

A science project on **SUSTAINABLE ENERGY**



This material aims to provide inspiration for a science project which focuses on sustainable energy and at the same time includes the 4 competences in Science Teaching. It also includes the possibility of arranging a company visit which will ensure that multiple forms of expressions will come into play.



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Competences

The natural science competences will be viewed as the ability to use knowledge as well as skills within relevant natural science contexts.

In the preparation of the teaching material we have aimed to draw-up a guide to the students which leaves room for working with knowledge within natural science as well as skills within the competence areas. The guide seeks to lead the students in a direction where they can relate their projects to something which is down-to-earth and relevant to their everyday life with natural science.

Ideas are listed within the different subtopics on how to work with the subjects in order to ensure that the students will bring their competences into play as much as possible. The ideas should be viewed as suggestions and support to those students who are in need of it. The students are encouraged to explore their own ideas, and as such, the ideas listed in the material should only be viewed as a stepping stone to further immersion.

Within the skills and knowledge area, the material is primarily focusing on “the conversion of energy”, but the structure which is used for this subject is applicable in other courses. It will for example be possible to do this jointly with the students when preparing for new science projects.

Literature

Please find suggestions for texts and material here:

- <http://hydrogenvalley.dk/frontpage-en/>
- <https://brintbranchen.dk/english/>
- <https://sustainabledevelopment.un.org/#>
- <https://www.renewableenergyhub.co.uk/main/solar-panels/how-do-solar-panels-work-for-kids/>
- https://www.ducksters.com/science/environment/wind_power.php
- <https://www.kidsdiscover.com/teacherresources/whats-good-whats-bad-wind-energy/>
- <https://www.alliantenergykids.com/>
- <https://stateofgreen.com/en/green-news/>
- <https://new.siemens.com/global/en/products/energy/topics/distributed-energy-systems.html>

The lesson plan

During the time in the lower secondary education, the students must work with at least 6 interdisciplinary lesson plans which will bring technical as well as scientific areas of focus into play.

The courses must be problem-oriented and give the students the opportunity to develop their talent for identifying, understanding and addressing scientific theses. It is not essential for the courses to have a certain length, but they must include the natural science subjects in interaction with relevant content from 2-3 technical subjects and possibly from non-technical subjects. Simultaneously, the courses must provide the student's basis for examination. In this context it is essential to consider how multiple forms of expression can be brought into play, because curriculum states that the exam must include 4 different forms of expression.

At Rosendalskolen we are focused on including open schooling in our work with the interdisciplinary science teaching. This manifests itself in our contact with organizations and companies, which gives the students the opportunity to go and visit the companies or for representatives from the companies to visit the school and give a company presentation.

In this material we are collaborating with Hydrogen Valley/CEMTEC.

Hydrogen Valley/CEMTEC is a partner in the international project HyBalance, which demonstrates the usage of green hydrogen in the future energy system. The HyBalance project is one of several initiatives to help transform energy systems from fossil dependency to relying on renewable and local energy sources by utilizing the potential of hydrogen.

Hydrogen Valley/CEMTEC is able to receive visitors at the HyBalance plant in the southern part of Hobro. The students will be offered a guided tour of the site as well as a presentation about the project and other relevant activities which the company engages in.

If there is neither time nor budget to send the students to the HyBalance site, it will also be possible to schedule a visit from a representative from Hydrogen Valley/CEMTEC who can visit the school and give a presentation instead.



SCIENCE PROJECTS

Teaching leading up to the project

As mentioned previously, the timeframe and the structure in the work with the interdisciplinary focus areas are not specified. In the following section we will incorporate the structure which is applied at Rosendalskolen in Hobro. At Rosendalskolen the focus areas are incorporated as individual project weeks with varying length.

Leading up to the project weeks, the individual science subjects work with different ideas related to the subject which will prepare the students to work in-depth with a topic of their choice. Such a preparation is briefly described in the following sections:

2 weeks before the project: the energy is generated

The overall subject is presented and the goals for the course are covered in class. During this week the students will be introduced to energy in the form of fossil energy supply. We will focus on how energy can be generated from fossil fuels and how to build a generator. The teacher will give a presentation on the construction of a combustion engine, and how this can work as drive power for the generator.

