UNIT 7: Generating Energy

This unit is comprised of 6 activities which are outlined in table 7.1. These activities have been informed by the ENERGE Energy Literacy Framework. A guide to the ENERGE Energy Literacy Framework can be found in UNIT 0. This unit introduces the mechanisms through which energy is harnessed to power global industry and human activity. It aims to increase awareness of how energy resources are currently being developed and managed. This unit explores the topics of energy generation, renewable and non-renewable energy sources, energy resource development and the building and management of energy resources and infrastructure. In activities 7.1 and 7.2 students students evaluate specific energy types, practical energy sources and identify energy types in their surroundings. In activity 7.3 students write to their politicians about energy issues that are important to them. In activities 7.4 and 7.5 students enhance their understanding of how renewable energy resources are developed and managed by designing, building and evaluating renewable energy systems. In activity 7.6 students act as government officials and explore through role-play the economic, financial, social and environmental impacts of energy decisions. The activities in this unit are suitable for lower and upper second level students. In particular, the energy literacy outcomes, the associated skills & competencies addressed and how the activities link to the national curricula are outlined in tables 7.2-7.4.

OVERVIEW of UNIT 7 Generating Energy

Table 7.1 Activities and titles are given, the time required to complete the activity and the ISCED classification.

	Activity Title	**Estimated time (min)**	**Level**	
			ISCED 2	**ISCED 3**
Activity 7.1	How do we generate Energy?	90-120	X	X
Activity 7.2	Identifying Renewable Sources of energy	45-60	X	X
Activity 7.3	Write to your prime minister about Fossil Fuels	45-60	X	
Activity 7.4	Designing a hydroelectric power plant	90-120	X	
Activity 7.5	How efficient is bio-energy?	90-120	X	X
Activity 7.6	The Game of Energy Choices (GOEC)	60-90		X

Activities Mapped to Subjects in National Curricula

Table 7.2 Activities are mapped to subjects in National Curricula .

	Science	Technology & Informatics	Engineering	Mathematics	Home Economics	Geography	English	Design & architecture	Civics & politics	Society & Health	Business & Economics
Activity 7.1	X	X	X								
Activity 7.2	X	X	X			X			X		
Activity 7.3	X	X	X			X	X		X		
Activity 7.4	X	X	X					X			
Activity 7.5	X	X	X								
Activity 7.6	X	X	X		X	X			X	X	

Activities Mapped to Energy Literacy Characteristics

Table 7.3 Activities are mapped to Energy literacy Characteristics.

	C1	C2	C3	C4	C5
Activity 7.1	X	X	X		
Activity 7.2		X	X	X	
Activity 7.3		X	X	X	X
Activity 7.4	X		X		
Activity 7.5	X		X	X	X
Activity 7.6		X	X	X	X

Skill & Competencies Addressed

Table 7.4 Activities are mapped according to Skills & Competencies addressed.

	Decision Making	Problem Solving	Design/innovating	Data Analysing	Collaborating	Communicating	Research	Critical Thinking	Numeracy
Activity 7.1				X			X	X	
Activity 7.2								X	
Activity 7.3	X	X			X	X	X	X	
Activity 7.4	X	X	X		X		X	X	
Activity 7.5				**X**			**X**	**X**	
Activity 7.6	**X**	**X**			**X**	**X**	X	X	**X**

Activity 7.1 How do we Generate Energy?

In this activity, students apply knowledge that they have already acquired to complete a set of exercises that cover four central ideas of energy: forms and sources, transfers, transformations and conservation. This activity provides students with the opportunity to explore the development and management of energy sources to generate electricity, renewable and non-renewable energy sources as well as the operation of commercial power-plants in order to develop a more grounded understanding of the science and how energy is harnessed and used to power human activity. This activity has been developed by Cookstown High School in Co. Tyrone, Northern Ireland.

