

Energy



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The SUSTAIN network has been created to develop significant connections between Inquiry-Based Science Education (IBSE) and Education for Sustainable Development (ESD) in order to create classroom activities and professional development resources for teachers and teacher educators.

To reach this goal, the network uses and disseminates effective and well tried methods of IBSE, that have been extensively developed throughout Europe in previous activities, especially in the Fibonacci project .

The network is composed of 11 European institutions actively involved in providing continuing professional development (CPD) to teachers and teacher educators in science in 10 European countries.

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Energy

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Introduction

Why address sustainable development through science education?

Climate change, loss of biodiversity, management of natural resources, pollution, are examples of global issues that are key for sustainable development which are related to science and technology and also have important implications for the socio-economical structure of a community. Consequently, they suggest a need for citizens and societies to engage in a deep behavioural change.

Education has a crucial role to play as a prerequisite for promoting change and providing all citizens with key competences needed to participate in the democratic debate. Citizens need better understanding of the scientific ideas that are inherent to these global issues in order to understand their causes and consequences, and the alternative choices that are proposed by governments and also by the corporate world. They also need to look at these issues critically and be aware that in many areas there are several options and choices with different consequences.

This is why new skills, methods and connections are required among pupils and teachers in order to create better links between education for sustainable development, scientific literacy, and active citizenship.

The SUSTAIN network has developed this handbook with the aim of contributing to the development of the understanding of ESD topics in the context of science teaching.

What is Inquiry-Based Science Education?

"Inquiry is a term used both within education and in daily life to refer to seeking knowledge or information by asking questions. It is sometimes equated with research, investigation, or 'search for truth'. Within education, inquiry can take place in several subject domains, such as history, geography, the arts, as well as science, mathematics and technology, when questions are raised, evidence is gathered and possible explanations are considered. In each area different kinds of knowledge and understanding emerge. What distinguishes scientific inquiry is that it leads to knowledge and understanding of the natural and made world around through methods which depend on the collection and use of evidence."¹

¹ From *Inquiry in science education*, Wynne HARLEN, 2013

The process of IBSE begins by trying to make sense of a phenomenon, or answer a question, about why something behaves in a certain way or takes the form it does. Initial exploration reveals features that recall previous ideas leading to a possible explanation or hypothesis to be tried. Working scientifically, students then proceed to see how meaningful the existing idea is by making a prediction based on the hypothesis, because ideas are valid only if they have predictive power.

To test the prediction, new data about the phenomenon or problem are gathered, then analysed and the outcome used as evidence to compare with the predicted result. From these results a tentative conclusion can be drawn about the initial idea. If it gives a good explanation then the existing idea is not only confirmed, but becomes more powerful 'bigger' because it then explains a wider range of phenomena. Even if it does not produce the expected result, and an alternative idea has to be tried, the experience has helped to refine the idea, so knowing that the existing idea does not fit is also useful.

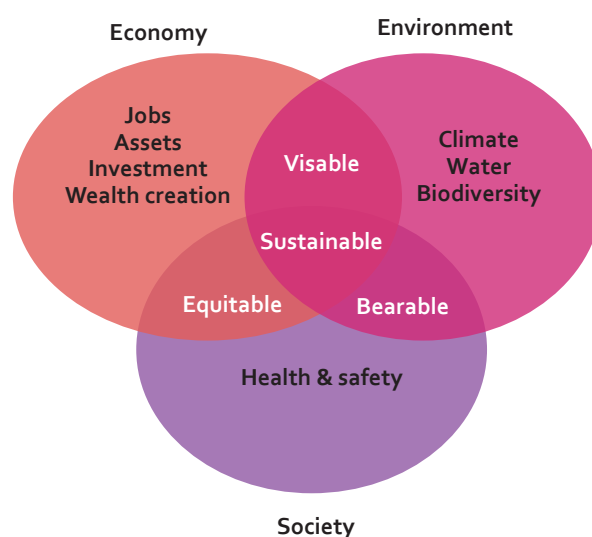
This process of building understanding through collecting evidence to test possible explanations and the ideas behind them in a scientific manner, we describe as learning through scientific inquiry.

What is Education for Sustainable Development?

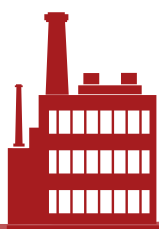
Before defining ESD, it is important to consider what sustainable development is.

Sustainable development is commonly defined as 'development which meets the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development, Brundtland Report, 1987).

It is usually depicted through a model of three-interdependent-pillars environmental, social and economic, as illustrated in the diagram below.



Three pillars of Sustainable Development



Sustainable development is a holistic societal project and as such it cannot be defined and implemented without science; indeed science plays a huge role in all the three pillars (the way we produce goods, the way we use natural resources, the way we care for people's health or how we communicate?). This also forms part of our common culture, and is now often considered a fourth pillar or a cross-cutting dimension of sustainable development. This is why cultural issues are addressed in this book, particularly within the Society pillar.

Because of this strong and crucial connection between science and the global ambition towards sustainable development, it is important to reinforce the links between Education for Sustainable Development and science education.

Education for Sustainable Development is defined by Unesco as "[education which] allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future."

Education for Sustainable Development means including key sustainable development issues into teaching and learning; for example, climate change, disaster risk reduction, biodiversity, poverty reduction, and sustainable consumption. It also requires participatory teaching and learning methods that motivate and empower learners to change their behaviour and take action for sustainable development. Education for Sustainable Development consequently promotes competencies like critical thinking, imagining future scenarios and making decisions in a collaborative way.²

The educational responses to the challenge of sustainable development, however, cannot be reduced to a unique perspective. In fact, as Sterling (2001)³ underlines, three approaches that can be identified:

- **Education about sustainability;** the emphasis is on knowledge related to sustainability. It assumes that sustainability can be easily defined and so it can become a separate subject within school curriculum. This response supports a "conservative learning" and the current educational paradigm remains unquestioned;
- **Education for sustainability;** the emphasis is on "learning for change" (as in the UNESCO's approach). It includes knowledge but goes further to involve values, attitudes, skills and behavior. This response includes a critical and reflective thinking;
- **Education as sustainability;** the emphasis is on the process and on "the quality of learning". It includes all the above responses but emphasizes "learning", seen as "a creative, reflective and participative process". In this perspective, learning is considered "as change" and involves individuals and institutions. The current educational paradigms are put into discussion, supporting a transformative and creative response to sustainability.

Within this global framework, it is clear that ESD, supporting individual's engagement through quality learning, can lead to positive personal and community actions.

On these presuppositions, IBSE can contribute to ESD as they share common values: cooperation, creativity, innovation. It particularly can help building the knowledge, skills and attitudes that support an objective reflection on environmental, social and economic phenomena which goes beyond opinion and anecdote.

Education for Sustainable Development and the place of inquiry: the contribution of SUSTAIN

Despite the fact that the three pillars of sustainable development are interrelated, educational disciplines tend to invest attention in just one of the three, thus perpetuating the compartmentalisation of traditional curriculum subjects.

Yet, ESD encourages more complex and multidimensional approaches. It includes a number of dimensions: scientific, geographical, economic, political, social, cultural.

Combining ESD with IBSE gives explicit attention to developing young people's awareness and ability to approach problems and imagine new scenarios through the active learning processes of conceptualising, planning, acting and reflecting. It provides the space for critical thinking to be combined with the creative act of interpreting images of the future.

This handbook explores the way IBSE can contribute to developing ESD: connecting more teachers and pupils with real life challenges and contemporary science; introducing topical issues related to science and technology, economy, culture, as they are debated in society; applying inquiry skills to issues related to sustainability; connecting schools to the diversity of sustainable development stakeholders within the different communities.

² Unesco website: <http://www.unesco.org/new/en/education/themes/leading-the-international-agenda/education-for-sustainable-development/>

³ Sterling, Stephen. *Sustainable Education – Re-visioning Learning and Change*, Schumacher Briefings, Green Books, Dartington, 2001.





Some examples of the way IBSE can contribute to ESD

ESD is not only about environmental problems, it assumes a cross disciplinary approach encompassing economic, social and cultural factors



IBSE is a method that develops the ability to approach complexity in a scientific way

ESD deals with complex issues, highly interrelated from personal to local to global levels



IBSE provides opportunities to develop deeper scientific conceptual knowledge and understanding about the nature of science that are needed to approach a complex world

ESD is oriented towards change of values, attitudes, behaviour and action patterns



IBSE develops a diversity of skills as well as knowledge; as such it engages children to seek answers and equips them to make informed decisions

ESD involves a wide range of subjects/ stakeholders



IBSE encourages an approach which develops strong links with economists, scientists and local communities

ESD often deals with controversial and debated issues



IBSE can help go beyond debate based on opinion by developing critical thinking and evidence based arguments

Assessment within SUSTAIN

Assessment of students' learning can take many forms and serve many purposes:

- *formative assessment* can be engaged with at any time to provide ongoing feedback and should influence your plans and practices in the classroom;
- *summative assessment* usually happens at the end of a sequence of lessons to determine the impact on student learning and the effectiveness of teaching.

SUSTAIN has a focus on integrating IBSE and ESD approaches, and so assessment needs to consider different types of learning outcomes. IBSE involves not only scientific knowledge, but also the ability to carry out and understand scientific inquiry. Learning outcomes in ESD include critical thinking and changes in attitudes and dispositions. Assessing this range of learning outcomes will involve a range of approaches, such as: looking at written reports about hands on activity, science notebooks, posters or worksheets, listening to students' arguments and explanations, observing how students undertake inquiries and questioning them about their decisions and conclusions.

Below we offer some tools to support you in assessing your students' progress, which you can use within the context of your own National Curriculum. These may also provide a useful basis for evaluating your own planning and teaching by considering whether you have provided adequate opportunities for the different kinds of learning activity. We also recommend more detailed information about assessment in IBSE which was developed by the Fibonacci Project, and which is available at <http://www.fibonacci-project.eu>⁴.

For **IBSE**⁵ these indicators are phrased in terms of student activity and could also be used to evaluate the learning opportunities provided.

⁴ Tools for enhancing inquiry in science education (2012),

⁵ Adapted from: National Research Council (2000). *Inquiry and the National Science Education Standards*:

A Guide for Teaching and Learning. Washington, DC: National Academy Press.



Key elements	Example indicators	Yes	No
Students engage in answering scientifically oriented questions	A starting point is linked to a real situation		
	Students consider what they already know and what they want to find out		
	Productive questions are selected		
	Students make predictions and conjectures		
Students give priority to evidence	Students decide what data to collect		
	Students design the procedure for collecting data, and how to ensure accuracy		
	Students collect data		
Students formulate explanations from evidence	Students analyse data and identify evidence		
	Students formulate conclusions or explanations based on evidence		
	Students answer the inquiry question(s) using this evidence		
Students evaluate their explanations	Students check whether the evidence supports the explanations, and adequately answers inquiry question(s)		
	Students check for any biases or flaws in their reasoning		
	Students check their results with those of their classmates		
	Students consider alternative explanations and link their results to scientific knowledge		
Students communicate and justify explanations	Students share their results and explanations with each other through written, visual or oral reports		
	Students explain why evidence is important, and link this to specific concepts or assumptions		

Key elements	Example indicators	Yes	No
The topic is developed in reference to the dimensions of sustainability	Its environmental implications are identified and analysed		
	Its social implications are identified and analysed		
	Its economic implications are identified and analysed		
	Local and global contexts and past/present/future perspectives are considered		
The topic is developed using an holistic approach	Connections between dimensions of ESD are sought and different disciplines are involved		
	The complexity of relationships between the natural environment and human activity are considered		
	There is awareness of uncertainty and its role in decision making		
The topic is developed using a participative approach	The activities support reflection on our (individual and collective) role as citizens and as consumers of goods and services		
	Different points of view and opinions, and the conflicts which may arise, are taken into account		
	Responsibility towards the environment and the common good is highlighted		
The topic is developed using a transformative approach	The activities stimulate critical reflection on issues		
	The activities promote creativity and pro-active responses		
	Attention is focused not only on knowledge, but also on values, life styles and behaviours		
	Alternatives for change are explored		

For ESD⁶ These indicators are phrased in terms of the design of learning opportunities and give some guidance about areas in which student learning could be assessed.

⁶ Based on: UNESCO World Conference on Education for Sustainable Development (Bonn 2009), Bonn Declaration (http://www.esd-world-conference-2009.org/fileadmin/download/ESD2009_BonnDeclaration.pdf), Sterling, S. (2006) *Educazione Sostenibile*, Anna Mundi Editrice, Cesena, UNECE Strategy for Education for Sustainable Development (2005) (<http://www.unece.org/fileadmin/DAM/env/documents/2005/cep/ac.13.2005.3rev.1.e.pdf>)





Presentation of the set of three handbooks

This handbook dedicated to the issue of Energy is part of a set that includes two other handbooks on the issues of Food and Everyday Objects. Together, these three handbooks form a large ESD oriented science teaching resource that allows teachers to approach sustainable development issues on the basis of children's everyday lives and experiences. Such an approach enriches the teaching content and relevance for the children of big ideas⁷ and key competences of science.

Why those issues?

Food is a normal, but essential commodity in our daily lives. The handbook will enable teachers to examine different foods regarding their composition (nutrition), production (growth), distribution and consumption. In that way, children will not only increase their scientific knowledge and skills, but also their knowledge about the interconnectivity between environment, society and the economy. Since the pupils will also reflect on their attitudes and values, they will be empowered to take action by making informed decisions and if wanted by changing their lifestyle. Energy is essential to all our lives. However, global warming appears to be underway as a consequence of our pursuit to increase energy supply to meet the needs of development and population expansion. Concern about this has given rise to limitations on the use of fossil fuels, improving energy efficiency and the use of renewable energy systems. These initiatives have an important role to play in the debate about and for sustainability; as such understanding the issues involved (using non-renewable and renewable energy; energy usage and conservation) is an important part of scientific literacy for the future. Everyday objects that we almost always take for granted can be a source of stimulating and accessible scientific inquiries for children. The handbook explores how investigating the ways that familiar objects work can provide opportunities to develop both scientific understanding and inquiry skills. But objects also have life stories: investigating how they were made, and what will happen to them after we have finished using them engages children in perspectives beyond their own needs and experiences, considering the environmental, social and economic issues relating to sustainable development, and gives interesting opportunities for crosscurricular activities.

Note

Please note that this handbook has been developed in the context of a European project involving institutions from 10 different countries. As such, there may be no direct links between class activities proposed and the specific curricula applicable in each European country. Thus, the reader may wish to consult official documentation of his/her country for reference and appropriate adaptation.