The students will build a single-phase generator and investigate which factors make it perform optimally. The students will also discuss their considerations on how the generator can be operated with fossil fuels as well as with renewable energy sources. Through their work and in the presentation, the students will be introduced to the terms: electromagnet, induction, transformation and combustion engine.

1 week before the project: Renewable energy

During this week the students will be introduced to energy in the form of renewable energy. We will focus on what makes energy renewable and on some of the alternative sources of energy we surround ourselves with and use in Denmark today. The teacher will give a presentation on alternative energy sources and will in class demonstrate the structure of solar power cells, solar panels and wind turbines. The students will investigate the construction and usage of solar panels and wind turbines. The students will subsequently investigate which factors are important in order for their energy source to perform optimally.



HYDROGEN

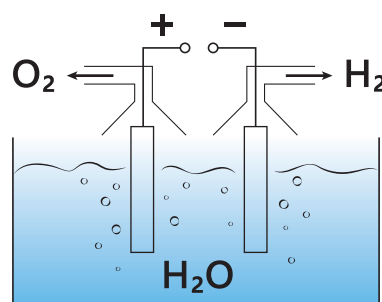
We will now look at hydrogen as an energy source for the whole or parts of our society. Many people think that hydrogen can be Denmark's new source for green and sustainable energy, particularly as a substitute for the fossil fuels which we use in the transport sector. But how do you produce hydrogen? Is it dangerous? How can you use hydrogen as fuel and how does it affect nature when we use water to produce hydrogen in order to solve the growing need for energy?

In your group you must write a problem formulation which covers something you find surprising about hydrogen. For the problem formulation you must prepare a number of questions for each of the 3 natural science subjects, as described above. We will now work with the questions and the problem formulation through the 4 natural science competences.

Investigation

In the group, you must carry out an investigation which illustrates one or more questions. A list has been composed with examples of topics you can investigate. Remember to consider what your hypotheses/expectations are for the investigation and which variables are present. You are not supposed to do all the investigations but just the ones which fit your questions and the problem formulation.

- How does electrolysis work?
 - Which chemical reactions occur?
- How is hydrogen converted into electricity?
 - Fuel cells.
- What is hydrogen?
- Which role does hydrogen play in a water circuit?
- How does the electrolysis facility affect the surrounding nature – if it has any impact at all?
- Where would it be beneficial to place a hydrogen facility when considering:
 - Water supply.
 - Consumers.
 - Storage of hydrogen.
 - Power input.



Modelling

In the group, you must either make or find a model which can answer one or more of your questions. When choosing a model, you must consider what you want the model to illustrate in relation to your questions (draw up for example 3 demands to your model). Consider if there should be text on the model, or if you want to explain it yourselves. Also consider how the model can confirm the results of your investigation or the subjects you want to handle theoretically. A few model examples have been done which show how you can work with the models. You can make more yourself or different ones if you like. You are not supposed to use all the models, but just the ones which fit your questions or problem formulation.

- Model of fuel cell.
- Model of electrolysis.
- Model of water circuit.

Communication

In your group you must find oral answers to one or several of your questions. You must find and select texts and articles which substantiate and answer your questions. Please consider the credibility of the material you find and select some scientific terms which you want to focus on. In the oral part, you will have to explain the theory which can form the basis of the answer to your problem formulation. The oral part must also confirm some of the theory you have investigated or confirm/elaborate your model's answer to the question.

Below you will find examples of communication you can work with, please find more yourself. You are not supposed to use all the suggestions but just the ones that fit your questions or problem formulation.

- Describe in your own words what electrolysis is.
 - How does the process which takes place during electrolysis work?
 - Balance the chemical reaction.
 - How does a fuel cell work?
 - What does it consist of?
 - How is it constructed?
 - What chemical reactions take place?
 - How is water converted into electricity?
 - From chemical energy in water to electrical energy.
- Water circuit.
- Biotopes, especially the ones that will match the location of an electrolysis facility.

Putting it into perspective

In your group you must now find subjects where you can put the whole sub topic or some of your questions into perspective. This can be subjects/topics which connect your problem formulation to your everyday life or to society, but it can also be a topic that faces the same issues or solutions as the ones you have found. By putting it into perspective you must use it to describe or discuss your sub-topic's influence on e.g. society, your everyday life or our joint future. Below you will find examples of subjects which you can discuss. Please find other topics yourself. You are not supposed to use all the suggestions, but you can use some of them if they match your problem formulation or questions.