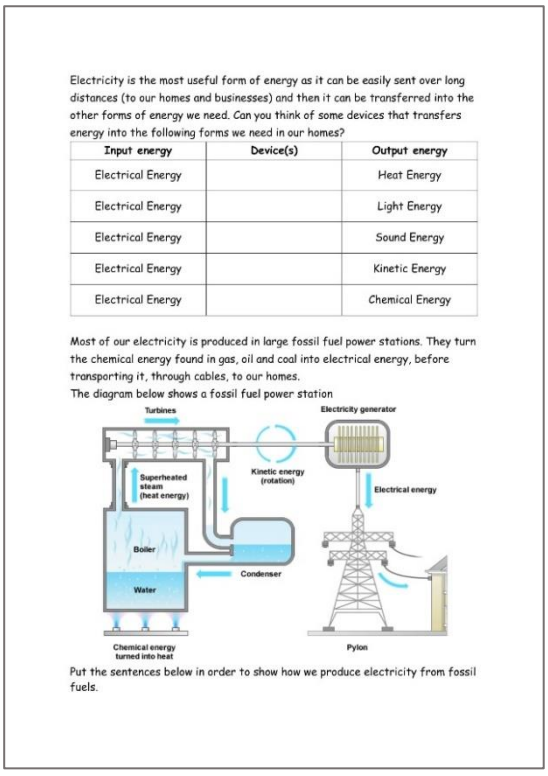
Duration	
90 – 120 minutes	
Energy Literacy Characteristics addressed:	
C1	Grounded understanding of science and how energy is harnessed and used to power human activity
C2	Understands the impact that energy production and consumption have on all spheres of our environment and society
C3	Sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources
Skills & Competencies addressed:	
• Critical Thinking • Data Analysis	• Research • Numeracy
Subject links in National Curricula:	
• Science • Technology & Informatics	• Engineering • Geography
Level	
• ISCED 2 • ISCED 3	

Suggestions for use:

1. Students can work individually or in pairs. Students should receive a copy of the student workbook to complete.

2. Students can be reminded to read the factsheets and reading materials included in the activity worksheet.

3. An accompanying teacher copy containing sample solution for this activity can also be downloaded for use in the classroom.



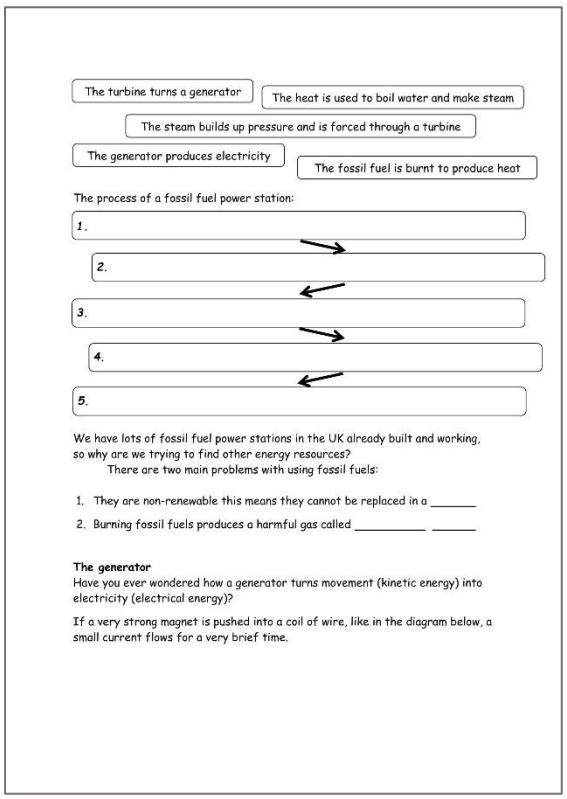
Electricity is the most useful form of energy as it can be easily sent over long distances (to our homes and businesses) and then it can be transferred into the other forms of energy we need. Can you think of some devices that transfers energy into the following forms we need in our homes?

Input energy	Device(s)	Output energy
Electrical Energy		Heat Energy
Electrical Energy		Light Energy
Electrical Energy		Sound Energy
Electrical Energy		Kinetic Energy
Electrical Energy		Chemical Energy

Most of our electricity is produced in large fossil fuel power stations. They turn the chemical energy found in gas, oil and coal into electrical energy, before transporting it, through cables, to our homes.
The diagram below shows a fossil fuel power station

Put the sentences below in order to show how we produce electricity from fossil fuels.

Fig. 1. Activity 7.1 Student Worksheet



The turbine turns a generator

The heat is used to boil water and make steam

The steam builds up pressure and is forced through a turbine

The generator produces electricity

The fossil fuel is burnt to produce heat

The process of a fossil fuel power station:

1.