A few resources

IBSE resources

Harlen W. (Ed.) Principles and big ideas of science education, Association for Science Education, 2010

Developed within the Fibonacci project, a FP7 European project: <http://www.fibonacci-project.eu>

- Artigue M., Dillon J., Harlen W., Léna P. Learning through inquiry, 2013
- Harlen W. Inquiry in science education, 2013
- Borda Carulla S. (Ed.) Tools for enhancing inquiry in science education, 2013

Harlen W. Assessment & Inquiry-Based Science Education: Issues in Policy and Practice, Global Network of Science Academies (IAP) Science Education Programme, 2013

ESD resources

Education for Sustainable Development, Source book, Unesco, 2012, available at: <http://unesdoc.unesco.org/images/0021/002163/216383e.pdf>
<http://unesdoc.unesco.org/images/0021/002163/216383e.pdf>

'Teaching and Learning for a Sustainable Future' - A multimedia teacher education programme of UNESCO, available at: http://www.unesco.org/education/tlsf/mods/theme_gs/modoa.html

Sterling, S. Sustainable Education – Re-visioning Learning and Change, Schumacher Briefings, Green Books, Dartington, 2001

The Energy Booklet

The SUSTAIN Energy handbook is a resource booklet for teachers. It includes a collection of IBSE activities and guidelines to help teachers support children in learning about energy, energy sources and saving energy. Throughout the Energy handbook, principles of IBSE and ESD have been linked, supporting primary school teachers in implementing an exciting and innovative programme for teaching about Energy for Sustainability. In particular the booklet aims to support children in developing their scientific knowledge about energy and energy sources and providing children with opportunities to research, consider and debate a range of economic, social and scientific issues regarding energy sources and energy savings. The Energy handbook is most suitable for children in senior primary classes (8 – 12 years). There are six units in the resource that provide primary teachers with detailed guidelines and inquiries for teaching about Energy. Teacher background information on IBSE, ESD and Energy is also provided in each unit. Figure 1 below provides a summary of what each of the units are.

⁷ Principles and big ideas of science education, Wynne Harlen (Ed.) Association for Science Education, 2010





Overview of units

Units 3, 4, 5 Renewable resources

6 units that are built on the following basis:

- Learning outcomes and skills to be acquired
- Activities related to one, two, or three pillars of ESD
- Each activity is based on IBSE, or inquiry

Unit 1: Why is energy so important?

The aim of this unit is to enable children to learn about the origin of energy, its various forms, conversion, its different sources and how energy can be measured.

Unit 2 Non-renewable resources

Unit 2: Global Energy: What is the problem?

The aim of this unit is to provide children with opportunities to learn about fossil energy and its use throughout the world. Children develop their understanding about the consequences of the widespread use of fossil fuels globally. Their attention is drawn to the importance of protecting the earth's natural resources and the importance of using renewable energy sources is highlighted.

Unit 3: Wind Energy

The aim of this unit is to provide children with opportunities to learn about wind energy through the use of real, unbiased scientific data and real life scenarios. The lessons adopt inquiry based approaches which encourage children to think critically and analyse the environmental, social and economic issues surrounding wind energy.

Unit 4: Solar Energy

The aim of the activities and inquiries in this unit is to help children develop their understanding about the nature, transformation and use of solar energy as a renewable energy source; the conversion of solar energy into other forms of energy (heat and electricity); and how different forms of energy are used in different applications.

Unit 5: Biomass Energy

This unit introduces biomass (in this case wood) as a source of energy and provides children with an opportunity to study an energy source that can be both renewable and non-renewable. Children are provided with opportunities to develop an understanding of the importance of sustainable use of biomass in everyday life.

Unit 6: Where to know?

Children review the advantages and disadvantages of renewable and non-renewable sources of energy. They measure energy consumed in school and at home and take action to reduce the amount of energy used daily.

Overview of Units

	Objectives	Lessons
Unit 1 Why is energy so important to me?	<p>The aim of this unit is to enable children to learn about the origin of energy, its various forms, conversion, its different sources and how energy can be measured.</p> <p>IBSE methodologies are used throughout to help children think critically about energy issues including environmental, social and economic aspects.</p>	<p>Lesson 1: Energy in children's lives</p> <p>Lesson 2: Part 1: Different types of energy Part 2: Used energy turns into another form Part 3: How do we measure energy?</p> <p>Lesson 3: Different sources of energy</p>
Unit 2 Global Energy: What is the problem?	<p>The aim of this unit is to provide children with opportunities to learn about fossil energy and its use throughout the world. Children develop their understanding about the consequences of the widespread use of fossil fuels all over the world. Their attention is drawn to the importance of protecting the earth's natural resources and the importance of using renewable energy sources is highlighted.</p>	<p>Lesson 1: Introducing fossil energy in the world</p> <p>Lesson 2: Fossil fuel power plants</p> <p>Lesson 3: Burning fossil fuels and climate change</p>
Unit 3 Wind Energy	<p>The aim of this unit is to provide children with opportunities to learn about wind energy through the use of unbiased scientific data and real life scenarios. The lessons adopt inquiry based approaches which encourage children to think critically and analyse the environmental, social and economic issues surrounding wind energy.</p>	<p>Lesson 1: What is wind energy?</p> <p>Lesson 2: Design and make a wind turbine</p> <p>Lesson 3: Where is the best location for wind farms</p> <p>Lesson 4: A wind farm in your locality</p>
Unit 4 Solar Energy	<p>In this unit the children engage with inquiry-based lessons that address environmental, social and economic issues concerning solar energy. These activities and inquiries will help the children develop their understanding about:</p> <p>The nature, transformation and use of solar energy as a renewable energy source.</p> <p>The conversion of solar energy into other forms of energy (heat and electricity).</p> <p>How different forms of energy are used in different applications.</p>	<p>Lesson 1: Sun - our source of energy</p> <p>Lesson 2: Conversion of solar energy into heat and electricity</p> <p>Lesson 3: The need for electricity in the home</p>
Unit 5 Biomass Energy	<p>This unit introduces biomass (in this case wood) as a source of energy and provides children with an opportunity to study an energy source that can be both renewable and non-renewable. Children are provided with opportunities to develop an understanding of the importance of sustainable use of biomass in everyday life.</p>	<p>Lesson 1: Biomass as a store of energy</p> <p>Lesson 2: Show that energy is stored in plants</p> <p>Lesson 3: Positive and negative aspects of using Biomass Energy</p>
Unit 6 Where to now?	<p>Children review the advantages and disadvantages of renewable and non-renewable sources of energy. They measure energy consumed in school and at home and take action to reduce the amount of energy used daily.</p>	<p>Lesson 1: The energy debate</p> <p>Lesson 2: Using energy</p> <p>Lesson 3: Energy saving</p>



Unit 1: Why is Energy so important?

Aims

The aim of this unit is to enable children to learn about the origin of energy, its various forms, conversion, its different sources and how energy can be measured. IBSE methodologies are utilised throughout to help children think critically about energy issues including environmental, social and economic aspects.

Overview of unit

Lesson 1: Energy in children's lives

In this introductory lesson children develop their understanding of how energy is all around us and everything that produces an action, such as; movement, heat, and making sounds, requires energy.

Lesson 2:

Part 1: Different types of energy

Children distinguish between different forms and sources of energy. They learn that energy is provided by a source, and takes different forms depending on the use. Children are provided with opportunities to identify different forms of energy in their surroundings.

Part 2: Used energy turns into another form

Through the use of practical activities children learn how energy can be changed from one form to another.

Part 3: How do we measure energy?

Through examination of food labels and analysis of the energy consumption of common electrical appliances, children are provided with opportunities to develop their understanding that energy can be measured.

Lesson 3: Different sources of energy

Children identify sources of energy and classify them as renewable and non-renewable. By engaging in a research activity, children explore some of the advantages and disadvantages of different sources of energy.

Lesson 1: Energy in children's lives

Learning outcomes

Children are encouraged to define energy as the ability to make things happen. They develop an awareness of what energy is, where it comes from and how it can be used.

Resources

Pencil and paper

Skills development

Scientific: Observing; Recording and Communicating; Collaborating; Analysing.

Energy in our school

Finding out children's ideas

Hold a classroom discussion to find out what children know about energy and which appliances use energy.

Questions to promote discussion and reflection

- What is energy?

Teaching Note

When the children compare their answers to this question, it will become apparent that the word 'energy' has a lot of different meanings. For example:

- * Physical strength (lifting weights etc.)
- * Physical concept (something that can exist in different forms and pass from one form to another one)
- * Economical concept (industrial way to "produce" energy in a form that is suitable for human needs)

- What do we use energy for? *Light the classroom, heat the classroom, grow a plant, etc.*
- Can you identify different appliances around the classroom that use energy? *How can you tell they use energy?*
- Where do they get their energy from?
- Where does the energy from the computer come from? *Electricity*
- Where does the heat from our radiators come from? *Oil/gas/electricity*
- Where does the energy from the light come? *Electricity, solar energy.*
- Where do humans get energy from? *Food*
- How many different sources of energy can you name? *Wind, solar, food, gas, oil, wood.*





Carrying out an energy audit in the classroom

In this group activity the children complete a list of appliances in their classroom / school that require energy to work. They could record their findings on a table similar to *Table 1.1*

Table 1.1: Energy audit

Things that use energy in your classroom	Evidence to support that it uses energy	Where does energy come from?
Light bulb	Tube lights up the classroom	Electricity
Radiator	Heats the classroom	Oil / gas

Discussion

After 15 minutes, each group presents their results to the rest of the class.

Questions to promote discussion

- How many different types of energy could you find in the classroom / school? *electrical, oil, gas, muscle, sun, (or electrical, thermal, radiant, mechanical) etc.*
- What kind of energy do you think the light / heater / interactive whiteboard use?
- How do you know these appliances use energy?

Following on from this discussion ask the children to brainstorm in groups what they think energy is. Record the groups' discussions on a worksheet / interactive whiteboard and discuss the similarities between each group's answers. The children should come to the conclusion that *energy allows things to happen*.

Drawing conclusions

What have you learned about energy?

We have seen that the objects do not work without using electricity, or oil, or muscle (thermal, mechanical). All these are examples of "energy". The use of energy is fundamental for the functioning of an object (system). Energy is what is needed as soon as we want something to happen.

Lesson 2 - Part 1: Different types of energy

Learning outcomes

The children develop their understanding about how energy is provided by a source and is then converted into different forms depending on the use. Children are enabled to identify different forms of energy in their environment and provide examples of each.

Skills development

Scientific: Observing; Recording and Communicating; Collaborating; Questioning; Analysing.

Forms of energy in our lives

Teacher Background Information

In the previous lesson children discussed energy as the ability to make things happen. When we talk about energy, we must specify whether we are referring to the source or the form in which it appears. These are two different things: For example, electricity is *not* an energy source but a form, this is because it is produced from sources (solar, wind, burning of fossil fuels). When energy is produced, it can be converted into different forms:

- Sound – from vibrations of sound waves.
- Chemical – fuel, gas, wood, battery, food.
- Radiant – sunshine.
- Electrical energy – electrons moving inside an electrical cord.
- Mechanical energy – run, walk.
- Thermal - Heat

Whole class discussion: Introducing light and electrical forms of light

Present the children with the following scenario: *"It is night time and we are in the forest"*.

Questions to promote discussion

- Can we see in the forest at night time?
- How can we see at night in the forest? *Flashlight / torch, smartphone*
- What form of energy is used? *Light & electrical*
- What could we do to help us to see, if we had no flashlight / torch / phone? *A lighter, candle, match.*
- Do these produce light energy? (yes) How? *They produce fire.*
- So can you name two ways we can produce light energy? *Electricity and fire.*



Whole class discussion: Introducing thermal and chemical forms of energy

Questions to promote discussion

- We just discussed how fire can give light. What else can fire give? *Heat*
- Can you think of something that when you light it gives heat and light? *Candle*
- What happens if you blow out / extinguish a candle? *No more light or heat*
- Where is light energy and heat energy hidden when a candle is extinguished? *Stored as chemical energy in candle*
- What have you learned so far about energy? *We have learned about four forms of energy: electrical, light, thermal, and chemical. But there is also mechanical energy (car moves)*

Activity

In groups ask the children to make a table that shows examples of forms of energy in their everyday lives. They should include two headings on their tables: 'Form of Energy' and 'encountered in' (See *Table 1.2* below)

The children could then construct a concept map based on their tables.

Table 1.2: Forms of energy in our lives

Form of energy	Encountered in
Electrical	Light bulb, computer,
Light/light radiation	Pot plant
Thermal/ heat	Heating soup, melting ice cream
Chemical	Food
Kinetic	Car, bicycle

Lesson 2 - Part 2: Used energy turns into another form

Learning outcomes

The children develop their understanding about how energy can be changed from one form to another.

Resources

Tennis ball.

Skills development

Scientific: Questioning; Observing; Investigating and Experimenting; Analysing; Recording and Communicating.

Transformation of energy

Teaching Note

The following three activities are examples of practical demonstrations that illustrate how one form of energy is converted into another.

Activity A: Teacher demonstration to show transfer of energy

Recap on the fact that energy exists in different forms.

Tennis Ball: Show a tennis ball to the children. Ask them do they think the ball has energy. *When the tennis ball is in your hand it is not showing any evidence of "energy" – movement, sound or heat.*

Drop the tennis ball and ask the children does the tennis ball have energy when it is bouncing. Yes the tennis ball moved and there was a sound when it hit the ground. The ball had stored energy because of its height, this was changed to movement, sound and heat when the ball hit the ground.

Jump off a chair: Ask the children to describe what forms of energy were present when you jumped off the chair. *Energy stored because of your position on the chair is changed to kinetic energy allowing movement. This energy is then absorbed by the ground and converted into heat and sound energy.*

Clap your hands: Kinetic energy in the form of movement is changed to heat and sound energy.

Activity B: Melting an ice cube

Show an ice cube to the children and ask them how they could make the ice cube melt as quickly as possible. *Place in sun, on radiator, over hot water, in their hand.*

Ask them what made the ice cube melt quickly. *Heat.*

Activity C: Cycling a bicycle

In groups ask the children to discuss and record how many different forms of energy they think are present when someone is cycling a bicycle. They could also discuss different energy transformations.



Teaching Note

Draw children's attention to the different forms of energy and energy transformations when cycling a bicycle:
For example:

The human body burns up the chemical energy available in food. The rider, who needs food (chemical):

- moves the bike, changing chemical energy into mechanical energy
- moves the bike, that turns the dynamo, which allows the lamp to function:
chemical → mechanical → Electric → light
- perspires: chemical → mechanical (body movement) → heat

Drawing conclusions

Each group reports back on their group discussions. Children should reach the conclusion that energy is transformed from one form to another depending on the action to be obtained. The transformation is possible for all forms of energy.

Lesson 2 - Part 3: How do we measure energy?

Learning outcomes

Children will develop their understanding that energy can be measured. They will analyse the energy content of food and electrical energy consumption of domestic appliances.

Resources

Food labels; Tables of energy consumption.

Skills development

Scientific: Observing; Analysing; Recording and Communicating; Collaborating.

Measuring energy

Teacher Background Information

Children should now understand that every action requires energy. They should be able to distinguish between the different forms and sources of energy and provide examples of each. This lesson will enable children to understand that energy is measurable.

Set the context

Bring children to a sports hall/ outside. The children carry out a number of activities to demonstrate that some actions require more energy than others. Instruct the children to:

- Walk to the end of the hall/ Run to the end of the hall.
- Kick a ball 5 metres/ Kick a ball 20 metres.
- Lift an empty bucket over a set distance/ Lift a bucket of water over the same distance.

Question the children after each activity.

