric power station makes the provision of the base load energy possible by its uninterrupted operation.

The tidal and wave power stations can also be classified under the category of base load supply as these natural effects also run continuously.

Storage power stations serve as an energy storage system. They store water at an elevated location. If needed they can convert the potential energy. When there is no need of electric energy or there is an "overproduction" the water can be pumped back to the elevated position. So the electric energy can be "stored" in the form of potential energy.

Tasks

1. Inform yourself on the Internet about different types of power stations and their functioning.
2. Define the terms **erosion** and **corrosion**. How are they important in conjunction with water power stations?
3. Which power station can be used for which power supply requirement? Work out a concept.
4. Tabulate the advantages and disadvantages of the different types of power stations.
5. Define the term **efficiency**. Search the Internet for the efficiency of a modern hydroelectric power station.
6. Prepare a short presentation together with the other members of your group. The presentation should provide a good overview of the topic. You can take the solutions of the tasks 1-6 as guidance for the contents. Prepare an experiment that explains the functional principle.

Solutions to the tasks

Photovoltaics

1. Inform yourself on the Internet about the semiconductor technology and about the photo effect. Portray the functional principle and the connection between the two terms in key points.
    a. Semiconductor Technology
    See Internet

    b. Photo effect
    „The photoelectric effect or photoemission is the production of electrons or other free carriers when light is shone onto a material. Electrons emitted in this manner can be called photoelectrons. [...]
    According to classical electromagnetic theory, this effect can be attributed to the transfer of energy from the light to an electron. From this perspective, an alteration in either the intensity or wavelength of light would induce changes in the rate of emission of electrons from the metal.“[1]

2. Find out why silicon is suitable for the semiconductor technology.
    Silicon is a semimetal, which has properties of metals as well as non-metals. So by photoelectric stimulation it is possible that electrons can migrate in the crystalline silicon wafers. That's why they are perfectly suitable for photovoltaic technology.

3. Define the term efficiency
    See methodical part

4. Search the Internet for the efficiency of a photovoltaic module.
    Maximum efficiency of monocrystalline silicon ~22%[2]

5. Compare the efficiency of a coal-fired power station to the efficiency of a solar cell. What do you observe?
    A coal-fired power station has an efficiency of 40% however a solar module only has 22%. But considering the environmental dimension the efficiency of 22% is absolutely defensible in the face of the pollution emissions of a coal-fired power station.

Solarthermics

1) Inform yourself on the Internet about **absorption** and **reflection**. Note down the definition of the two terms in short key words.
    a) Absorption
    In physics, absorption of electromagnetic radiation is the way in which the energy of a photon is taken up by matter, typically the electrons of an atom. Thus,
    the electromagnetic energy is transformed into internal energy of the absorber, for example thermal energy. The reduction in intensity of a light

[1] https://en.wikipedia.org/wiki/Photoelectric_effect (29.07.2016 17:08)
[2] http://www.photovoltaik.org/wissen/photovoltaik-wirkungsgrad (14.06.2016 19:44)

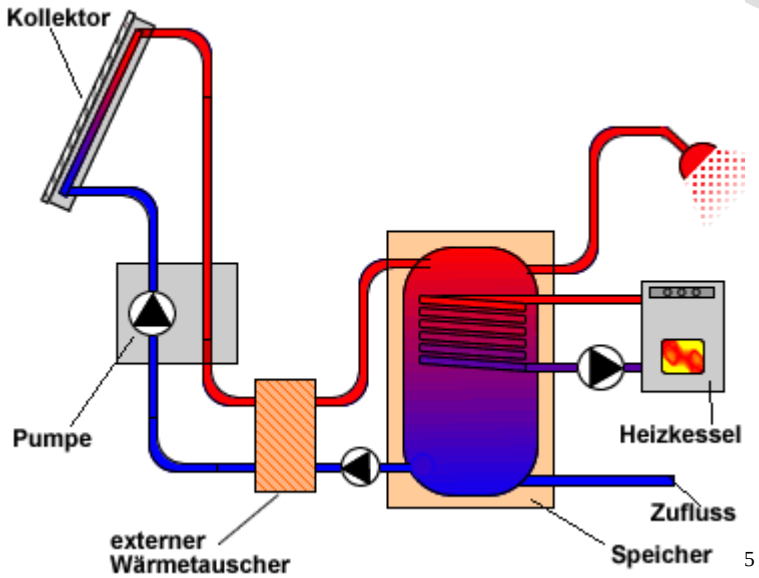
wave propagating through a medium by absorption of a part of its photons is often called attenuation. Usually, the absorption of waves does not depend on their intensity (linear absorption), although in certain conditions (usually, in optics), the medium changes its transparency dependently on the intensity of waves going through, and saturable absorption (or nonlinear absorption) occurs."[3]

b) Reflection

„Reflection is the change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated. [...] Reflection of light is either specular (mirror-like) or diffuse (retaining the energy, but losing the image) depending on the nature of the interface. [...] A mirror provides the most common model for specular light reflection, and typically consists of a glass sheet with a metallic coating where the reflection actually occurs. Reflection is enhanced in metals by suppression of wave propagation beyond their skin depths. Reflection also occurs at the surface of transparent media, such as water or glass."[4]

2) Explain how short-wave radiation can be converted into long-wave radiation.
When the wave strikes an impermeable material it loses energy and the wavelength changes. As a result short-wave radiation can be reflected a long-wave radiation.