2.

3.

4.

5.

We have lots of fossil fuel power stations in the UK already built and working, so why are we trying to find other energy resources?

There are two main problems with using fossil fuels:

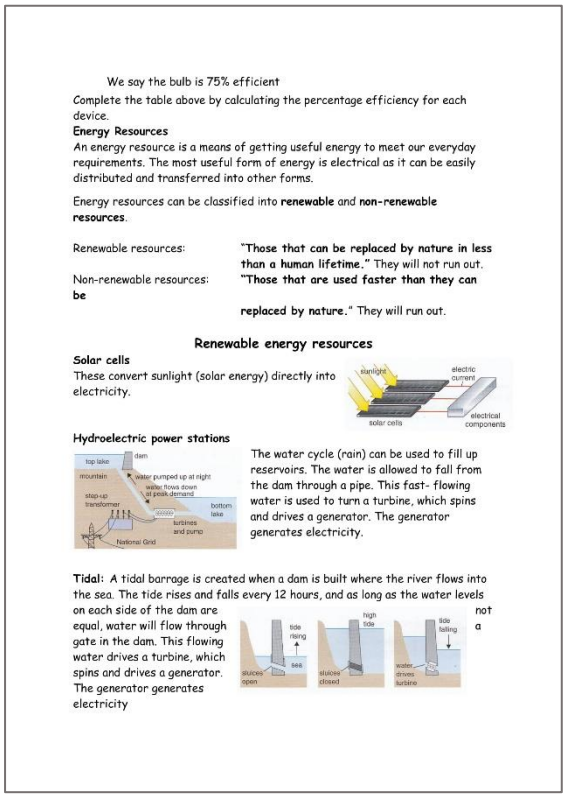
1. They are non-renewable this means they cannot be replaced in a _____
2. Burning fossil fuels produces a harmful gas called _____ _____

The generator

Have you ever wondered how a generator turns movement (kinetic energy) into electricity (electrical energy)?

If a very strong magnet is pushed into a coil of wire, like in the diagram below, a small current flows for a very brief time.

Fig. 2. Activity 7.1 Student Worksheet



We say the bulb is 75% efficient

Complete the table above by calculating the percentage efficiency for each device.

Energy Resources

An energy resource is a means of getting useful energy to meet our everyday requirements. The most useful form of energy is electrical as it can be easily distributed and transferred into other forms.

Energy resources can be classified into **renewable** and **non-renewable resources**.

Renewable resources: **"Those that can be replaced by nature in less than a human lifetime."** They will not run out.

Non-renewable resources: **"Those that are used faster than they can be replaced by nature."** They will run out.

Renewable energy resources

Solar cells

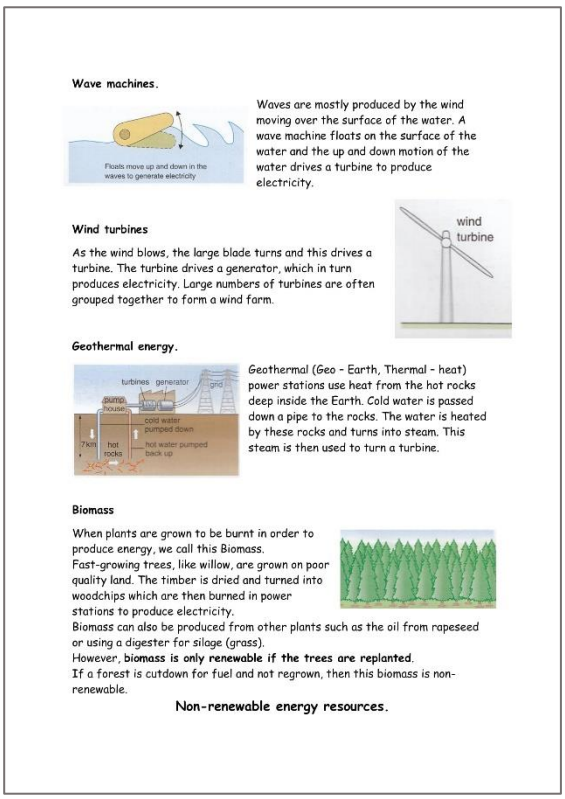
These convert sunlight (solar energy) directly into electricity.