Questions to promote discussion

- What forms of energy did you use when you were running / kicking the ball / emptying the bucket? *Chemical, mechanical, heat.*
- What source of energy did you use to carry out these activities? *Food.*
- Was the source of energy converted into a different form? Yes How? *Chemical to movement to heat.*
- Which action do you think consumed the most energy? Why?
- Do you think energy can be measured? How? *Children should discover that a measurement unit will enable them to compare the amounts of energy they used for the activities above; so that they could be easily compared.*

Activity: Reading food labels

Provide the children with four food labels/pictures of food labels. Help them to understand that the only unit concerning energy is a unit called "kJ" or "kilojoule". Draw the children's attention to where they will find the kilojoules content per serving and per 100 gram on their labels.

Divide the children into groups and ask them to analyse their labels and complete a table similar to *Table 1.3* below. Each group then presents their findings to the class and concludes that chemical energy in food is measured in kilojoules.

Table 1.3: Reading food labels

Food Item	Kilojoules Per serving	Kilojoules Per 100g.
Medium Banana	378 kJ	378 kJ
1 slice of white bread	375 kJ	950 kJ

Activity: The Energy table

Table 1.4 below illustrates the average number of kilojoules required to undertake a number of tasks.

Ask the children to read and discuss *Table 1.4* below.



Table 1.4: The energy table

Task	Energy required in kilojoules*
Run a marathon (42 km)	7500 kJ (approx)
Travel 100km by bicycle	12000 kJ (approx)
Walking (30 minutes)	200 kJ (approx)
Sweeping the floor (10 minutes)	120 kJ (approx)
Washing the car (20 minutes)	150 kJ (approx)

* Please note these are approximate figures and vary from person to person.

Questions to promote discussion

- Which activity requires the most energy? *Cycling a bicycle.*
- Which activity requires the least energy? *Sweeping the floor.*
- What could you eat before washing the car? *Banana/slice of white bread.*
- How many slices of bread would you need to eat before running a marathon? *20 slices*
- What have you learned about KJ? *The unit kJ allows us to measure the energy and know what consumes the most or the least.*

Activity: Finding the kilowatt hour

Present each group with an electricity bill. Ask the children to see if they can find the unit that is used to measure electricity.

Conclusion: Just as we can measure the energy of food in kilojoules, we can measure electrical energy using a kilowatthour (KWh for short).

Figure 1.1 below illustrates an average usage of electricity guide. Ask the children to read and discuss this figure.

Questions to promote discussion

- How long will 1 kWh give you in the shower? *(10 minutes).*
- How many hours of TV can I get for 1KwH? *(7 – 9 hours).*
- Which is more energy efficient (uses less energy) the washing machine or toaster? *(Washing machine).*
- The unit kWh allows us to measure the consumption of energy which is in electric form.

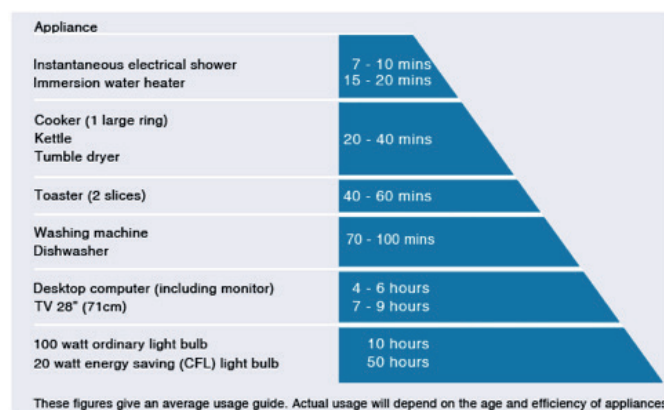


Figure 1.1 : Guide to average usage of electricity
According to the reference <https://www.electricireland.ie/news-media/article/news/2014/05/21/all-you-need-to-know-about-the-nightsaver-meter>

Drawing conclusions

What have you learned about measuring energy?

Energy is measurable. All energy is measured in kilojoules but electrical energy is measured in Kilowatthour. But as kilojoules and kWh are equivalent, human activity or food energy can also be expressed in kWh: For example, 1kWh would allow you to run 1/2 marathon.

Lesson 3: Different sources of energy

Learning outcomes

Children are enabled to classify sources of energy into renewable and non-renewable. Children discuss the advantages and disadvantages of different sources of energy.

Resources

Library, access to internet.

Skills development

Scientific: Observing; Recording and Communicating; Collaborating; Analysing.



Sources of energy

Teacher Background Information

In lesson 2 the children learned about the different forms of energy, in this lesson they will learn about the different sources of energy: renewable and non-renewable. Non-renewable sources of energy or fossil fuels have environmental disadvantages such as causing pollution and climate change and if we continue to use them to the extent we are using them now, we will run out of fossil fuels. There are also advantages to using fossil fuels. For example they are cheaper and more easily accessible to the public. There are advantages and disadvantages to using renewable sources of energy. Disadvantages include cost and dependency on weather. One advantage is they are environmentally friendly. Children should be encouraged to think critically about the advantages and disadvantages of both sources of energy.

Set the context

Refer back to different forms of energy the children learned about

Questions to promote discussion

- What are the different forms of energy? *Heat, light, mechanical.*
- Where do we get our energy from? *We get some energy directly from the sun. However, most of our energy comes from fossil fuels.*
- Do you know what the difference is between a renewable and non-renewable source of energy?
Renewable: Energy from natural sources which are replenished naturally. Non-renewable: Energy which cannot be replaced when it is used.

Raising awareness about renewable and non-renewable energy sources

Activity: Matching energy forms and sources

Make a set of picture cards for the class. Distribute a card to each child. Explain to the children that each card will contain either:

- A picture of an energy source/form.
- Something that uses energy.

Ask the children to move around the classroom and try match their item with a source of energy. For example (Child A) a plant will match to (Child B) the sun. Other examples could include radiator, computer, light bulb, food, oil, coal, wind, sun, etc. Some children will have more than one match for example the radiator could be matched to electricity or oil. Children must discuss this with each other when they make a match. Children present their matches to the class and the game can be repeated. Hold a whole discussion on renewable and non-renewable sources of energy.

Questions to promote discussion: whole class

- How many different sources of renewable energy can you think of? *Solar, wind, hydro, etc.*
- How many different sources of non-renewable energy can you think of? *Coal, wood, peat, etc.*

Activity: Renewable and non-renewable resources

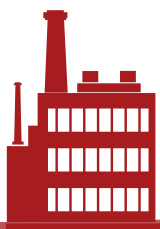
Show the children pictures of a range of renewable and non-renewable sources of energy. Ask the children to sort the pictures into two groups (renewable and non-renewable sources) giving reasons for including a source in a specific group. Ask the children to select one source of energy e.g. wind energy, oil, ocean energy etc. and use the internet to find out two advantages and two disadvantages associated with their chosen energy source. Each group then reports back their findings to the class. Children then create a poster of the advantages and disadvantages of using different energy sources. Children will be given the opportunity to read each other's posters.

Drawing conclusions

- Energy sources can be divided into two categories: renewable and non-renewable.
- Each category has its advantages and disadvantages.

Teaching Note

The advantages and disadvantages of using renewable and non-renewable sources of energy will be revisited in more detail in units 2, 3, 4, 5 and 6.



Unit 2: Global Energy: What is the problem?

Aims

The aim of this unit is to provide children with opportunities to learn about fossil energy and its use throughout the world. Children develop their understanding about the consequences of the widespread use of fossil fuels all over the world. Their attention is drawn to the importance of protecting the earth's natural resources and the importance of using renewable energy sources is highlighted.

Overview of unit

Lesson 1: Introducing fossil energy in the world

In the first lesson the children examine a map of earth by night and discuss the uneven distribution of the earth's energy sources. Their attention is also drawn to the fact that fossil fuels will run out if mankind continues using them at the current rate.

Lesson 2: Fossil fuel power plants

In this, lesson, children discover what is inside an electrical power plant. They learn about how most classical power plants burn fossil fuels that create pollution.

Lesson 3: Burning fossil fuels and climate change

Children are introduced to the concept of climate change. The aim is to provide them with a brief introduction to the close relationship between fossil fuel use, global warming and the negative consequences of climate change and the importance therefore of using renewable energy sources.

Lesson 1: Introducing fossil Energy in the World

Learning outcomes

Children learn how much and where fossil energy sources are being used all over the world. They learn that fossil energy sources will soon be depleted if mankind continues to burn the fuels at the current rate.

Resources

100 bottle caps, 80 of one colour and 20 of another colour.

Skills development

Scientific: Observing; Inferring; Hypothesising; Predicting; Recording and Communicating; Problem Solving; Collaborating.

Mathematical: Applying and Problem Solving; Reasoning; Implementing; Understanding and Recalling.

Teacher Background Information

The human population has almost tripled over the past 50 years – from 2.5 billion to over 7 billion today. An estimated 10 babies are born every 4 seconds. As the population rises, so does the use of natural resources. Furthermore, our limited natural resources are not always evenly and effectively managed. Currently rich Western countries, which account for 20% of the world's population, use 70% of the world's energy resources. This means that developed countries who have enough money to buy the resources, usually receive more of the resource than countries who cannot afford to buy them. This is illustrated by the satellite image of the world at night which depicts the uneven access to electricity and light by the developing countries¹ of Africa, Latin America and Asia. The following activities introduce the children to the uneven distribution of the Earth's natural resources.

Uneven distribution of energy

Set the context

Display and discuss *Figures 2.1* and *2.2* to the children.



Figure 2.1: Satellite photo of the world by night
www.nasa.gov/mission_pages/NPP/news/earth-at-night.html





Figure 2.2: Population density
www.commonswikimedia.org/wiki/File:Countries_by_population_density.svg

Questions to promote discussion

- Examine the satellite photo (Figure 2.1). Has the satellite only taken one photo to make this map? *No. This is a reconstructed photo because of the earth's rotation.*
- What are the white points in the satellite photo? *Lights.*
- How are they placed in the map? *Developing countries of Africa, Latin America and Asia have less "lights" than the other countries on the satellite photo.*
- What can we see on the second map (Figure 2.2)? *Population density.*
- What is the current population of the world? *7 billion.*
- What do you think the impact of continued population growth have on our natural resources? *They will be used up quicker.*
- How do the white points in the satellite image relate to the population density in the second map? *The more densely populated continents do not have the most lights. In fact the lights are very sparsely distributed over the developing continents of Asia, Latin America and Asia.*
- Can you predict what you think will happen within the next 50 years once the developing continents begin developing like Europe and America? *Natural resources will be used up more quickly.*

Distribution of the world's resources

Divide the children into two groups. One group will represent Latin America, Asia and Africa (developing countries). The other will represent, Europe, North America, Australia (developed countries). Divide 100 cubes (bottle caps) between the two groups. These cubes (caps) represent the non-renewable resources left in the world (coal, peat, oil, etc.). Cubes (caps) should be divided into a ratio of 30:70, 30 (caps) cubes to the developing countries and 70 (caps) cubes to the developed countries. This illustrates the current distribution of our natural resources between developing and developed countries. Then ask the children to divide them equally in their groups.



Questions to promote discussion

- How many cubes (caps) did each child receive in the developed countries?
- How many cubes (caps) did each child receive in the developing countries?
- How does this activity relate to the world's distribution of our natural resources?
Currently rich Western Countries which account for 20% of the world's population use 70% of the world's natural resources.
- What do the developing and developed countries do differently that leads to the extreme difference in natural resources use? *More vehicles, industries, etc.*
- What is the even distribution of resources?
- What have you learned about in this activity?
If we take in to account the population, energy resources are unevenly available in countries.

Fossil resources are limited

Set the context

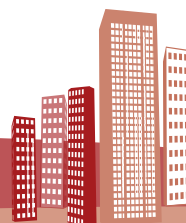
Place 80 red cubes (red bottle caps) and 20 black cubes (other colour of bottle caps) into a bag. Inform the children that the red cubes (bottle caps) represent non-renewable sources of energy. Find out from the children what these sources of energy could be – oil, gas, peat, nuclear, coal. The black cubes (bottle caps) represent renewable forms of energy. Elicit from the children the different forms of renewable energy – wind, solar, hydro. Explain to the children that the bag represents a country in Europe and the cubes (bottle caps) an energy source.

What to do

- Ask a child to take out 10 random cubes (caps). This represents the energy source used in a year. The black cubes (caps) can be put back into the bag as they are renewable. Red cubes (caps) must remain out.
- Ask another child to take out 10 cubes (caps).
- Repeat process until all the red cubes (caps) are gone.

Questions to promote discussion

- Why did we take out the red cubes (bottle caps)?
Non-renewable sources of energy.
- What happened to the number of red cubes (bottle caps) in the bag? *Got smaller and smaller.*
- What happened to the black cubes (bottle caps)? *Number stayed the same as they are renewable sources of energy.*
- How many "years" did it take the non-renewable source of energy to run out? What does this tell us?



- What have you learned about in this activity? *If mankind goes on using such amounts of non-renewable sources of energy, these sources will be depleted.*

Introducing energy resources used for producing electricity

Display Figure 2.3 to the children (available at www.iea.org/publications/freepublications/publication.html)
The pie chart represents how much electricity is produced by different sources in the world.

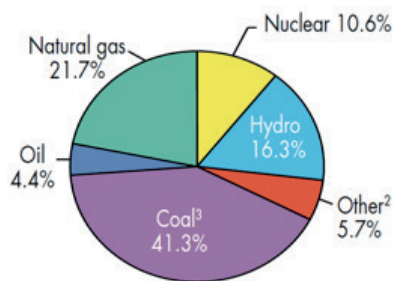




Figure 2.3: Energy resources that produce electricity

Questions to promote discussion

- What source of energy is used most in the world to produce electricity? *Coal.*
- What source of energy is used least? *Other/ Nuclear.*
- Can you name all the sources of renewable energy?
- Can you name all the sources of non-renewable energy?
- By looking at Figure 2.3 what have you learned about how electricity is produced? *Electricity is produced by different sources. Coal, which is a non-renewable source (see above), is the main source of energy used in the world for producing electricity.*

How much energy do we have left?

Display and discuss Figure 2.4, How much energy is left?

	Oil	Coal
Fossils Resources		
Left Quantity Years	51	114

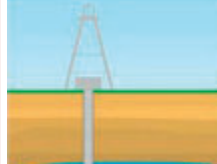

	Gas	Uranium
Fossils Resources		
Left Quantity Years	53	90

Figure 2.4: How much energy is left?

According to the reference: https://fr.wikipedia.org/wiki/Ressources_et_consommation_énergétiques_mondiales

Please note these figures are only an estimate, as new resources may be discovered in the future and/or used, depending on the change of energy cost.

Questions to promote discussion

- Which source of energy do you think will run out first? *Oil*
- What do we use oil for? *Generate electricity/ Fuel for vehicles, etc.*

Drawing conclusions

The energy resources are unevenly allocated and unevenly used between developing and developed countries. It is an unfair use of Earth's natural resources. Moreover, our global consumption of non-renewable sources of energy (oil, coal, gas, uranium) will make them extinct.





Lesson 2: Fossil Fuel Power Plants

Learning outcomes

As electricity is one of the most common forms of energy used every day, and knowing that fossil fuels are widely used all around the world, in this lesson the children learn about fossil fuel electrical power plants. In the first activity they develop their understanding of how a bicycle dynamo works. Using this knowledge the children will then learn about what is inside a power plant. The final activity provides them with the opportunity to consider and discuss some of the negative impacts power plants have on the environment.