- Hydropower.
- Solar energy.
- Wind turbines.
- The carbon cycle in relation to a combustion engine and/or in relation to the production of electricity.

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WIND TURBINES

In the following section we will look at wind turbines as an energy source for our society on a local, national and global level. Wind turbines are the largest source of green and sustainable energy in Denmark and we have an extensive history with wind turbines as part of Danish society. Many years ago, wind turbines were used to mill grain, and today the power generated from wind turbines is used to light up our homes. But how does a wind turbine work? Where is the best location to erect a wind turbine? How is a wind turbine built, and how does it affect our nature when wind farms continue to shoot up in order to solve our growing demand for energy?

In your group you must now formulate a problem formulation which covers something which you find surprising about wind turbines. For your problem formulation you must formulate questions to each of the 3 natural science subjects, as described earlier. We will be working with the questions and the problem formulation through the 4 natural science competences.

Investigation

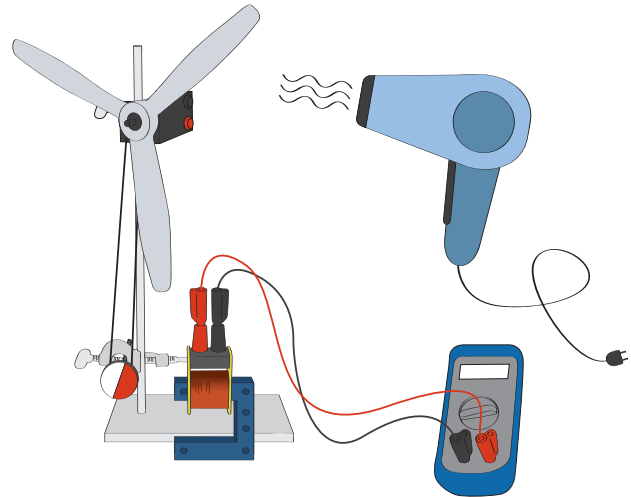
In your group you must now carry out an investigation which illustrates one or more questions. A list has of examples of topics you can investigate has been made. Remember to consider what your hypotheses/expectations are to the investigation and which variables are present. You are not supposed to do all the investigations but just the ones which match your questions and the problem formulation.

- Build a wind turbine with a single generator and investigate:
 - Which factors have the most effect of the wind turbine?
 - The size of the spools.
 - The rotation speed of the magnets.
 - The size of the iron core.
 - How does the number of blades affect the effect of the wind turbine?
 - Less than 3 blades.
 - 3 blades.
 - More than 3 blades.
 - What connection is there between the shape of the blade and the effect?
- Investigate where wind farms are located in Denmark, and in which biotope.
 - Land as well as sea.
 - Investigate if there are specific animal life or vegetation in the biotopes which are sensitive to sound.
- Build a wind turbine where you can change the number of blades and measure the sound level when the wind turbine runs at similar revolutions.
 - Regulate the revolutions and measure the effect.
- Investigate which geographical location would be optimal for a wind turbine by looking into:
 - Where would it be best to place a wind turbine with regard to wind?
 - Where would it be best to place a wind turbine with regard to consumers?
 - Where would it be best to place a wind turbine with regard to transport and energy loss?
- Investigate the connection between wind speed and the performance of the wind turbine.
 - How strong is the wind energy in Denmark right now and how strong is the average wind speed?
 - Danish wind turbines are built to produce most at 8 m/s. Investigate why this is.

Modelling

In the group, you must either make or find a model which can answer one or more of your questions. When choosing a model, you must consider what you want the model to illustrate in relation to your questions (draw up for example 3 requirements to your model). Consider if there should be text on the model, or if you want to explain it yourselves. Also consider how the model can confirm the results of your investigation or the subjects you want to handle theoretically. A few model examples have been done which show how you can work with the models. You can make more yourself or different ones if you like. You are not supposed to use all the models, but just the ones which match your questions or problem formulation.