Hydroelectric power stations

The water cycle (rain) can be used to fill up reservoirs. The water is allowed to fall from the dam through a pipe. This fast- flowing water is used to turn a turbine, which spins and drives a generator. The generator generates electricity.

Tidal: A tidal barrage is created when a dam is built where the river flows into the sea. The tide rises and falls every 12 hours, and as long as the water levels on each side of the dam are not equal, water will flow through a gate in the dam. This flowing water drives a turbine, which spins and drives a generator. The generator generates electricity

Fig. 3. Activity 7.1 Worksheet Reading Materials



Wave machines.

Waves are mostly produced by the wind moving over the surface of the water. A wave machine floats on the surface of the water and the up and down motion of the water drives a turbine to produce electricity.

Wind turbines

As the wind blows, the large blade turns and this drives a turbine. The turbine drives a generator, which in turn produces electricity. Large numbers of turbines are often grouped together to form a wind farm.

Geothermal energy.

Geothermal (Geo – Earth, Thermal – heat) power stations use heat from the hot rocks deep inside the Earth. Cold water is passed down a pipe to the rocks. The water is heated by these rocks and turns into steam. This steam is then used to turn a turbine.

Biomass

When plants are grown to be burnt in order to produce energy, we call this Biomass.
Fast-growing trees, like willow, are grown on poor quality land. The timber is dried and turned into woodchips which are then burned in power stations to produce electricity.
Biomass can also be produced from other plants such as the oil from rapeseed or using a digester for silage (grass).
However, **biomass is only renewable if the trees are replanted.**
If a forest is cutdown for fuel and not regrown, then this biomass is non-renewable.

Non-renewable energy resources.

Fig. 4. Activity 7.1 Worksheet Reading Materials

Extensions to Activity

Materials

- Activity 7.1 Student Worksheet
- Activity 7.1 Teacher Copy (solutions)

Activity 7.2 Identifying Renewable Sources of energy

This activity, students apply knowledge that they have already acquired to answer a series of questions about renewable and non-renewable sources of energy as well as the generation of energy and electricity. In particular, students explore what renewable and non-renewable energy sources are and name them. Student also explore how electricity is generated, the parts of power stations, their functions and the energy transfers that take place in power stations. This activity has been developed by Lycée Gaudier Brzeska in Saint-Jean-de-Braye, France.

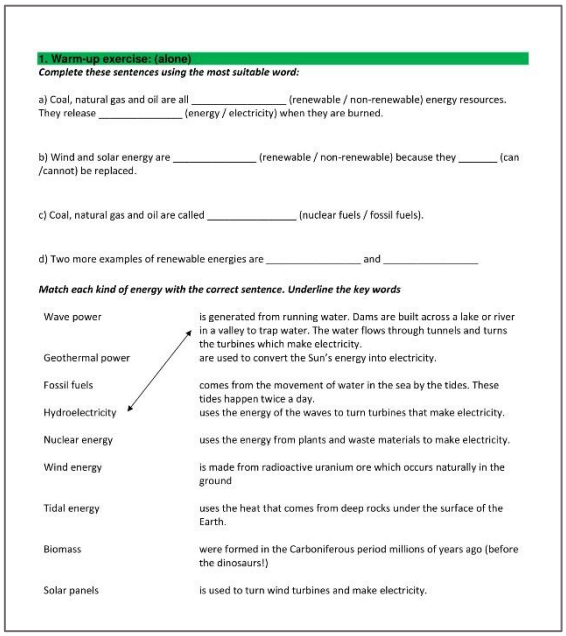
Duration	
45-60 minutes	
Energy Literacy Characteristics addressed:	
C2	Understands the impact that energy production and consumption have on all spheres of our environment and society
C3	Sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources
C4	Cognisant of the impact of personal energy-related decisions and actions on the global community
Skills & Competencies addressed:	
• Critical Thinking	
Subject links in National Curricula:	
• Science • Technology & Informatics • Engineering	• Social & Health • Civics & Politics • Home Economics
Level	
• ISCED 2 • ISCED 3	

Materials

- Activity 7.2 Student Worksheet
- Activity 7.2 Teacher Copy (solution)

Suggestions for Use

1. Students can work individually or in pairs. Students should receive a copy of the student workbook to complete.



1. Warm-up exercise: (alone)

Complete these sentences using the most suitable word:

a) Coal, natural gas and oil are all _____ (renewable / non-renewable) energy resources. They release _____ (energy / electricity) when they are burned.

b) Wind and solar energy are _____ (renewable / non-renewable) because they _____ (can /cannot) be replaced.