Resources

Some suggested materials: electrical wires, crank, belt, dynamo light bulb, LED, plug, photos and drawings of classical power plant: pictures and drawings showing process of different power plants (burning coal, fuel, gas, and using a turbine or an engine to run the generator)

Skills development

Scientific: Exploring; Planning; Making; Problem Solving; Collaborating.

Understanding a dynamo...To the power plant

Set the context

Children will have learned in lesson 1 that a lot of electrical and fossil energy is used in Europe.
The focus in this lesson is on electrical energy.

Teacher Background Information

The electric generators that are used in a power plant work in a similar way to a dynamo on a bicycle, but on a much bigger scale. It is therefore easier for children to initially focus on the bicycle dynamo. When a bicycle wheel rotates, a dynamo clipped to the wheel spins around. This makes a magnet rotate inside a coil. When it is quick enough, this relative movement can produce enough electricity to light a small bulb. The faster the bicycle moves, the greater the induced current and the brighter the light bulb will be. A power plant generator works in a similar manner. However, steam power is used to rotate an engine or a turbine and then make a huge magnet rotate inside a big coil. Most electricity is made in power plants by burning fossil fuels, but there are other ways to produce electricity: producing steam by burning wood or through nuclear energy, or rotating the inner magnet through wind or hydraulic energy.

Teaching Note

The generator in a power plant is quite similar to a bicycle dynamo. In the following activities, children first explore what a dynamo is. They then use this information to develop a basic understanding of how a power plant produces electricity.

Activity: Observing a dynamo

Show the children a bicycle dynamo and help them become aware that it is possible to light a bulb by rotating a wheel, which means: starting from movement.

Activity : Testing a dynamo

Each group is given a dynamo and a light bulb and asked if they can make the bulb light.

Questions to promote investigation.

- How do you think we could link the bulb to the dynamo?
- How do you think the rotating speed of the dynamo will affect the amount of electricity produced?

If possible, take a dynamo apart:

- What are the different parts of a dynamo?
- Can you describe them?

After sharing results and observations, the teacher encourages the children to name the different parts of a dynamo :

- a rotating magnet,
- coils of copper wire,
- terminals of the coils,
- metal blades or pieces.

Drawing conclusions

Discuss with the children what they have learned about dynamos.

The dynamo is a little electricity generator where a current is produced in the coils due to the magnet rotation. In everyday life, for a small lamp, we can use a dynamo to produce electricity. As a dynamo is activated by a person one can say that children's chemical energy is transformed into electrical energy.



Understanding what a power plant is

Set the context

When we switch on lights in the classroom, we connect them with a source of electricity. This source is able to provide electricity to a whole city or more. It is not just a battery similar to the electricity source in a mobile phone, but a big power plant which may be located far from the school.

Discuss the analogy between a dynamo and a powerplant: In the last activity the children saw an electrical circuit between the dynamos to the light bulb. In a similar way, lights in a classroom are connected to a powerplant.

Using pictures (see *Figure 2.5* as an example), let the children analyse the electrical circuit between the classroom and a power plant. Make the connection between

- Dynamo (small size) and power plant (large size). They are called *generators*.
- Electric wires (small) and electric lines plus pylons (large) are for electricity transportation.
- Light bulb (small) and classroom lighting (large): uses of electricity.

Questions to promote discussion

- What is a power plant? *A collection of buildings used to make electricity from a source such as water dam, peat, coal, gas, nuclear power, wind, sun.*
- Have you ever seen a power plant? Where?
- Do you know where the nearest power plant is to the school? *The lesson could also start with a visit of the closest power plant.*
- Are there pylons and high voltage lines in the countryside?

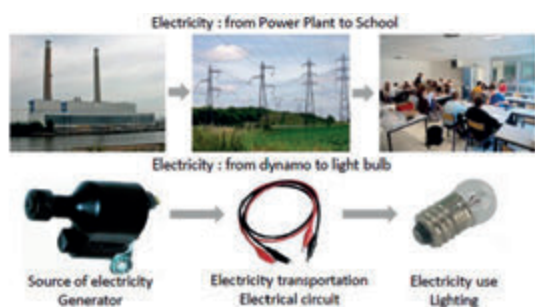


Figure 2.5: Electricity from powerplant to school

Additional activity

Show a map of electrical power plants in the country, or more locally in your area, indicating which source they use (coal, gas oil, wood ...).

What is inside a power plant?

Teacher Background Information

About 75% of all the electricity generated in Europe comes from power plants operated by fossil fuels. These power plants, that use non-renewable sources of energy, are called "classical" in comparison to the more progressive power plants that use renewable energy (wind, solar, wood ...). At this stage, it is important to help children become aware of what is inside a classical power plant. Ideally the class should visit the nearest power plant. Otherwise activity below provides some information.

Activity

Divide the class in groups. Give each group a diagram that displays the inside of a classical power plant (see example in *Figure 2.6* below). Ask the children to try to explain to each other (first in small groups, then in the whole class) what they can see in the diagram and what they understand about what is happening.

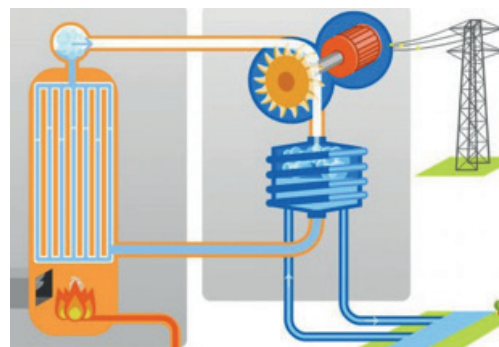


Figure 2.6: A classical power plant etab.ac-poitiers.fr/coll-ta-thouars/spip.php?article1348

Questions to promote discussion

- Where can you find any device similar to the dynamo (a device that produces electricity) in these diagrams? *We can see a turbine that is linked to a generator. This one is similar to the dynamo.*
- What is the incoming source of energy in this power plant? *Fossil fuel (coal, oil, gas) burnt in a boiler.*
- What happens to water? *Its boils and changes to steam.*
- What is steam useful for? *Steam generated by the boiling water is able to rotate the turbine.*
- What have you learned about power plants? *Electrical energy comes from a power plant. All power plants have an electrical generator which is like a big dynamo. In a classical power plant, fuel is burned to boil water and make steam. Steam makes a turbine spin. Spinning turbine rotates the generator which produces electricity.*





Influence of a classical power plant on its surroundings

Teacher Background Information

The aim of this part of the unit is to enable the children to become aware of some of the environmental consequences of classical power plants. In particular this lesson focuses on air pollution and Carbon Dioxide (CO₂) emissions.

Set the context

Elex would like to build a coal power station in your area. The community must decide on whether the power plant should be allowed to be constructed. Discuss the idea with the whole class group.

Questions to promote discussion

- What are the advantages of building a power plant in your area?
- Think about 1) electrical suppliers in the area 2) people who live in the area near the plant 3) people living in the whole area where electricity will be provided. Imagine what their lives would be like if there was no electrical power plant at all?
- What do you think are the disadvantages of building a power plant in your area? *Noise, air and water pollution.*

Debate

Divide the children into groups. Half of the class will support the construction of the coal power plant and the other half will oppose the construction. Each group conducts some research to support their positions. They then develop a poster and make a presentation to the class.

Drawing conclusions

Ask the children what they have learned about burning fossil fuels in classical power plants. By burning fossil fuels like coal, oil or gas, classical thermal power plants produce large amounts of electricity. *This is important for the everyday life of billions of people. However burning fossil fuels also are a cause of pollution.*

Lesson 3: Burning fossil fuel and climate change

Learning outcomes

In this lesson the children learn briefly about the close relationship between fossil fuel use, global warming and the negative consequences of climate change. This lesson then leads into the importance of using renewable energy.

Resources

Newspaper articles related to global warming and its consequences.

Skills development

Scientific: Observing; Estimating and Measuring; Analysing; Recording and Communicating.

Effects of classical power plants on health and environment

Teacher Background Information

The issue of fossil energy and climate change is very complex. For instance, it would need the study of temperature and carbon dioxide (CO₂) concentrations data over long periods of time. This lesson initially focuses on air pollution and CO₂ emissions on the basis that CO₂ is a good representative of all polluting gases produced by burning fuels.

Set the context

The last lesson highlighted that fossil fuel power plants cause pollution. Hold a discussion on the impact air pollution has on health.

Questions to promote discussion

- Why is air so important for us? *We need to breathe air to stay alive. Air contains many gases. One of them, called oxygen, is the most important gas for breathing.*
- What do you think makes the air dirty? *A lot of things which make our lives comfortable such as cars, electricity and heating, create bad gases which make the air dirty. We can smell this when we have to stay in a traffic jam or behind an old truck or when we have to breathe the smoke of a fire.*
- Why is clean air important to us? *If we breathe dirty air, we are more likely to develop health problems and become ill. Air pollutants can cause a variety of health issues including rashes, eye/nose irritation, headaches, fatigue, coughing, sneezing and dizziness. Plants and animals need clean air too.*
- Show the children pictures depicting air pollution (see example in Figure 2.7 below). What can you see in the picture(s)? Is there a problem? *Air pollution may become a nuisance in large cities. The following photograph shows what happened some days in Beijing. It is fog created by pollution (smog).*





Figure 2.7: Air Pollution commons.wikimedia.org/wiki/File:Smog_pegin.JPG

Teaching Note

Air pollution caused by human activity disturbs the Earth's atmosphere. It is harmful to both humans and the environment. The next activity focuses on one gas, carbon dioxide (CO₂), which is one of the components of air. It is one of the gases that are created by burning substances like fossil fuels. Thus large amounts of carbon dioxide are emitted in the atmosphere by classical power plants.

Discovering carbon dioxide

Questions to promote discussion

- Examine figures 2.8 and 2.9 below. Which human activities do you think leads to the most CO₂ emissions? *Electricity and heat production 41%. In Figure 2.8 "heat" refers to the useful residual heat that is generated while producing electricity.*
- Which fuel emits the largest amount of CO₂ in electricity production? *Coal & Gas.*
- What have you learned from Figures 2.8 and 2.9? *Burning fossil fuels to produce electricity is a major cause of air pollution and therefore it is important to reduce the amount of fossil fuels we are burning for electricity production.*

Carbon dioxide emissions from fossil fuel combustion

Carbon dioxide emissions from fossil fuel combustion

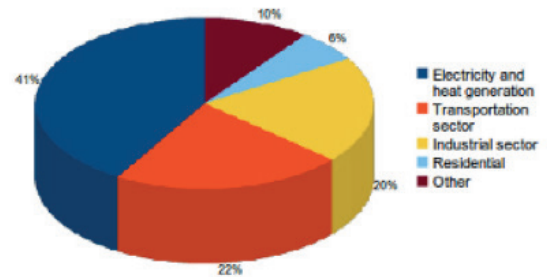


Figure 2.8: Carbon dioxide emissions from fossil fuel consumption. According to the reference <http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources>, coming from 2012 International Energy Agency Report.

Please note figure 2.8 refers to global data for whole world in 2012. Fuel energy used for residential use is divided in 2 parts : one part is included in Electricity and heat generation (about 10 % from 41 %) and the other part is clearly indicated as residential use (6 %)

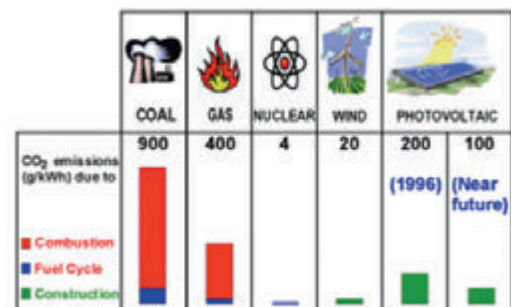


Figure 2.9: CO₂ emissions related to electricity generation

According to the reference <http://www.giss.nasa.gov/meetings/pollution2002/summaryd.html>

Carbon dioxide and global warming

Teacher Background Information

It is very difficult for children to understand what the "average temperature on Earth" could mean. This figure needs a huge amount of data from all around the world to be evaluated. Especially, depending on where the children live, it could seem strange that the average temperature is around 15°C. This could need some explanation, taking into account the seasons and the great temperature difference between poles and equatorial areas.

In the following activity a comparison is made between the rise in temperature that started during the 19th Century and the change in CO₂ concentration during the same period.





Beyond pollution issue: why too much carbon dioxide is a tricky problem

In this lesson children plot charts to help them learn about climate change. Divide the class into two groups, one group plots a chart showing how the average temperature on Earth has changed for the last 100 years and how the change is most likely to continue until the end of 21st Century. The second group plots a chart showing how CO₂ has changed and is likely to continue changing during the same period. The children could use the following website can be used to source information on climate change.

<https://www3.epa.gov/climatechange/kids/basics/past.html>

Drawing conclusions

Display both graphs to the whole class

- What do you notice about the two charts? *Their shapes are very similar.*
- What does this mean? *Temperature rise and concentration rise occurred at the same time and quite at the same rate.*
- When did these rises happen? Why do you think this happened then? What do you think happened in Europe at this time? *Industrial revolution (see above).*
- What have you learned about global warming from looking at these charts? *Increasing CO₂ concentration in the Earth's atmosphere is closely linked to the increase of Earth's average temperature, called "global warming".*

To go further

This is not enough to reach a scientific conclusion. However, according to the work of hundreds of scientists during many years, it is generally accepted that increasing CO₂ concentration is a major cause for the increase in the Earth's temperature. This means therefore that fuel burning plants are contributing to global warming.

The consequences of global warming

Teacher Background Information

It is also difficult to understand why a change of (for instance) 2°C of the Earth's average temperature is so important for climate. In order to illustrate this point, this section deals with a few examples of the negative consequences of climate change. Obviously for some people there are also good consequences, but the aim here is to introduce the children to global warming.

Activity: Documentary research

The media frequently reports on the environmental consequences of global warming. Divide the class into groups and distribute a range of newspaper articles to each group. The newspaper items could include articles relating to:

- ice-fields and glaciers melting,
- sea level elevation,
- farming problems induced by drought or flood,
- Population moving due to lack of water supply or starvation.
- Wave frequency and species migration.

Each group is asked to read the different articles relating to global warming and to make a short presentation to the class about what they have learned. Each group presents information and data. Comparing the presentations, the children become aware of some negative consequences of climate change.

Drawing conclusions

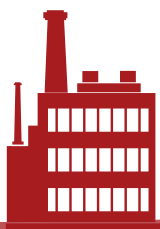
- After reading the articles, what have you learned about some of the consequences of increasing temperatures for people living in different countries? *Some areas get drier, others get wetter. New mosquitoes may invade some countries, like the tiger mosquito in the Mediterranean region.*
- From your reading of the articles how do you think local climates change? *Answers will depend on the local experience: hotter in summer, colder in winter, wetter, drier... On another scale, mention that storms and hurricanes in the tropical regions are reported to get more violent.*
- What have you learned about global warming? *As a result of global warming many negative things are happening in different countries all over the world that are having negative impacts on people, animals and plants.*

Bringing it all together - Conclusion of Unit 2

The children will have learned that for the last few centuries mankind has been using a lot of the Earth's natural resources. Even today most of the energy that is consumed is from non-renewable sources which will run out and never regenerate.

To avoid this and to reduce pollution, caused by burning fossil fuels, every citizen needs to take responsibility for reducing the use of non-renewable energy. This can be achieved either by replacing it with renewable energy or by saving energy.