- A model of a wind turbine which can be used to explain the construction of a wind turbine.
- Various models of different biotopes.
 - Water biotopes.
 - Land biotopes.
- Use a model of the Earth in order to illustrate where different wind systems are present.
- Use a model of the ocean currents and depths around the world to argue for the practical location of wind turbines. Compare it to the model of wind systems.



Communication

In your group you must find oral answers to one or several of your questions. You must find and select texts and articles which substantiate and answer your questions. Please consider the credibility of the material you find and select some scientific terms which you want to focus on. In the oral part, you will have to explain the theory which forms the basis of the answer to your problem formulation. The oral part must also confirm some of the theory you have investigated or confirm/elaborate your model's answer to the question.

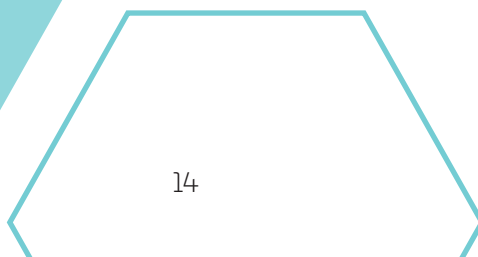
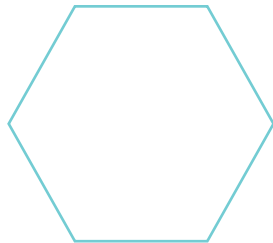
Below you will find examples of communication you can work with, please find more yourself. You are not supposed to use all the suggestions but just the ones that match your questions or problem formulation.

- Describe in your own words what a wind turbine is.
 - How is it constructed – what does it consist of?
 - How does the blade of the wind turbine work?
 - How does the generator work?
 - How is wind energy converted into electrical energy?
- Describe in your own words:
 - How can sound affect animal life?
 - What characterizes a biotope?
 - The animal life or vegetation you will find in at least two different biotopes.
- Explain something about wind systems.
 - What drives a wind system?
 - Wind systems and geographical location.
 - The Coriolis force.
 - High- and low-pressure systems.

Putting it into perspective

In your group you must now find subjects where you can put the whole sub topic or some of your questions into perspective. These can be subjects/topics which connect your problem formulation to your everyday life or to society, but it can also be a topic which is faced with the same issues or solutions as the ones you have found. By putting it into perspective, you must use it to describe or discuss your sub topic's influence on e.g. society, your everyday life or our joint future. Below you will find examples of areas which you can discuss. Please find other topics yourself. You are not supposed to use all the suggestions, but you can use some of them if they match your problem formulation or questions.

- Look at the generator in other facilities e.g. hydropower or coal power, and find similarities and differences.
- Compare it to energy produced in solar power cells in relation to the energy conversion.
- Look into where you will find other types of facilities e.g. hydropower or coal power in different biotopes and find similarities and differences.
- Ocean currents.



NOTES

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SOLAR ENERGY

In this section we will focus on the sun as a source of energy for our society. Many people already use the sun as an energy source, either in the form of solar power cells or solar panels, and it is considered a green and sustainable source of energy. But how does solar energy work? How are the rays of the sun converted into energy, and which circumstances must we take into consideration in relation to where in the world we must live in order to get the most out of solar energy?

In your group you must now formulate a problem formulation which covers something which you find surprising about solar energy. For your problem formulation you must formulate questions to each of the 3 natural science subjects, as described earlier. We will be working with the questions and the problem formulation through the 4 natural science competences.

Investigation

In your group you must now carry out an investigation which illustrates one or more questions. A list has been drawn up with examples of topics you can investigate. Remember to consider what your hypotheses/expectations are to the investigation and which variables are present. You are not supposed to do all the investigations but just the ones which match your questions and the problem formulation.

- How does a solar power cell work?
 - Which materials are used to make a solar power cell?
 - Is it possible to make a solar power cell yourself?
 - If this is possible, how good would it be, and would it be able to make a light bulb light up?
 - How does the solar cell convert energy from light rays into electricity?
- Can a solar park affect the surrounding nature?
- The geographical location of the park in relation to the tilt and the effect.
- With a topographical map and the location of different solar farms, investigate if there is a connection between topography and the degree to which the solar cells are used.
 - Investigate how a changed topography affects the tilt of the solar cells, if it has any affect at all.