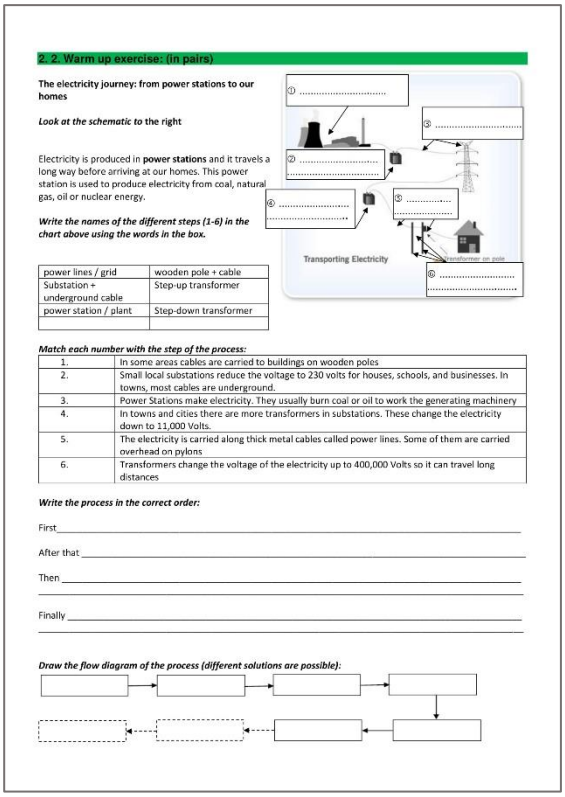
c) Coal, natural gas and oil are called _____ (nuclear fuels / fossil fuels).

d) Two more examples of renewable energies are _____ and _____

Match each kind of energy with the correct sentence. Underline the key words

Wave power	is generated from running water. Dams are built across a lake or river in a valley to trap water. The water flows through tunnels and turns the turbines which make electricity.
Geothermal power	are used to convert the Sun's energy into electricity.
Fossil fuels	comes from the movement of water in the sea by the tides. These tides happen twice a day.
Hydroelectricity	uses the energy of the waves to turn turbines that make electricity.
Nuclear energy	uses the energy from plants and waste materials to make electricity.
Wind energy	is made from radioactive uranium ore which occurs naturally in the ground
Tidal energy	uses the heat that comes from deep rocks under the surface of the Earth.
Biomass	were formed in the Carboniferous period millions of years ago (before the dinosaurs!)
Solar panels	is used to turn wind turbines and make electricity.

Fig. 5. Activity 7.2 Student Worksheet



2. 2. Warm up exercise: (in pairs)

The electricity journey: from power stations to our homes

Look at the schematic to the right

Electricity is produced in **power stations** and it travels a long way before arriving at our homes. This power station is used to produce electricity from coal, natural gas, oil or nuclear energy.

Write the names of the different steps (1-6) in the chart above using the words in the box.

power lines / grid	wooden pole + cable
Substation + underground cable	Step-up transformer
power station / plant	Step-down transformer

Transporting Electricity

Match each number with the step of the process:

1.	In some areas cables are carried to buildings on wooden poles
2.	Small local substations reduce the voltage to 230 volts for houses, schools, and businesses. In towns, most cables are underground.
3.	Power Stations make electricity. They usually burn coal or oil to work the generating machinery
4.	In towns and cities there are more transformers in substations. These change the electricity down to 11,000 Volts.
5.	The electricity is carried along thick metal cables called power lines. Some of them are carried overhead on pylons
6.	Transformers change the voltage of the electricity up to 400,000 Volts so it can travel long distances

Write the process in the correct order:

First_____

After that_____

Then_____

Finally_____

Draw the flow diagram of the process (different solutions are possible):

Fig. 6. Activity 7.2 Student Worksheet

Activity 7.3 Write to your Prime Minister about Fossil Fuels

In this activity, students apply the knowledge and awareness that they have acquired and undertake action by writing a letter to their local politician or Prime Minister arguing for or against the continued use of fossil fuels. This activity develops students' skill in critical thinking, forming coherent arguments and communicating through the medium of writing. Students think creatively about how to solve climate change while balancing economic, equity and other societal issues. This activity has been developed by St Mark's High School in Warrenpoint, Co. Down, Northern Ireland.