Units 3, 4 and 5 introduce three renewable sources of energy and unit 6 addresses energy saving.



Unit 3: Wind Energy

Aims

The aim of this unit is to provide children with opportunities to learn about wind energy through the use of real, unbiased scientific data and real life scenarios. The lessons adopt inquiry based approaches which encourage children to think critically and analyse the environmental, social and economic issues surrounding wind energy.

Overview of unit

Lesson 1: What is wind energy?

Using a web quest to guide their learning, the children: research wind as a source of energy; consider how a wind turbine works; examine the locations of wind farms; and, explore advantages and disadvantages of using wind as a source of energy.

Lesson 2: Design and make a wind turbine

Children design and make their own model of a wind turbine using a variety of materials.

Lesson 3: Location of wind farms

Children learn about how information on wind speed and wind direction helps engineers decide where to locate wind turbines. Children make their own anemometers and wind socks and use them to measure wind speed and direction at various locations around the school.

Lesson 4: A wind farm in your locality

A large wind farm developer is interested in building a wind farm in the school's area. The children must research and analyse information and explore factors that support or oppose the development. They then present their findings to the class group.

Lesson 1: What is wind energy?

Learning outcomes

Children develop their knowledge about wind energy by using computers for self-guided research. Children analyse the advantages and disadvantages of using wind as a source of energy. Children demonstrate a sound knowledge and understanding of wind energy through group presentations.

Resources

Access to internet, poster paper, markers.

Skills development

Scientific: Investigating and Experimenting; Analysing; Recording and Communicating.

Web quest

This activity is a web quest. Working in groups the children use the internet to research the answers to a number of questions about wind energy. Children then use their research to develop a presentation on wind energy. The use of photographs, videos, and pictures should be encouraged. Each group gives a short five minute presentation to the class about wind energy.

Sample questions for the children's web quest might include:

- How does wind produce energy?
- How is this energy transformed into electricity?
- How does a wind turbine work?
- Can you draw and label a wind turbine?
- Where are wind turbines usually located?
- Why is wind considered to be a renewable and clean energy source?
- Approximately how much does it cost to build and install a wind turbine?
- Can you list and describe some advantages of using wind energy to produce electricity?
- Can you list and describe some disadvantages of using wind energy to produce electricity?
- What percentage of electricity comes from wind in your country/ Europe?
- What country in Europe produced the most/least energy from wind last year?
- Would you be happy to live near a wind farm? Why/Why not?



Suitable websites

The following are websites that the children could use to gather information:

Video links:

https://www.youtube.com/watch?v=niZ_cvugFts

Webpages:

- <http://www.darvill.clara.net/altenerg/wind.htm>
- <http://www.energyquest.ca.gov/story/chapter16.html>
- http://www.eia.gov/kids/energy.cfm?page=wind_home-basics-k.cfm
- <http://www.childrensuniversity.manchester.ac.uk/interactives/science/energy/renewable/>
- http://www.ewea.org/fileadmin/ewea_documents/documents/publications/reports/purepower.pdf
- http://windpower.org/en/knowledge/wind_with_miller.html

Lesson 2: Design and Make a Wind Turbine

Learning outcomes

Children demonstrate their understanding of wind turbines through planning, designing and making a wind turbine model using a variety of everyday materials. Children evaluate the effectiveness of their wind turbines through investigating what load it can lift.

Resources

Suggestions of materials that could be used: Skewer sticks, plant sticks, string, plastic cups, foam cylinders/polystyrene balls, plastic spools, corks, cardboard, straws, washers, paper plates, rubber stopper, weights, scissors, stapler, weights.

NB: a large fan (or hair dryer) is required to test the wind turbines.

Skills development

Scientific: Observing; Planning; Exploring; Making; Evaluating; Investigating; Problem Solving; Collaborating; Recording and Communicating.

Mathematic: Applying and Problem Solving; Reasoning; Implementing; Understanding and Recalling

Set the context

Elex have chosen (a location of your choice near the school) as a suitable site to build a wind farm. This proposed wind farm will include 19 turbines that are 121 metres tall. Elex are reviewing their wind turbine structures and want you to design an effective wind turbine. Before you present your design to Elex, you must make a prototype. Set the children the following challenge: In groups they must design and make a wind turbine that moves freely in front of a fan and that lifts a weight of at least 10g.

Exploration

Teaching Note

Children explore photographs of different wind turbines. This allows them to examine and critically analyse a range of different wind turbine designs. Children then use this knowledge to plan their wind turbine design.

Distribute photographs of different types of wind turbines to each group and ask the children to carefully observe the images. See sample photographs below. Discuss the images with the children.



Teaching Note

Compare the designs of the different turbines and discuss how you think they work. The main difference in design is that turbines producing electricity need to spin fast and so have fewer, thinner blades. Those that harness wind power to drive machinery, such as water pumps and windmills, need a higher number of larger blades.

Questions to guide observations

- How many turbines have three blades?
- Have you seen any of these wind turbine designs before? Where?
- What angles are the blades at?
- What shapes are the blades of the turbines?
- Which turbine do you think is the most effective at generating electricity? Give a reason to support your answer.



Planning

In groups the children explore the range of materials that are available to them to make their wind turbines (see suggested materials in resource list above).

Using the information they have from the exploring phase above each group draws a detailed diagram of their wind turbine design. Encourage the children to think about some of the following variables before deciding on their final designs:

Wind turbine variable

- Size of blades
- Number of blades
- Thickness of blade
- Shape of blade

Teaching Note

It is important *not* to show the children any turbine designs. It is better to allow the children to create their own designs. *Figure 3.1* is an illustration to help teachers support / guide children as they plan their wind turbine designs.

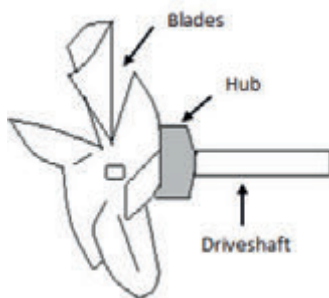


Figure 3.1: Possible design solution

Other designs (teacher information only) can be found on the following website <http://www.stemmom.org/2012/10/building-wind-turbines-engineering-lab.html>

Making

Each group then makes their wind turbines carefully following their designs. As they make their designs each group should be encouraged to test their turbines to ensure that the blades rotate when placed near the large fan/ hair dryer.

NB: Children may find some design faults when testing their turbines, so it is important to afford them time to revise and retest their designs based on their observations.

Evaluating

Each group then presents their design to the whole class group, explain how it works, and makes links as to how their designs model how a wind turbine work.

Questions to promote discussion

- How is your design similar to how a wind turbine works?
- Which wind turbine do you think is the most effective? Why do you think this?
- Why do you think this turbine performed better than other types?
- Did you adhere to your original plan?
- What do you like most about your wind turbine?
- If you were to make another wind turbine is there anything you would do differently?
- If you had to locate your turbine on school grounds where would you put it? How could we test the suitability of a site?

Investigate. Can your wind turbine lift a load of 10 grams?

Children investigate the strength of their turbines. They could do this by attaching a basket (paper cup) with a small weight to the shaft. They then place the turbine in front of the fan and investigate whether their turbine can lift the weight.

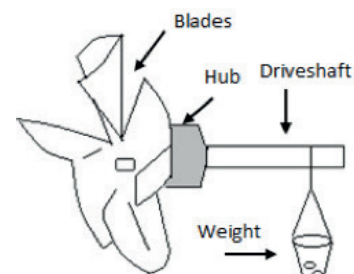


Figure 3.2 presents a possible design solution (teacher use only).

Questions to promote discussion

- Which wind turbine lifted the most weight?
- Why do you think this turbine performed better than other types?
- If you were to revise your turbine what would you do differently? Why?





Extension Activities

Using their turbines the children could brainstorm other inquiry questions that they could investigate. For example:

- Does the length of the blade affect the speed the wind turbine rotates?
- Does the design of the blade affect the speed the wind turbine rotates?
- Does the angle of the blade affect the speed the wind turbine rotates?
- Does the distance from fan affect the speed the wind turbine rotates?

The following headings could guide the children's planning:

Starter Question: What do we want to find out?

Our investigation: What are we going to do?

Resources: What equipment will we need?

Keeping the same/changing: How will we make sure it is a fair test?

Results: How are we going to record and communicate our results?

Our Prediction: What do we think will happen?

Lesson 3: Location of wind farms?

Learning outcomes

Children analyse the advantages and disadvantages of different wind farm locations. Children make an anemometer to measure wind speed and a wind sock to measure wind direction. Children gather data on wind speed and direction and evaluate the most suitable location for a wind turbine near the school.

Resources

Wind Sock: Paper (A4), tissue paper, scissors, string, hole puncher.
Anemometer: Cardboard strips, stapler, plastic cups, pencil with eraser on top, drawing pins.
Map of local area.

Skills development

Scientific: Observing; Predicting; Investigating and Experimenting; Estimating and Measuring; Recording and Communicating; Analysing.

Set the context

Display photographs of different wind farm locations. Children examine and discuss the images.

Questions to promote discussion

- In what kind of locations do you find wind turbines?
- Look at the direction in which the wind turbines are facing. Why do you think they are facing in this direction?
- Do you think a mountain/farmland/sea is a good location for a wind farm? Why/why not?
- How do you think people/buildings might be affected by the installation of wind turbines?
- What impact do you think wind turbines might have on the environment?
- How do you think engineers decide where to locate wind farms? *Wind speed, direction, access to grid, terrain of land, buildings in area.*

Investigation: Where is the best location for a wind turbine?

Set the context

Elex is planning to build a wind farm near your school. The children must investigate where the best location for the wind turbine would be. Children take on the role of engineers and build their own simple anemometers and wind socks to investigate the best location to place a wind turbine. Anemometers and wind socks are important instruments for determining the best locations for wind farms

Display a photo of an anemometer to the children.

Teacher Background Information:

An anemometer is the instrument used to measure wind speeds. It has three to four cups which rotate as the wind blows. The speed is determined by how many times the cup spins round in a given time.

Display a photo of a wind sock to the children.

Teacher Background Information:

A wind sock shows the direction of the wind. The direction of the wind is shown when the wind blows into the larger open end and the sock points in the direction the wind is blowing. If the sock is pointing to the west, then the wind is coming from the east.

Measuring Wind Direction and Speed.

Children work in groups to make a wind sock/anemometer/ both. Children examine photos of wind socks/anemometer and are shown the equipment available to them to make their designs. They then draw a design and make a wind sock/ anemometer.



The following directions could be useful to guide the children.

Wind Sock

1. Roll an A4 sheet of paper and secure.
2. Cut tissue paper in long strips and glue around the bottom inside of the wind sock.
3. Punch two holes in the top of the wind sock.
4. Feed string through the punched holes and tie a knot at the end.
5. Tie the wind sock to the top of a pole.

Anemometer

1. Make a cross with cardboard strips using a stapler.
2. Mark one cup.
3. Staple the cups to the ends of the cross with the mouth facing the bottom of the other cup around the cross.
4. Hold a pencil under the centre of the cardboard cross and push a drawing pin through the cross into the eraser to attach the cross to the pencil.
5. Ensure the cups rotate freely.

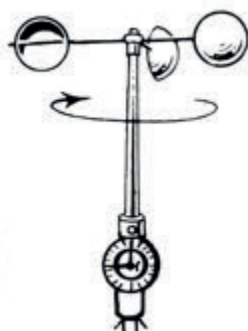


Figure 3.4: Sample anemometer

Location near the school

Children examine a map of the school and surrounding area and select three possible locations in which the wind turbines might be placed. They should discuss why they have chosen these three locations. Using their anemometers and wind socks the children investigate the wind speed and wind direction at each of the three locations. Children count the number of times the anemometer spins round in a minute (rotational rate). They must devise a method of keeping track of the number of spins. For example they may decide to mark one of the cups or use a different coloured cup etc. Children should be encouraged to take three readings at each location and calculate the average rotational rate.

Children then record their data on a table, see *table 3.1* below, present their results on a graph and then analyse which location they think would be most suitable for the wind turbine. Conclude with a whole class discussion comparing each group's results.

Questions to promote discussion

- Which is the windiest/caldest location? How do you know?
- What location do you think would be the most suitable location for a wind turbine? Why?
- What direction do you think the wind turbine should face on this location? Why?
- How do you think a wind turbine in this location might impact on children/parents/teachers?

Table 3.1: Sample table to record results

Location	Trial 1	Trial 2	Trial 3	Average	Wind Direction
Location 1					
Location 2					
Location 3					



Lesson 4: A Wind Farm in your Locality

Learning outcomes

Children engage critically with information on wind farm developments. Children draw on information gathered to support their role when debating a wind farm development from different perspectives in the community.

Resources

Role Cards – (i) Government, (ii) Resident in support of development, (iii) Resident in opposition of development, (iv) Wind farm company, (v) Tourism association and (vi) farmer.

Internet access.

Skills development

Scientific: Applying and Problem Solving; Questioning; Analysing; Recording and Communicating.

Set the context

Elex are interested in building a wind farm in your area. Some of the community support this development while others oppose it. The teacher reads a letter to the children that explains that the local council want to hold a debate to determine whether or not the development should go ahead.

The following is a summary of a letter that could be read to the class:

I am writing to inform you of a proposed new development in your area. Recently, Elex has submitted an application to build a wind farm at (insert local area). The wind farm is to consist of sixty, 120 metre high wind turbines. The total investment required is 6.4 million euro and the proposed site would generate roughly 180 million kWh of energy a year.

Whilst wind turbines are a valuable source of renewable energy, some groups in the community are unhappy about the location of the site being so close to their family homes and local school. This may have a significant impact on the area in question. It is important that all viewpoints are heard. Therefore, the Town Planning Department of (insert your local area) have decided to hold a debate on the subject. During this debate, all interested parties can put forward their views, before a decision is made about whether or not the wind farm development should go ahead. The meeting will take place in (insert classroom location) at (time) on (date).

Questions to promote discussion

- Do you think that a wind turbine in the local area is a good idea? Why/why not?
- Why do you think some people might not be happy about this?

Debate

In groups, the children brainstorm people who might be affected by the decision to build a wind turbine in an area. For example families, farmers, government, wind turbine company, etc. The children are then informed that they are going to participate in a 'community' debate and that they are going to represent different people in the community. Each group is assigned a 'role'. To prepare for the debate each group must discuss their roles; find information to support their argument and work collaboratively to create a poster representing their opinions / findings. They then make a presentation at the 'community meeting'.

Group work

Distribute the role play cards. Samples of different roles can be found in the table below:

The children discuss the information on the cards and then carry out some internet research to find out as much information as they can to support their arguments. They must design a presentation / poster that summarises their arguments. They must also write a persuasive statement that would encourage the community to listen to their points of view.

For the Wind Farm Development

Residents

You are the residents of the proposed Wind Farm. Even though you understand the importance of using renewable energy, you don't understand why it needs to be in your back gardens. You are worried about noise pollution and the impact of the wind farm on the value of your properties.

Elex Energy

You are a representative from Elex Energy, the company that want to build these wind turbines. You are unpopular with groups that are against wind farms, so you need to work hard to persuade them that your plan will benefit the local area in terms of employment, contributing to the local community and providing a "clean" source of energy.