3) The text mentions the use of solar panels to heat up industrial water. Explain the functional principle of heat exchange by means of a sketch.



[5]

[3] https://en.wikipedia.org/wiki/Absorption_(electromagnetic_radiation) (29.07.2016 17:19)
[4] https://en.wikipedia.org/wiki/Reflection_(physics) (29.07.2016 17:26)
[5] https://www.solaranlagen-portal.de/images/solaranlagen-portal/st/technik/externe-waermetauscher-anlage.gif (14.06.2016 20:03)

4) Work out the criteria that make the solar panel as efficient as possible and note the key points.
   a) Orientation of the solar panel to the side that faces the sun (best midday sun)
   b) Use of materials that binds and absorbs the entire incoming radiation
   c) Efficient heat exchange of the solar panel and of the industrial hot water storage tank.
5) Define the term **efficiency**. Search the Internet to find out the average **optical** efficiency of a solar panel.
   Definition of efficiency: see above
   The optical efficiency always refers to the effectively incoming radiant power, not the optimal one. But if high-end panels work optimally they can achieve an efficiency of 95%[6].

[6] http://www.solarthermie.net/wissen/optischer-wirkungsgrad (10.06.2016 20:07)

Wind Energy

1. Inform yourself on the Internet about the functioning and the construction of a generator.

   "In electricity generation, a generator is a device that converts mechanical energy to electrical energy for use in an external circuit. The source of mechanical energy may vary widely from a hand crank to an internal combustion engine. Generators provide nearly all of the power for electric power grids.

   The reverse conversion of electrical energy into mechanical energy is done by an electric motor, and motors and generators have many similarities. Many motors can be mechanically driven to generate electricity and frequently make acceptable generators."

2. Research and note down the key points of the conditions for the choice of a suitable location with regard to wind-safety and terrain effects.
   The choice of location and the dimensioning of the size play a leading role when it comes to wind power stations. Concerning the size it should be noted that the power increases in quadratic proportion to the diameter of the rotor. That means there is a fourfold power for twice the size. That means a big wind turbine is advantageous. Concerning the choice of location the deciding factor is that the power increases by the cube of the wind force. This means double the wind speed leads to an eight times greater power. The other way round means that half the wind force leads only to one eighth of the power. The locations should ensure a certain level of wind-safety. Therefore offshore wind power stations are very efficient as they can tap into the land/onshore circulation and consequently have a certain wind-safety as a basis.
   The height of the wind power station is also very important. The higher the region the lower the wind breaking terrain effects, which leads to constant and strong winds.

3. Explain how the wind turbine protects the generator from overheating and the material from failure.
   The wind turbine is able to turn off itself by moving its blades out off of the wind. This prevents the speed from exceeding the critical point and therefore protects the generator from overheating and the material from failure.

4. What dangers can occur if the material fails? Write down some of them and work out suitable prevention strategies.
   https://www.youtube.com/watch?v=4qtQaZh6Ih0 (14.06.2016 20:24)
   a. See task 3
   b. Choosing high safety values for the materials and the joints

5. Define the term efficiency. Search the Internet for the efficiency of a modern hydroelectric power station.
   See above
   Theoretical efficiency: 59,3 %[7]

[7] http://www.weltderphysik.de/gebiet/technik/energie/gewinnungumwandlung/windkraft/physik-der-windenergie/ (29.07.2016 17:34)

Water Power

1. Inform yourself on the Internet about different types of power stations and their functioning.

    a. Run-of-the-river power station
    b. Storage power station and pumped-storage hydro power station
    c. Tidal power station
    d. Osmotic power station and ocean thermal energy conversion
    e. Glacier power plant

2. Define the terms **erosion** and **corrosion**. How are they important in conjunction with water power stations?

    (a) Erosion

    "Erosion is the gradual removal of a substance by chemical or mechanical means."
    "Various parts of jet engines, nuclear reactors, and steam turbines and boile rs are subjected to destruction by erosion.
    Increased resistance of parts against erosion can be achieved by improving process technology or unit design and by
    selecting more suitable material; heat treatment also increases resistance ag ainst erosion."[8]

    (b) Corrosion

    "Corrosion is a natural process, which converts a refined metal to a more stable form, such as its oxide, hydroxide, or sulfide. It is the gradual destruction of materials (usually metals) by chemical and/or electrochemical reaction with their environment. Corrosion engineering is the field dedicated to controlling and stopping corrosion."[9]

    For hydropower stations the effects erosion and corrosion are of particular importance when it comes to the construction of the turbines, as it must be noted that there is a certain wear by their environment. Especially metals are susceptible to corrosion in aqueous media.

3. Which power station can be used for which power supply requirement? Work out a concept.

    Base load supply: run-of-river, tidal, wave, ocean thermal energy conversion, osmotic power

    Energy storage: storage power plant (also pumped-storage power stations with reservoir)

[8] https://en.wikipedia.org/wiki/Erosion_(disambiguation), http://encyclopedia2.thefreedictionary.com/Erosion+of+Metals (29.07.2016 17:47)
[9] https://en.wikipedia.org/wiki/Corrosion(14.06.2016 20:36)

4. Tabulate the advantages and disadvantages of the different types of power stations.
   There are multiple solutions.

5. Define the term efficiency. Search the Internet for the efficiency of a modern hydroelectric power station of your own choice.
   See above, efficiency: Internet research (can vary)