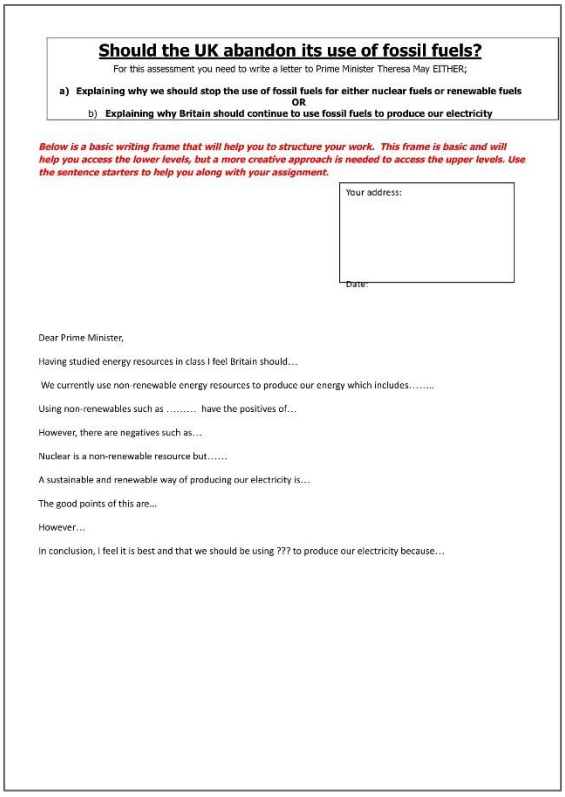
Duration	
• 45-60 minutes	
Energy Literacy Characteristics addressed:	
C1	Grounded understanding of science and how energy is harnessed and used to power human activity
C2	Understands the impact that energy production and consumption have on all spheres of our environment and society
C3	Sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources
C5	Strives to make choices and decisions that reflect these attitudes with respect to energy resource development and energy consumption
Skills & Competencies addressed:	
• Problem Solving • Research • Critical Thinking	• Data Analysis • Collaborating • Communicating
Subject links in National Curricula:	
• Science • Technology & Informatic • Engineering	• Geography • Civics & Politics • English
Level	
• ISCED 2 • ISCED 3	

Suggestions for Use

1. Students are provided with a basic writing frame that will help them to structure your work. This frame is basic and will help you access the lower levels of achievement, but a more creative approach is needed to access the upper levels of achievement. Students can use the sentence starters to help them along with their assignment.

2. Teacher should adopt this framework to suit their region or country.

3. Students should research what they wish to write about and ensure that their arguments are



Should the UK abandon its use of fossil fuels?

For this assessment you need to write a letter to Prime Minister Theresa May EITHER;

a) **Explaining why we should stop the use of fossil fuels for either nuclear fuels or renewable fuels**
OR
b) **Explaining why Britain should continue to use fossil fuels to produce our electricity**

Below is a basic writing frame that will help you to structure your work. This frame is basic and will help you access the lower levels, but a more creative approach is needed to access the upper levels. Use the sentence starters to help you along with your assignment.

Your address:

Date:

Dear Prime Minister,

Having studied energy resources in class I feel Britain should…

We currently use non-renewable energy resources to produce our energy which includes……..

Using non-renewables such as …… have the positives of…

However, there are negatives such as…

Nuclear is a non-renewable resource but……

A sustainable and renewable way of producing our electricity is…

The good points of this are…

However…

In conclusion, I feel it is best and that we should be using ??? to produce our electricity because…

Fig. 7. Activity 7.3 Student Worksheet

Extensions to Activity 6.3

Materials

- Activity 7.3 Student Worksheet

Activity 7.4 Designing a hydroelectric power plant

In this activity, learn about the topic of energy conversion in a hydroelectric power plant; functional principles and properties of hydroelectric power plants; by building a working model of a hydroelectric power plant and using this model to power an electric device (e.g. a light bulb) with it. Students also have the opportunity to research about the implications of hydroelectric power for society and the environment and explore its controversies as a renewable enegry technology. This activity was adapted from the ESTABLISH project which included a consortium of over 60 teachers across European countries. The ESTABLISH Teaching and Learning Units conform to the ESTABLISH definition of Inquiry Based Science Education (IBSE) and link to real world and industrial applications.