Modelling

In the group you must either make or find a model which can answer one or more of your questions. When choosing a model, you must consider what you want the model to illustrate in relation to your questions (draw up for example 3 requirements to your model). Consider if there should be text on the model, or if you want to explain it yourselves. Also consider how the model can confirm the results of your investigation or the topics you want to handle theoretically. A few model examples have been made which show how you can work with the models. You can make more yourself or different ones if you like. You are not supposed to use all the models, but just the ones which match your questions or problem formulation.

- A model of a solar power cell.
- A model of biotopes where it is possible to erect solar power cells.
- A model of the Earth which shows the connection between location and the tilt of the solar power cells.
- A topographical map of selected countries or areas.

Communication

In your group you must find oral answers to one or several of your questions. You must find and select texts and articles which substantiate and answer your questions. Please consider the credibility of the material you find and select some scientific terms which you want to focus on. In the oral part, you will have to explain the theory which forms the basis of the answer to your problem formulation. The oral part must also confirm some of the theory you have investigated or confirm/elaborate your model's answer to the question.

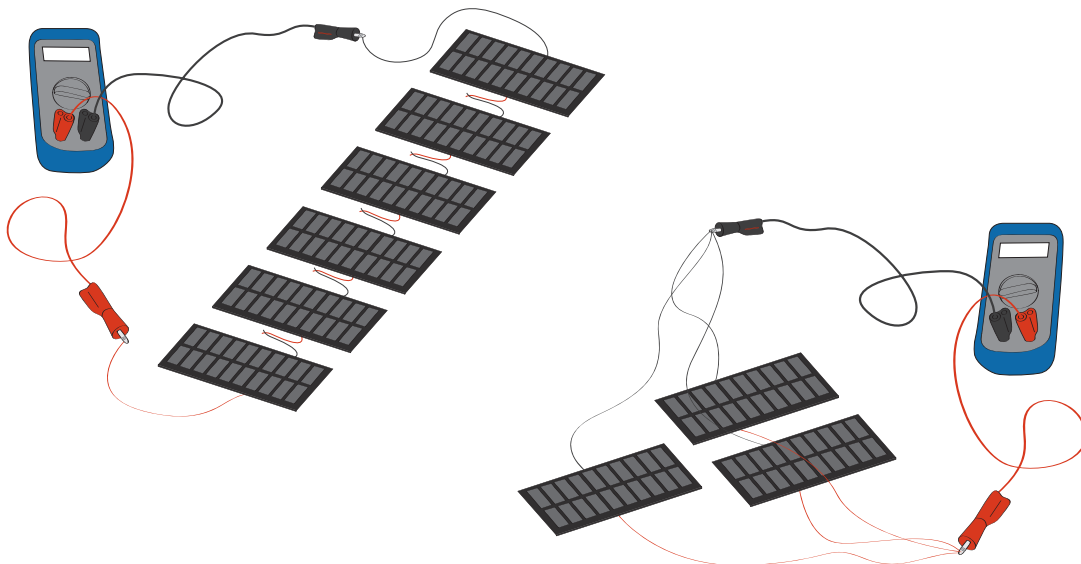
Below you will find examples of communication you can work with, please find more yourself. You are not supposed to use all the suggestions but just the ones that match your questions or problem formulation.

- Describe in your own words how a solar cell works
 - Are any processes taking place inside the solar cell?
 - What does a solar cell consist of?
 - How is it constructed?
 - Are any chemical or physical processes taking place?
 - How are solar rays converted into electricity?
 - From solar radiation to electrical energy
- Biotopes, especially the ones which would suit the location of an electrolysis facility.

Putting it into perspective

In your group you must now find subjects where you can put the whole sub topic or some of your questions into perspective. This can be subjects/topics which connect your problem formulation to your everyday life or to society, but it can also be a topic that faces the same issues or solutions as the ones you have found. By putting it into perspective you must use it to describe or discuss your sub topic's influence on e.g. society, your everyday life or our joint future. Below you will find examples of subjects which you can discuss. Please find other topics yourself. You are not supposed to use all the suggestions, but you can use some of them if they match your problem formulation or questions.

- Changes in energy other than chemical to electrical.
- Water power.
- Wind turbines.



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