Farmers

You are a farmer who has land to grow crops and graze your cattle. You have been informed that a wind farm may be built on part of your land. You think that using renewable energy is a bad idea and you are worried about the impact of a wind farm on your crops and animals.



Against the Wind Farm Development

Residents

You are the residents of the proposed wind farm. You understand that we cannot continue to burn fossil fuels for energy. The wind farm development will support organisations in the community while providing employment. It will also decrease our reliance on imported energy. You think the wind farm development should go ahead.

Government representative

You are the government representative. As the leaders of the country, you need to think about what will benefit your people, your economy and the environment - not only on a local scale, but also a global scale. Your aim is to showcase your country as one that is leading the way in terms of environmental issues.

Tourism association

You are a member of the tourism association. You think the wind farm development will ruin our beautiful landscape and have a negative effect on tourism.

The following websites could be used by the children to help them gather information on their role in the debate:

- <http://www.iwea.com/environmentalimpacts>
- <http://www.iwea.com/windenergymyths1>
- http://www.seai.ie/Renewables/Wind_Energy/Wind_Farms/Wind_Farms_and_the_Environment/Birds_and_wind_farms/
- <http://www.windawareireland.com/social-issues/>
- http://www.seai.ie/Renewables/Wind_Energy/Wind_Farms/Wind_Farms_and_the_Environment/Wind_farm_noise/

Presentation

Each group then presents their poster to the other community groups. Allow a two minute question and answer session at the end of each presentation.

Drawing conclusions

Questions to promote discussion

- Do you support the wind farm? Why/why not?
- Were the decisions based upon different pieces of information?
- Did everyone in your group agree?
- Did one feature outweigh the other in terms of importance?
- Where did you source your information from?





Unit 4: Solar Energy

Aims

In this unit the children engage with inquiry-based lessons that address environmental, social and economic issues concerning solar energy. These activities and inquiries will help the children develop their understanding about:

- The nature, transformation and use of solar energy as a renewable energy source.
- The conversion of solar energy into other forms of energy (heat and electricity).
- How different forms of energy are used in different applications.

Overview of unit

Lesson 1: Sun - our source of energy

In this introductory part, teachers facilitate a classroom discussion whereby the children discuss solar energy and consider some of the advantages and disadvantages concerning the use of solar energy.

Lesson 2: Conversion of solar energy into heat and electricity

Children develop their understanding about how; solar energy can be transformed into heat and electricity and; how the efficiency of this process can be affected by a number of factors.

Lesson 3: The need for electricity in the home

In this activity the children calculate the cost of the electricity they consume at home on an average day and consider energy savings that could be achieved by investing in solar panels.

Lesson 1: Sun - our source of energy

Learning outcomes

Children develop their understanding about how energy that comes from the sun can be transformed into visible light, heat and electrical energy. They will also learn about the advantages and disadvantages regarding solar energy.

Resources

Web Quest activity sheet, Internet access.

Skills development

Scientific: Questioning; Investigating; Analysing; Collaborating.

Mathematical: Reasoning; Problem solving.

Teacher Background Information

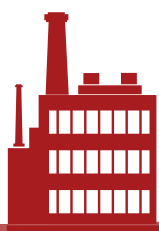
Most of our energy comes from the sun. It is called solar energy. The Earth's surface is permanently subjected to solar radiation which, when concentrated in an appropriate manner, can produce a significant amount of heat or can be transformed into electricity. The Earth gets a small part of this solar energy; the rest is lost in space. Solar energy is used by plants to grow through the process of photosynthesis. Plants are the basis of the food-chain for both animals and humans, being transformed through complex chemical processes into the energy living organisms need to survive. Solar energy is responsible for the production of winds and marine currents, whose energy can be converted into electrical or mechanical energy. Solar energy is renewable, as the sun is an almost endless source of energy. Mankind is continuously looking for new possibilities to collect, store and use it.

Web Quest

Working in groups the children use the internet to research the answers to a number of questions about solar energy. Children then use their research to prepare a presentation on solar energy. The children should be encouraged to include photographs, videos, and pictures in their presentations. Each group then gives a short five minute presentation to the class about what they have learned about solar energy.

Sample questions for the children's Web Quest might include:

- What is the sun? *A planet, a star which gives us energy.*
- What is solar energy? *The sun's rays that reach the earth.*
- Why is the sun useful? *It makes plants grow, warms seas, atmosphere and land. It is responsible for the weather on Earth.*
- How can we use solar energy? *By converting it into other forms of energy: heat and electricity.*



- Can you find examples of solar energy conversion to heat? *Heat water: for swimming pools or used in houses; Heat spaces: greenhouses, buildings.*
- Can you find examples of solar energy conversion to electricity? *Solar cells or Photovoltaic cells: change sunlight into electricity; Power Plants; change sunlight indirectly into electricity: water is heated to produce steam used in a power generator.*
- Can the sun's energy be harmful? *It can burn our skin and deteriorate our vision. That is why we wear sunscreen and sunglasses.*
- Can you identify some advantages and disadvantages of solar energy? (See the table 4.1 below).

Table 4.1: Advantages and disadvantages of solar energy.

Advantages
<ul style="list-style-type: none"> • It is abundant (the sun delivers more energy to Earth in an hour than we use in a year from fossil, nuclear and all renewable sources). • It is virtually an unlimited source of energy. • It is free (as radiant energy). • Different life forms have adapted to use this source of energy. • Using solar energy produces no air or water pollution. • It can be stored
Disadvantages
<ul style="list-style-type: none"> • It is only available during the day time. • It requires some costs in order to be converted into other forms of energy. • The amount of solar energy received at ground level is not constant; it varies between seasons, the geographic location, and the atmospheric conditions. • There is the risk associated with UV radiation, as it is increased by ozone layer depletion. • Photovoltaic units have to be disposed of.

Suitable websites

The following are some websites the children could use to gather information:

- <http://www.childrensuniversity.manchester.ac.uk/interactives/science/energy/renewable/>
- http://www.eia.gov/kids/energy.cfm?page=solar_home-basics-k.cfm

- <http://energyinformative.org/solar-energy-pros-and-cons/>
- <http://www.solarenergy-facts.org/>
- <http://www.energyquest.ca.gov/story/chapter15.html>
- <http://www.energysavingtrust.org.uk/domestic/solar-water-heating>
- <http://environment.nationalgeographic.com/environment/global-warming/solar-power-profile/>
- <http://www.nrel.gov/workingwithus/re-photovoltaics.html>
- <http://energy.gov/eere/energybasics/articles/solar-photovoltaic-technology-basics>

Lesson 2: Conversion of solar energy into heat and electricity

Learning outcomes

Children conduct simple investigations in order to develop their understanding about how:

- Solar energy can be used to heat water.
- The colour of a container holding water can speed up the heating process.
- Using mirrors or lenses can speed up the rise of water temperature.

Resources

Thermometers, glass containers mirrors, lenses, solar cells, connecting wires, multi-metres, desk lamps.

Skills development

Scientific: Formulating Questioning; Observing; Inferring; Hypothesising; Predicting; Investigating; Formulating conclusions based on evidence; Recording and Communicating.

Mathematic: Applying and Problem Solving; Reasoning; Implementing; Understanding and Recalling; Handling Instruments.

Solar energy converted into heat

Planning and carrying out the investigation

Divide the children into groups. Distribute 2 glass containers of equal size and 2 thermometers to each group. The children fill the containers with equal amounts of tap water. They record the temperature of water in each container and place one container in a sunny place and the other in a shaded one. Ask the children to make predictions about what they think will happen to the temperature of the water in each container and why they think this will happen. Then they record the temperature every 10 minutes for an hour and write the results in a table similar to that of Table 4.2 below.



Table 4.2: Recording temperature of water

Time (minutes)	Temperature of water in a sunny place °C	Temperature of water in a shaded place °C
10		
20		
30		
40		
50		
60		

Data from the table can be plotted on a graph (time on X axes and Celsius degrees on Y axes) for final interpretation and conclusion.

Extension

Children could investigate whether the colour of the container affects the temperature of the water (compare a bright colour to a dark one). To do this the children repeat the investigation using different coloured containers. The amount of water should be the same in all cases. Compare the results and observe whether the colour of the container affects the temperature of the water.

Drawing Conclusions

The children present and compare their results with other groups. They discuss what they have learned from their investigation. *How solar energy can be used to heat water and how the colour from which a container is made can speed up the heating process.*

Activity: How can we heat water to a higher temperature

Teacher Background Information

Concave and convex lenses as well as mirrors can be used to "concentrate" solar radiation.

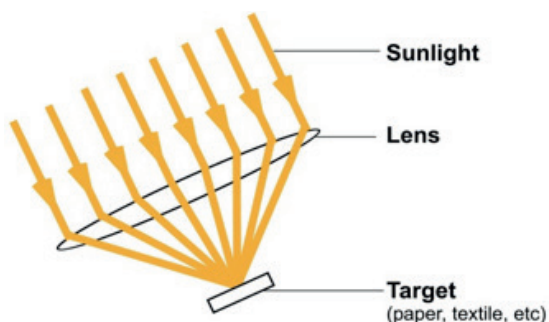


Figure 4.1: Sunlight concentrated through a lens

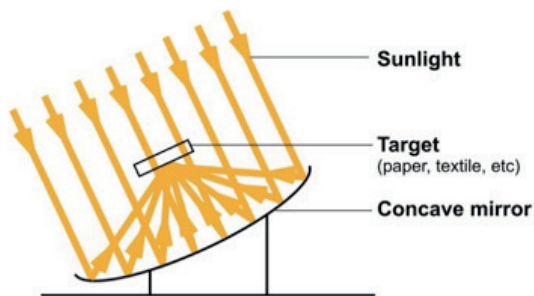


Figure 4.2: Sunlight concentrated through mirror

Teaching Note

In this investigation, the previous investigation is repeated however, this time the heating process of water is enhanced by using lenses or mirrors. Each group is given a glass container and a lens or mirror and they are asked to explore how the sunlight can be directed to the container.

Safety Note

Plastic bottles should not be used in this investigation as they can be damaged by the concentrated light.

Planning and carrying out the investigation

Distribute different lenses and mirrors to the children. Revisit the statements from the previous investigation. The children are asked to consider the following additional statement: *If I used a mirror could I increase the temperature of the water in the container?* In groups children discuss the statement, make predictions, plan and conduct a fair test investigation to gather evidence to support their predictions.

One possible method of carrying out the investigation

The children fill 2 glass containers (330-500ml) with the same amount of water. They record the initial temperature of water in both containers and place them in a sunny location. They leave one container untouched and use a mirror / lens to direct a concentrated light on the second container. They record the temperature of the water in both bottles every 10 minutes for an hour and record the results in a table. The children compare the temperature of the water in both containers. Data from the table can be plotted onto a similar graph that was used for the previous investigation for the final comparisons and discussion.

Drawing conclusions

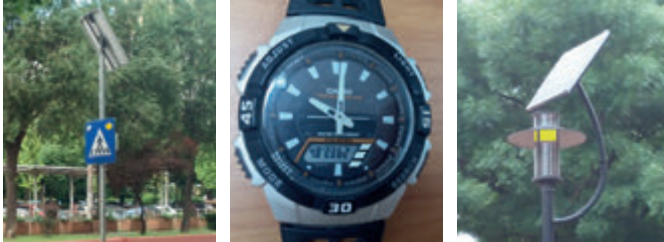
The children discuss what they have learned from their investigation. *Solar energy can be used to heat water. The mirrors will speed up the rise of water temperature. The more mirrors that are used, the faster the heating process will be.*



Solar energy can be converted into electricity

Setting the context

Display the following photographs to the children



Questions to promote discussion

- What do you know about solar cells?
- What source of energy do you think is being used in each of these photos?
- How do you think the sun's energy is converted to electricity? *Photovoltaic cells. Photo means light and volt is a measure of electricity.*
- Do you think a sunny or a cloudy day would affect the amount of electricity made by the cells? Why? How could we find out?
- What else might affect how much electricity the cell produces? *Size of cell, intensity of heat.*
- What time of day would a cell produce the most electricity? *11 am – 3 pm when the sun is at its hottest.*
- What are the benefits of using solar energy to produce electricity? *Free source of energy; does not damage the environment, etc.*
- What are the drawbacks of using solar energy to produce electricity? *Weather is not always suitable to produce enough energy from solar power.*

Following on from the initial discussion the children could watch a video that explains how solar cells convert solar energy into electricity. Here are some recommendations:

- <https://www.nrel.gov/workingwithus/re-photovoltaics.html>
- <http://energy.gov/eere/energybasics/articles/photovoltaic-technology-basics>

Teacher Background Information

Solar cells are also called photovoltaic cells (photo meaning light and volt is a measure of electricity). They can convert up to 25% of solar energy into electricity. The amount of electricity produced depends on several factors: cell size, its conversion efficiency and the intensity of light source. The most common material a solar cell is made from is silicon. Sunlight shines on the cell surface and produces, by a specific mechanism, a flow of electrons inside it: the electric current. It can be conducted by connecting wires to a light bulb or other electric appliances as in the *Figure 4.3*. Cells are grouped in modules and panels in order to increase the amount of current they produce.

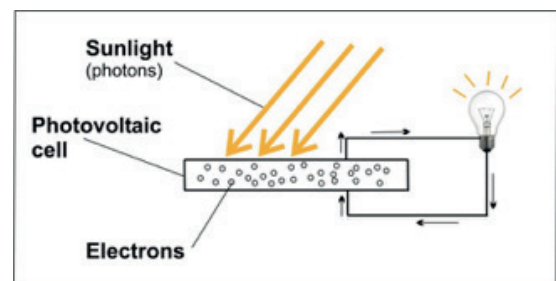


Figure 4.3: The principle of functioning of a photovoltaic (solar) cell

Teaching Note

It will be necessary to show the children how to make the electric circuit before they carry out the following investigations.

Investigation: How does the intensity of sunlight affect the amount of electricity produced by a solar cell?

In groups the children make the circuit as in the *Figure 4.4* below. They point the solar cell towards the sun and using the multi-meter measure, the current and the voltage of the solar cell at different times throughout the day. Approximately 10 measurements should be taken and recorded over the course of the day. For each measurement the children should make a note of how cloudy or clear the sky is. The children should continue to take recordings for at least five days. They could draw a graph for each day representing the readings of the meter (Y axes) and the time (X axes). They should then discuss their observations.



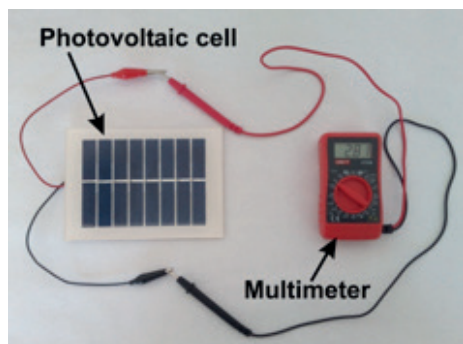


Figure 4.4: The circuit for current and voltage measurements

Investigation: Does the size of the photovoltaic cell affect the amount of electricity produced?

Each group is given three different sized photovoltaic cells. Children are asked to measure each of the cells and then predict which cell they think will generate most electricity. They should be encouraged to give reasons for their predictions. They are then given the resources and asked to plan and carry out a fair test investigation to see which cell produces the most electricity. They record and discuss their findings.

