Title: Ecology – Energy from sun and wind

Topics: percentage, surface area, energy, solar panels, wind mills	**Time**: 90 minutes	**Age**: 13-14

Differentiation:

Higher level: Physical principles of power generation by wind or sun can be discussed in more depth; semiconductors may be discussed

Lower level: Silicon properties can be omitted from work sheet 1

Guidelines, ICT support etc.:

Experts from local NGOs (Non-Government Organisations) or energy production companies may be invited for a panel discussion. Alternatively, teams may be formed by students to present different standpoints of alternative vs. traditional energy resources.

Equipment needed for this activity:

Work sheets

Internet access

Model kit of wind mill, model kit of solar powered device (e.g. toy)

Required knowledge:

Concept of energy

Calculation of percentages

Health and Safety:

Learning outcomes for this activity:

Students should be able to perform the calculations and practical tasks on the work sheets

Students should be able to follow the discussion and see the need for reasonable data and calculations to form an informed opinion about controversial topics

Students should be able to understand the physical principles of solar cells and windmills

Lesson description

Starter Activity

Teacher introduces topic of "traditional" vs. "alternative" energy sources. Students are asked to name examples of such sources that they know of. Students are then asked whether they think that the energy consumption of a country (as an example we took Austria, but teachers can substitute data in the work sheets and use their own country) can be covered by solar cells. Those in favour of it shall make several guesses as to what area (in %) of the country they think would then be covered by solar cells. These guesses will be written on the board. The same procedure is done with wind turbines, and students shall guess how many wind turbines are required.

Main Activity

Students form teams of 6. Each team chooses either "solar cell" or "wind turbine" as a topic and receives the corresponding work sheet and model kit (depending on class size, there will be one or two teams for each topic). Three of the team will be named "engineering crew", they will have to do the theoretical calculations on the work sheet. The other three will be named "construction crew", they will have to build the model kits. Each crew performs the tasks as described on the work sheet, and then explains what they were doing to the other crew of their team.

Teams will then receive work sheet 2 where they should think about and write down possible advantages and disadvantages of their chosen form of electricity production, and about obstacles of implementing the theoretical results from work sheet 1.

Plenary Activity

Each team will nominate a speaker who presents the finished model and describes the results of the calculations. If two teams worked on this topic, the second teams' speaker performs the same tasks. Results are written next to the original guesses on the board.

After all teams presented their results, there will be a discussion-and-debate session about the possible obstacles of implementing the theoretical calculations into practical construction (e.g. number of solar cells required, where to construct huge areas of solar cells in a densely populated country, expense of building wind turbines, resistance of local communities against wind turbines etc.).

Ecology – Energy from sun and wind

Work sheet 1a

Photovoltaic is a technology used to convert sunlight (mainly the visible part of the spectrum) into electric energy. In Austria, only 0.03% of the energy consumption is covered by photovoltaic. People who are active in environmental protection urge to dramatically increase this kind of energy production, particularly to avoid burning of fossil fuels or nuclear power production. Let us see how much energy can be produced by photovoltaic, and whether it is possible to eventually cover all energy production with solar panels.

Task 1: A standard solar panel has a rectangular shape and a size of 160 cm x 90 cm. It has a maximum power output of 200 W.

a) What is the size of the area that would be covered with solar panels in Austria to cover the total electric power consumption (by 2013, this was 69,600 GWh) by using solar panels? Estimate that the sun shines for an average of 8 hours per day.
b) Austria has a total area of 83,872 km^2. What percentage of that area would be covered with solar panels?

Task 2: The actual "solar energy" (irradiance, i.e. power per unit of area) reaching the earth's surface depends on the time of the year as well as on ones' position on the earth's surface. In Austria, the maximum value is approximately 700 W/m^2. What would be the efficiency of the above-mentioned solar panel if the maximum irradiance occurs and the power output of the panel is 200 W?

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Work sheet 1b

You probably have seen windmills standing somewhere on the coast, on barren land, or in the middle of a wheat field – and we do not talk about the old, wooden mills that were used to grind corn etc. but about modern, concrete-and-steel constructions. From the distance they don't look like much, but if you stand next to one you can see that they are really big – typically around 80 m! In some countries, they are very numerous, while other countries are reluctant to put them up. Let's see whether we could cover the Austrian electricity needs by wind power!

Task 1: A wind turbine can produce up to 3600 kW of power (the actual power output depends on the wind speed; usually wind turbines work in a range between 4 m/s and 25 m/s wind speed).

a) Suppose the wind blows day and night within the ideal speed of 13 to 25 m/s, which gives the maximum power output of most windmills. How many windmills would have to be constructed to cover the total electric power consumption of Austria (by 2013, this was 69,600 GWh)?
b) Obviously the wind does not blow day and night with the same strength. Try to find out the actual wind speed for a place nearby and repeat the calculation!

Task 2: Betz' law says that the maximum achievable efficiency of a wind turbine is 59.3 %. Practical inefficiencies, like drag and friction, further decrease the actual efficiency to about 45 %. Compare this with the efficiency of "conventional" power production, and with the efficiency of solar cells!

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Work sheet 2a

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What are the advantages of solar power vs. wind power?

What are the disadvantages of solar power vs. wind power?

What practical (e.g. engineering, environmental, social etc.) obstacles may occur when implementing the theoretical calculations of work sheet 1, i.e. when you try to cover the entire electricity needs of Austria by solar cells?

Ecology – Energy from sun and wind

Work sheet 2b

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What are the advantages of wind power vs. solar power?

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What are the disadvantages of wind power vs. solar power?

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What practical (e.g. engineering, environmental, social etc.) obstacles may occur when implementing the theoretical calculations of work sheet 1, i.e. when you try to cover the entire electricity needs of Austria by wind mills?

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