Duration	
• 90-120 minutes	
Energy Literacy Characteristics addressed:	
C1	Grounded understanding of science and how energy is harnessed and used to power human activity
C3	Sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources
Skills & Competencies addressed:	
• Problem Solving • Design • Critical Thinking	• Collaborating • Research
Subject links in National Curricula:	
• Science • Engineering	• Technology & Informatics
Level	
• ISCED 2 • ISCED 3	

Suggestions for Use

1. Students may copy design ideas from existing plants and should make a list of needed material. Trial and error methods may be necessary to get everything working. They should then determine the power output of their model.

2. Students should determine possible influences on the power of a hydroelectric power plant and test these out, then present their findings easy to understand.

3. An industry visit at a hydroelectric power plant or expert interview would be beneficial if practical.

   Ask students the following questions to guide discussion:

- How does a hydroelectric power plant work?
- Which types of hydroelectric power plants exist, which are planned?
- How much energy can be generated by your hydroelectric power plant?
- Which values influence the power of a hydroelectric power plant?
- Why are hydroelectric power plants so expensive?
- What do you need for building a hydroelectric power plant? Which materials are useful?
- Is your hydroelectric power plant efficient enough to …?
- What do experts know about building a hydroelectric power plant?
-

Extensions to Activity 6.3

Materials

- Activity 7.4 Teacher Guide

Activity 7.5 Investigating the efficiency of bio-fuels

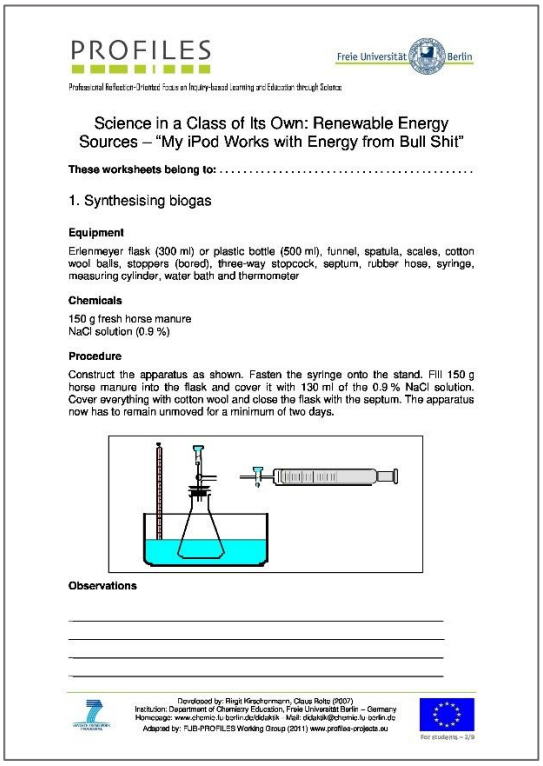
This activity focuses on the question of how biogas is produced and in how far the production of biogas can be used as an alternative to conventional energy production (e.g. fossil fuels). Working together in groups, students have the opportunity to synthesise biogas. Afterwards, they determine the heating value of the biogas and analyse the explosiveness of air-biogas-mixtures. Students compare the results of the heating value determination to the heating values and analysis results of other sources of energy.