One possible way to do the investigation

The children to set up the circuit as in Figure 4.4. In turn they place the three different cells approximately 20cm from the desk lamp. Using the multi-meter they measure the current and the voltage of each cell. They record their results and analyse their findings (The larger the cell the more electrical energy is produced). The investigation can be done also using a single solar cell and covering one third, half or two-third of its surface at a time.

Additional activities

Other investigations could be carried out by:

1. Varying the angle of a photovoltaic cell relative to the light source.
2. Using a large number of cells coupled both in series and in parallel.

Lesson 3: The need for electricity at home

Learning outcomes

In this activity the children calculate the cost of the electricity they consume at home on an average day and consider energy savings that could be achieved by investing in solar panels.

Resources

Electricity Bills; Information on household electrical appliances

Skills development

Scientific: Applying and Problem Solving; Recording and Communicating.

Mathematic: Applying and Problem Solving; Reasoning; Implementing; Understanding and Recalling

Power used by different household appliances

Each group is given a monthly electricity bill to discuss.

Questions to promote discussion

- How much electrical energy did this family consume on an average day that month?
- Do you know from where was the energy supplied?
- Has anyone got solar panels at home?
What are they used for?

In groups, the children find out the power rating of different household appliances. For example, a refrigerator, a washing machine, a microwave oven, a computer/laptop, etc. This information can be found on the labels of different electrical appliances. They could record their findings on a table similar to Table 4.3 below.

Table 4.3: Power Rating rating of various appliances

Appliance	Power (in watts)	Hours used per day	Daily kWh (see formula below)	Yearly kWh (see formula below)
Television				
Microwave				
Kettle				
Washing machine				
Refrigerator				
Total				



The children then have to calculate how much power would be required per day/ per annum to run each of these appliances.

1. Find the daily energy consumption using the following formula: $(\text{Wattage} \times \text{Hours Used Per Day}) \div 1000 = \text{Daily Kilowatt-hour (kWh) consumption}$.
2. Find the annual energy consumption using the following formula: $\text{Daily kWh consumption} \times \text{number of days used per year} = \text{annual energy consumption}$.
3. Find the annual cost to run the appliance using the following formula: $\text{Annual energy consumption} \times \text{utility rate per kWh (This can be found on the electricity bill)} = \text{annual cost to run appliance}$.

Example:

Following the steps above, find the annual cost of operating a microwave oven.

1. *Estimate of time used: The microwave oven is used several times per day, for about 2 total hours.*
2. *Wattage: The wattage is on the label and is listed at 1450 W.*
3. *Daily energy consumption: $(1,450 \text{ W} \times 2) \div 1,000 = 2.9 \text{ kWh}$.*
4. *Annual energy consumption: The microwave oven is used almost every day of the year. $2.9 \text{ kWh} \times 365 = 1,058.5 \text{ kWh}$.*

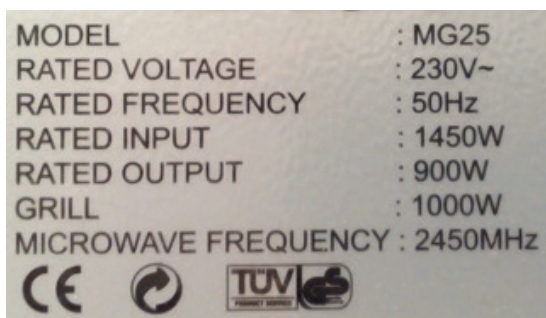


Figure 4.5: Label of a microwave

Drawing conclusions

- Look at the electricity bill again. On average how much does this family spend on electricity a year?
- If the installation cost of solar panels was €6,000 for your average 4 person home, how long do you think it would take to pay off the installation fee based on your yearly energy savings?
For example if a family spends €1,000 a year on electricity, it would take them (6000 divided by 1000) 6 years to pay back the installation fees).
- What else would you have to consider if you were considering installing solar panels on your house?
The availability of sun in your country; location of the solar panels; maintenance fees.





Unit 5: Biomass Energy

Aims

This unit introduces biomass (in this case wood) as a source of energy and provides children with an opportunity to study an energy source that can be both renewable and non-renewable. Children are provided with opportunities to develop an understanding of the importance of the sustainable use of biomass in everyday life.

Overview of unit

Lesson 1: Biomass as a store of energy

Children are introduced to the concept of biomass as a source of energy and its use. They are also presented with the advantages and disadvantages of using biomass as a source of energy.

Lesson 2: Show that energy is stored in plants

Children monitor and measure plant growth. They calculate the biomass and burn it to estimate how much heat energy is released.

Lesson 3: Positive and negative aspects of using Biomass Energy

Children examine the use of biomass as an energy source from different perspectives in the community. They use convincing techniques to present clear arguments. Children evaluate the different viewpoints and examine the advantages and disadvantages of using biomass as a source of energy.

Lesson 1: Biomass as a store of energy

Learning outcomes

Children learn about: biomass as a store of energy; how it is used; and, the advantages and disadvantages of using biomass. Children examine the process used to convert biomass into bio energy.

Resources

Computer, internet access, poster paper, markers.

Skills development

Scientific: Researching; Investigating; Analysing; Recording and Communicating.

Teacher Background Information

Biomass is the organic material derived from living or recently living plants and animals, fungi and microorganisms. It contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis. This energy is passed to animals and people after the plants are consumed. On the other hand, fossil fuels are derived from organisms that have been dead for a long time. Biomass is a very good energy source. The chemical energy in biomass is released as heat when it is burned. It can also be used for generating electricity and transporting fuels. Increasing the use of biomass as an energy source in Europe can help diversify Europe's energy supply, create economic growth and jobs, and lower greenhouse gas emissions. In 2012, biomass and waste accounted for about two-thirds of all renewable energy consumption in Europe.

Web quest

Working in groups children use the internet to research the answers to a number of questions about biomass energy. Children use information gathered to create a poster presentation/digital presentation on biomass energy. The children should be encouraged to use photographs, videos and pictures in their presentations. Each group gives a short five minute presentation to the class on what they have found out about biomass energy.

Sample questions for the children's web quest might include:

- What is biomass? *Biological material derived from living, or recently living organisms.*
- Name some biomass fuels. *Wood, crops and landfill gas.*
- What are the similarities and differences between plants and trees? *Structure, life span.*
- How was wood used as a source of energy in the past? *Cooking and heating.*



- How many families use wood as a source of energy for heating?
Varies between countries and regions within countries.
- Name two types of trees/plants that are suitable for the production of biomass energy. Why are they suitable? Is all wood the same? What are the properties of these trees/plants? *Fast growing trees (conifer) wood used as fuel for burning / plants (sunflower/rapeseed) produce oil that can be used as biofuels.*
- Why is biomass considered to be a renewable source of energy?
New plants can always be grown using sunlight and water in a short time period.
- When might biomass be considered a non-renewable source of energy? *Trees/plants cut down and not replaced.*
- How is biomass converted to energy? *Burned to create heat or processed to create biofuel.*
- Where does this energy come from? *Sun.*
- What are the advantages/ disadvantages of using biomass energy?
Abundant and renewable / expensive and inefficient compared to fossil fuels.
- How do biomass fuels benefit the environment? *Reduce dependency on fossil fuel.*

Some suggested websites

The following are some website that the children could use to gather information for their web quests:

- <http://www.energykids.eu/res-biomass>
- <http://www.energykids.eu/res-biomass>
- <http://photosynthesiseducation.com/photosynthesis-for-kids/> <http://www.kids.esdb.bg/biomass.html>
- <http://www.eschooltoday.com/energy/renewable-energy/biomass-energy.html> http://www.eia.gov/kids/energy.cfm?page=biomass_home-basics-k.cfm

Drawing conclusions

After the children have completed the presentations the following questions could be used to promote a whole class discussion on biomass energy.

Questions to promote discussion

- Why do you think biomass is an important energy source?
Renewable and reduced dependency on fossil fuel.

- Do you think the information that you read on the website was balanced? Why? Why not?
Websites should provide information on advantages and disadvantages of using biomass as energy source.
- Do you think biomass could be considered to be a non-renewable source? In what circumstances?
E.g. no recycling of forests – no planting of new trees when forests are harvested.
- What do you think are the advantages/disadvantages of using biomass energy?
Abundant and renewable / expensive and inefficient compared to fossil fuels.
- What have you learned about biomass energy? *Biomass can be both a renewable and non-renewable source of energy. Biomass fuels include wood, wood waste, straw, manure, etc. There are many advantages and disadvantages of using biomass energy.*
- What else would you like to find out about biomass energy?

Lesson 2: Show that energy is stored in plants

Learning outcomes

Children develop their understanding of biomass energy that is stored in plants. They measure the plant growth, calculate the biomass, and measure the heat released from burning biomass.

Resources

Ruler, wool, notebook, thermometer; calorimeter, books, cans, precise balance (without plastic layer inside)

Skills development

Scientific: Observing; Measuring; Investigating and Experimenting; Analysing; Recording and Communicating

Activity: Observing and measuring the growth and development of a plant

Teaching Note

This activity should be conducted over several weeks.

Teacher Background Information

The dry mass of an organism is called its biomass. Up to 70% of a plants weight can be water, so to measure the biomass of the plant the water in it needs to be removed i.e. dry weight measured. Fast growing species are favourable for observation; knotweed, being an invasive species is suitable for this investigation. Other suitable plants for this investigation could include: wheat, corn or oats.



Activity: Observing Knotweed

Question: How much does a Knotweed (*Falopia japonica*) plant grow in one, two, three and four weeks?

In groups the children select several Knotweed or other plants (wheat, oats, corn) and mark the area around their chosen plants (for example with wool threads of different colours or lengths). The children then measure the height of the stems. Children observe and record the changes every week in a table, see sample *Table 5.1* below. They can measure the height of the plants, count the number of leaves that have grown and / or record the colour of the leaves and stems. The height of the plants over the four weeks should be presented on a graph, see sample graph (*Figure 5.1*) below.

Teaching Note

Differences in the speed of growth between the measured plants can be expected. The teacher can explain that many environmental factors influence the growth of plants, such as light intensity (also shading), nutrients, temperature, precipitation, herbivores, etc.

Drawing conclusions

After 3 / 4 weeks discuss with the children what they have learned about knotweed (or other plant) as a source of biomass energy.

Questions to promote discussion

- Which plant is the fastest growing plant? How do you know? *Grows faster than the other two plants.*
- What do you think makes a plant grow quickly? *Sunlight, water.*
- Why do you think a plant will grow quicker in the sun / shade?
- What did you learn from observing growing plants? *Knotweed, being a fast growing plant, is a good source of biomass energy. Plants grow at different rates depending on sunlight, nutrients, precipitation, etc. Children should use the results to analyse the conditions required for optimum plant growth.*

Table 5.1: Height of the selected knotweed plants.

Knotweed plant height	Week 1	Week 2	Week 3	Week 4
Plant 1				
Plant 2				
Plant 3				

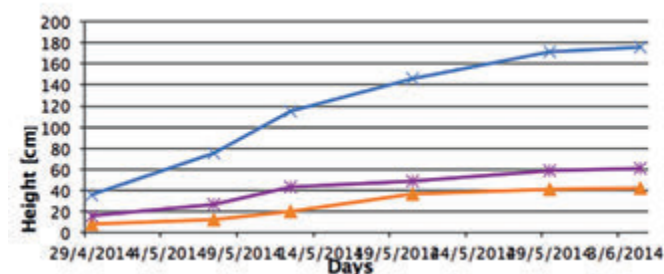


Figure 5.1. An example of a Knotweed plant's growth in Slovenia.

Activity: Measuring plant biomass

Teaching Note

At the end of their observations in the first activity the children carefully excavate one whole plant (roots included) from the soil and clean all the dirt off. They should cut the plant into smaller pieces and weigh the plant. They can do this in two ways:

Option A

Cut and weigh a small piece of the plant (3-5 cm of a stem). A precise balance is required. The teacher then places the piece of the plant in an oven for 12 hours (at 100 °C). After the piece is taken out of the oven and cooled off, the children measure the weight of the piece of plant and compare it to its weight before it was dried out. From this data the biomass of the whole plant can be calculated. ($\% \text{ of biomass} = \frac{\text{final weight}}{\text{initial weight}} \times 100$).

Option B (without the use of the oven)

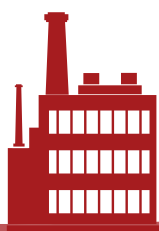
Place the plant in the sun to dry for 2-3 days. Weigh before and after drying. From this data the biomass of the whole plant can be calculated. $\% \text{ of biomass} = \frac{\text{final weight}}{\text{initial weight}} \times 100$.

Drawing conclusions

Discuss the two activities with the children

Questions to guide discussion.

- What have you learned about biomass? *The weight of a plant is called biomass. Plant biomass is measured in terms of dried organic mass. This is usually about 30% of the original weight of the plant.*
- Why it is necessary to dry the plant before measuring the biomass? *Plant biomass should be measured in terms of the dried matter, so only 30% (approximately) of the actual mass might count, the rest being water.*



- Where do you think the plant gets its water from?
From soil through the roots.
- Do you think different species of plants would have the same percentage of water in them? Why?
Environment factors – climate, sunlight, water etc.

Activity: Measuring the heat released by burning a plant

Teaching Note

In a previous activity the growth of Knotweed plants was measured. When plants are growing they gain extra mass – biomass - which contains stored energy from the sun. In this activity the children make a calorimeter that can measure energy stored in a biomass of a Knotweed plant. Calorimetry, derived from the Latin calor meaning heat, and the Greek metry meaning to measure, is the science of measuring the amount of heat.

Safety Note

This activity can be undertaken as a teacher demonstration or a student activity. Before starting this experiment, it is important that the teacher / children know exactly what procedures to follow to make the calorimetre. Only a small amount of biomass (e.g. 3 grams) should be burned. Protective equipment (gloves, safety glasses and lab coats) should be worn when burning the biomass. This activity should only be done outside in an open area that is not exposed to strong winds.

Materials

- Big can without plastic layer inside (*Figure 5.2, A*)
- Small can without plastic layer inside (*Figure 5.2, B*)
- Nail (*Figure 5.2, C*)
- Small can without plastic layer inside for burning material (*Figure 5.2, D*)
- Candle (*Figure 5.2, E*)
- Thermometer
- Cold water
- Biomass (3 grams)



Figure 5.2: Materials to make the calorimeter.

Procedure

1. To make calorimeter select two aluminium cans without a plastic layer inside (*Figure 5.3, A, B*). The two cans should fit inside one another. The smaller can needs to be placed sufficiently higher so that the dried piece of the plant can be placed beneath it.
2. Make two holes in the small can (this should be done by an adult (teacher); use a small hammer or a stone to punch holes in a can with a nail) and put a nail through the holes to place the small can inside the big can (*Figure 5.3 (a)*). The smaller can will hold the water to be heated by burning the dried plant.
3. Pour 100 ml of water into the small can.
4. To burn the dried plant use the smallest can (*Figure 5.2 (D)*) where you can place the burning material safely. We recommend that you use a candle (*Figure 5.2, (E)*) to burn the dried plant.
5. Place a big can (with the small can with water inside) (*Figure 5.2 (A, B)*) over the smallest can (*Figure 5.2 (D)*) with burning plant material inside (*Figure 5.3 (B)*). Let the biomass burn till the fire extinguishes / the material is burned.
6. Measure the temperature of the water before and after the burning is completed and calculate the change in temperature. (*Figure 5.4*).
7. Record your results and calculate the heat captured. See example below.