Duration	
• 90-120 minutes	
Energy Literacy Characteristics addressed:	
C1	Grounded understanding of science and how energy is harnessed and used to power human activity
C3	Sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources
C4	Cognisant of the impact of personal energy-related decisions and actions on the global community
Skills & Competencies addressed:	
• Research • Critical Thinking	• Collaborating • Communicating
Subject links in National Curricula:	
• Science • Social & Health • Geography	• Civics & Politics • English
Level	
• ISCED 2 • ISCED 3	

Suggestions for use:

1. The worksheets accompanying this series of investigations will help you to carry out
2. the experiments necessary. Please refer to these.
3. You may choose from any of the 4 experiments included in the source material: (1) Synthesising biogas, (2) Determining the Heating Value of Natural Gas and Biogas, (3) Experimental Procedure using Biogas, (4) Analysis of the Above Heating Value Experiments & (5) Explosion Capability of a Methane-Air-Mixture.
4. Ask students to predict and evaluate what they expect to happen. An industry visit at a biogas plant or expert interview is recommended. Discussion Questions:

- How is biogas produced?
- What are the main difficulties in biogas production?
  Which material do you need for building a biogas plant?
- How efficient is your biogas plan



PROFILES

Freie Universität Berlin

Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science

Science in a Class of Its Own: Renewable Energy Sources – "My iPod Works with Energy from Bull Shit"

These worksheets belong to: .....

1. Synthesising biogas

Equipment

Erlenmeyer flask (300 ml) or plastic bottle (500 ml), funnel, spatula, scales, cotton wool balls, stoppers (bored), three-way stopcock, septum, rubber hose, syringe, measuring cylinder, water bath and thermometer

Chemicals

150 g fresh horse manure
NaCl solution (0.9 %)

Procedure

Construct the apparatus as shown. Fasten the syringe onto the stand. Fill 150 g horse manure into the flask and cover it with 130 ml of the 0.9 % NaCl solution. Cover everything with cotton wool and close the flask with the septum. The apparatus now has to remain unmoved for a minimum of two days.

Observations

Developed by: Birgit Kirschhermann, Claus Roitz (2007)
Institution: Department of Chemistry Education, Freie Universität Berlin – Germany
Homepage: www.chemie.fu-berlin.de/didaktik · Mail: didaktik@chemie.fu-berlin.de
Adapted by: FUB-PROFILES Working Group (2011) www.profiles-projects.eu

For students – 2/9

Fig. 8. Activity 7.5 Student Worksheet

Materials

- Activity 7.5 Student Worksheet

Activity 7.6 The Game of Energy Choices (GOEC)

This activity has been developed by the the United States Environmental Protection Agency. Generate: The Game of Energy Choices is an interactive game that allows students to explore energy choices and teaches the considerations and costs in deciding what type of energy generation to build. It examines impacts on the environment, including how different mixes of electricity can affect emissions of carbon dioxide (CO_2) and water use. The game also has the potential to explore different energy contexts specific to geographic regions as well financial and socio-political considerations. The ENERGE Project has been granted permission to promote this activity. Access this activity using the following link: Generate: The Game of Energy Choices | Climate Change Research | US EPA

Duration	
60-90 minutes	
Energy Literacy Characteristics addressed:	
C2	Understands the impact that energy production and consumption have on all spheres of our environment and society
C3	Sensitive to the need for energy conservation and the need to develop alternatives to fossil fuel-based energy resources
C4	Cognisant of the impact of personal energy-related decisions and actions on the global community
C5	Strives to make choices and decisions that reflect these attitudes with respect to energy resource development and energy consumption
Skills & Competencies addressed:	
• Research • Critical Thinking	• Collaborating • Communicating
Subject links in National Curricula:	
• Science • Social & Health • Geography • Home Economics	• Civics & Politics • Health & Society • Business • Economics
Level	
• ISCED 2 • ISCED 3	

Suggestions for use:

The game serves as a dynamic platform for teaching players about the considerations involved in deciding what type of energy generation to build, as well as the costs (financial and otherwise) involved in providing electricity.

1. Instructions for carrying out this activity can be downloaded by visiting the link included in this document and downloading the materials.

Extensions to Activity

Materials

Teachers scan use these links to download the following materials:

- Introduction to Generate -- slide presentations (PDF)(10 pp, 2 MB)
- Generate High School Instructor's Guide (PDF)(13 pp, 351 K)
- Generate Middle School Instructor's Guide (PDF)(16 pp, 433 K)
- Generate Game Board and pieces (PDF)(15 pp, 6 MB)
- Full-size Generate Game Boards (PDF)(5 pp, 31 MB)
- Generate Game Score Card (PDF) (1 pg, 83 K)
- Editable companion Excel file for quickly calculating team scores and showing team rankings for multiple rounds (138 K)