Figure 5.3 A: Assembling the calorimetre.



Figure 5.3 B: Assembling the calorimetre.



Figure 5.4: Measuring water temperature in the calorimetre.





Activity: How to calculate how much energy is stored in a biomass of knotweed.

Teaching Note

This activity is used for determining the heat released by burning fuels (in our case biomass). The heat from burning the biomass heats up the water. The thermometer records the temperature rise of water. From the rise in water temperature you can calculate how much heat was released by burning biomass. Measure the temperature of the water before the start and after the end of burning the biomass. Subtracting one from the other gives the temperature change.

Example calculation

Water temperature before heating: 23 °C and after heating = 36 °C: Water temperature change = 13 °C. Volume of water heated in a can: $V_{\text{water}} = 100 \text{ ml} \Rightarrow m = 100 \text{ g}$. Considering that 4200 J of heat is needed to warm 1 kg water for 1 °C (specific heat of water is 4200 J/kgK), 420 J is needed to heat 100 g of water for 1 °C. We calculate the heat captured by the water during burning biomass as 420 J multiplied by the number of degrees the temperature of 100 g of water in the calorimeter has changed: $Q \text{ (heat captured)} = 420 \text{ J} \times \text{temperature change in } ^\circ\text{C} = 420 \text{ J} \times 13 = 5460 \text{ J} - 5500 \text{ J}$. Approximately 5500 Joules of heat was captured in water while burning.

Teaching Note

The amount of heat captured in water is far smaller than heat actually released while burning. Open fire efficiency is around 20%. Because of the poor accuracy of method all results should be rounded. Pupils can notice that the air around the cans is also hot (they can feel the heat while measuring temperature) – meaning that a lot of heat is lost (not collected in the water).

If calculation of exact amount of heat captured is too demanding for children, just notice that water is warmer at the end of burning the biomass and connect this with energy from the flame / energy stored in the plants.

Questions to promote discussion

- Did the temperature of the water in the can change? By how much? Where did the necessary heat for the change come from?
- How much energy is stored in a biomass of one whole knotweed plant (and can be released as heat)? In a square meter of plants?
- Where did the energy in biomass come from?
- What other plants do people use as fuel in fireplaces?

Concluding Discussion

- Where did biomass energy come from? *From the Sun and stored in wood.*
- How do we use energy from biomass in our households? *(Note for teachers: make sure they think also about the food they eat) Cooking, heating and chemicals from food.*
- Can you think of any problems with burning biomass like this? *Pollution; Loss of energy – only approximately 20% of energy is transferred.*
- What have you learned from these activities? *A calorimeter can be used to measure how much energy, stored in the biomass of a plant, is released as heat. Results show that burning biomass is not an efficient way of using energy. The amount of heat captured in the water is far less than the heat released while burning. Burning biomass also produces carbon dioxide which contributes to global warming.*

Lesson 3: Positive and negative aspects of using Biomass Energy

Learning outcomes

Children explore the issues around using biomass as an energy resource and research the advantages and disadvantages of using biomass as a source of energy. They debate different perspectives in a community context about using biomass as an energy source.

Resources

Cards with different perspectives, access to internet / library

Skills development

Scientific: Questioning; Researching; Analysing; Recording and Communicating; Collaborating.

Set the context

Your community wants to assess the advantages and disadvantages of using Biomass as a source of energy. Divide the children into six groups. Each group will represent a different stakeholder in the community. Distribute the below role cards to each group. The children read the role cards and discuss. Allow the children time to research the perspective provided on their cards. This can be done through the use of the internet or a visit to the library. They must prepare a 5 minute presentation explaining their perspective. Children will be invited to ask questions after each presentation.



The following are sample perspectives that could be used to guide the children's research:

Wood Furniture Manufacturer

You own an outdoor wood manufacturing company located in the town. Your company has been using local wood to make wooden furniture for the past 50 years. Your business is experiencing financial difficulties recently. You are worried that using wood for energy will make it more difficult for you to buy wood to manufacture furniture. If there is more of a demand for wood, wood prices could rise. Any additional money you spend on wood affects your profits. In addition your business benefits the local community by providing jobs and income to the area.

Forest Land Owner

You own 500 acres of forested land just outside your town. However the market for wooden products has slowed down in recent years. Using wood for energy is very appealing because it creates a new market for your wood.

Fossil Fuel Advocate

You are promoting the fossil fuel industry. Oil, gas and coal are clean, plentiful and inexpensive. Fossil fuels are readily available and power stations to use these fuels are already in place. Renewable energy resources will only make a minor contribution to our energy needs. You think it is necessary to continue to improve the technologies used to generate electricity from coal and natural gas to reduce the amount of emissions they produce. This would continue to support jobs in the locality. In addition there are concerns that our local forests will be destroyed as a result of the supply needed for wood energy.

Renewable Energy Provider

You strongly believe your community need to make responsible energy decisions. Clean, renewable sources of energy are required to protect our environment for future generations. Using wood as a renewable source of energy is a feasible option for your community. An adequate supply of wood is available locally. While burning wood as a fuel does release some carbon dioxide, this is merely the carbon that was absorbed from the atmosphere by the growing tree. If wood used in a power station comes from properly managed forests, then the carbon that comes out of the chimney can be cancelled by the carbon that is captured and stored in newly planted trees. Wood can therefore be "carbon-neutral". Wood energy is also far more reliable than the sun and the wind.

Employment Officer

You are responsible for ensuring that any changes to the community will be positive and sustainable in terms of employment. You need to consider the additional jobs that will be created from the construction of a new energy facility. If your community wants to consider using wood for energy, they need to analyse the jobs produced.

Wood Energy Advocate

Wood is considered humankind's very first source of energy. Today it still is the most important single source of renewable energy providing over 9% of the world's energy supply. Wood energy is as important as all other renewable energy sources put together. Wood fuel is increasingly price competitive with fossil fuel alternatives. The environmental benefits of wood fuel are now being recognised and valued. The production and use of wood fuel provides additional employment, especially in rural areas.

The following websites could be used by the children to help them gather information on their role in the debate:

- <http://www.kids.esdb.bg/biomass.html>
- <http://www.alliantenergykids.com/EnergyandTheEnvironment/RenewableEnergy/022398>
- <http://www.eschooltoday.com/energy/renewable-energy/biomass-energy.html>
- <http://www.funkidslive.com/learn/energy-sources/biomass-energy-source-fact-file-2/>
- <http://climatekids.nasa.gov/fossil-fuels-coal/>
- <http://kids.britannica.com/elementary/article-399465/fossil-fuel>

Teachers Background Information

Advantages of using natural and synthesised gas

- A properly operating wood gas generator produces less air pollution than a gasoline or diesel powered motor.
- Wood gasification is also considerably cleaner than wood burning: emissions are comparable to those of burning natural gas.
- Vehicles can use synth gas. These vehicles have less emissions than those using gasoline or diesel (20 ppm HC, 0,2% CO).
- Gas generators can be used to produce electricity or for heating water for central heating.



Teachers Background Information

Disadvantages of using natural and synthesised gas

- If we were to convert every vehicle, or even just a significant number, to wood gas, all the trees in the world would be gone and we would die of hunger because all agricultural land would be used for energy crops. Indeed, the wood-mobile caused severe deforestation in France during the World War II.
- Producing bio-fuel from plants can be problematic. Some fast growing trees e.g. willow and eucalyptus emit isoprene during growth. Isoprene produces dangerous ozone in combination with other pollutants and sun light.
- Wood-mobiles are user-unfriendly compared to traditional cars. At least 15 min is needed to prepare the gas before starting the engine (heating the generator...).

Drawing conclusions

After the debate encourage a whole class discussion on Biomass as a source of energy.

Questions to promote discussion

- Do you support the development? Why/why not?
- Were the decisions based upon different pieces of information?
- Did everyone in your group agree?
- Did one feature outweigh the other in terms of importance?
- Where did you source your information from?
- List the advantages and disadvantages of using Biomass as a renewable source of energy?
 - * Advantages: *Local supply of wood; bring employment to the locality; wood is carbon neutral; most reliable of all renewable sources of energy.*
 - * Disadvantages: *Deforestation; Investment needed to change coal power plant to a wood burning power plant; Not all energy can be supplied from wood.*
- Did any other group convince you with their perspective of wood energy? Why / why not?



Unit 6: Where to now?

Aims

Children review the advantages and disadvantages of renewable and non-renewable sources of energy. They measure energy consumed in school and at home and take action to reduce the amount of energy used daily.

Overview of unit

Lesson 1: The great energy debate

Children work in groups to analyse a graph of Europe's energy consumption. They analyse information on sources of energy and present the advantages and disadvantages of using renewable and non-renewable sources of energy.

Lesson 2: Using energy

Children are made aware that when they use everyday appliances, such as a phone, television, computer etc., they use energy. Much of this energy comes from non-renewable resources. Children also understand what this energy costs in monetary terms.

Lesson 3: Energy saving

Children learn that there are many ways to conserve energy and save money in our everyday lives, both at home and in school

Lesson 1: The Energy Debate

Learning outcomes

Children investigate and evaluate advantages and disadvantages of using renewable and non-renewable sources of energy.

Resources

Internet, sources of information (see table below), poster, markers.

Skills development

Scientific: Questioning; Investigating; Analysing; Interpreting; Recording and Communicating.

Set the context

The figure 6.1 below displays the consumption of energy in Europe from 1990 to 2014. Give the children time to discuss and analyse the data on the graph.

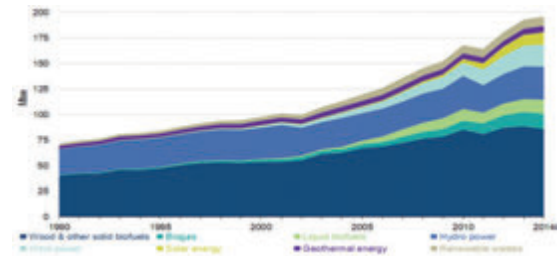


Figure 6.1: Consumption of energy in Europe from 1990 to 2014
http://ec.europa.eu/eurostat/statisticsexplained/index.php/Energy_from_renewable_sources

Question to promote discussion

- What energy source was used most in 1990? 2014?
- Which of these sources are renewable? Non-renewable? How do you know? What other fuels do you think could be included in the "wood & other solid biofuels unit"?
- Can you find a pattern in the graph? What do you think this pattern tell us?
- Can you predict what the graph might look like in a year / two / three years?
- What would you like the graph to look like in 10 years?
- Can you find out how much renewable and non-renewable sources of energy were used in your country in 2015?

Set the context

Inform the children that the head of the school is considering changing the school's current source of energy and would like to learn more about different sources of energy that are currently being used in the school and those that could be used in the future.

Web quest: What source of energy should our school use?

Divide the children into groups and assign each group a specific renewable and / or non-renewable source of energy that they must research. (See *Table 6.1* below for some useful websites). Based on their research each group must prepare a 5 minute presentation for their head of school informing him/her why they should or should not consider the particular source(s) of energy they researched. Allow time for a question and answer session after each presentation.



Drawing conclusions

Hold a whole class discussion on what the children have learned from their web quests and group presentations *There are many different sources of energy available, both renewable and non-renewable. There are advantages and disadvantages associated with each source. These advantages and disadvantages need to be evaluated in order to decide the best source of energy for both you and the environment.*

Table 6.1: Sources of renewable and non-renewable energy

Useful Websites	
Solar	
<ul style="list-style-type: none"> • http://www.childrensuniversity.manchester.ac.uk/interactives/science/energy/renewable/ • http://www.eia.gov/kids/energy.cfm?page=solar_home-basics-k.cfm 	
Wind	
<ul style="list-style-type: none"> • http://www.energyquest.ca.gov/story/chapter16.html • http://www.eia.gov/kids/energy.cfm?page=wind_home-basics-k.cfm 	
Oil	
<ul style="list-style-type: none"> • http://www.ecokids.ca/pub/eco_info/topics/energy/ecostats/ • http://tiki.oneworld.net/energy/energy3.html#!prettyPhoto[iframes]/o/ 	
Gas	
<ul style="list-style-type: none"> • http://education.nationalgeographic.com/education/encyclopedia/natural-gas/?ar_a=1 • http://www.ecokids.ca/pub/eco_info/topics/energy/ecostats/ 	
Coal	
<ul style="list-style-type: none"> • http://www.ecokids.ca/pub/eco_info/topics/energy/ecostats/ • http://www.kids.esdb.bg/coal.html 	
Hydro	
<ul style="list-style-type: none"> • http://www.eia.gov/kids/energy.cfm?page=hydropower_home-basics • http://www.energyquest.ca.gov/story/chapter12.html 	

Nuclear
<ul style="list-style-type: none"> • http://www.energyquest.ca.gov/story/chapter13.html • http://www.kids.esdb.bg/uranium.htm
Biomass (wood)
<ul style="list-style-type: none"> • http://www.energyquest.ca.gov/story/chapter10.html • http://www.eia.gov/kids/energy.cfm?page=biomass_home-basics
Geothermal
<ul style="list-style-type: none"> • http://www.eia.gov/kids/energy.cfm?page=geothermal_home-basics • http://www.energyquest.ca.gov/story/chapter11.html

Lesson 2: Using Energy

Learning outcomes

Children develop their understanding that when they use everyday appliances, such as a phone, television, computer etc., they use energy and that much of this energy comes from non-renewable resources. Children develop an awareness of what this energy costs in term of money.

Resources

Energy bills (electricity/gas/oil/etc.) from previous year (school & home); calculator; graph paper.

Skills development

Scientific: Observing; Questioning; Analysing; Estimating and Measuring; Collaborating.

Setting the context:

How much energy do we actually use?

We use energy when we turn on the lights; have a shower; watch television; turn on the kettle; heat a room, etc. Discuss *Table 6.2* (below) with the children. It illustrates approximately how much it costs to run everyday household appliances.



Table 6.2: The cost of using energy

Appliance	Day €*	Month €	Year €
1 Radiator (oil)	4.64	11.80	141.60
60 watt light bulb	0.20	6.00	72.00
Fluorescent bulb	0.05	1.43	17.16
Television	0.26	7.70	92.40
Full desk computer	0.28	8.50	102.00

*Approximate cost

Question to promote discussion

- How much would it cost to light a kitchen with three 60 watt bulbs for a month? €18.00
- How much would you save in a year if you used a fluorescent bulb in place of a 60 watt bulb? €54.84
- How much more does it cost to run the computer than the T.V. for the year? €9.60
- My house has ten radiators. How much would it cost to heat my house using these radiators for the year? €1416.00
- Calculate how much it would cost to

(i) Light a house with ten fluorescent light bulbs for the year?
€171.60

(ii) Heat a house with ten radiators for the year? €1416.00

(iii) Run two televisions for the year? €184.80

(iv) Run one computer for the year? €102.00

Now find the total cost for the above items for the year?
€1874.00

- Using the above information can you calculate the total cost of the energy used in your bedroom for the year?

Activity: How much energy does the school use?

In groups ask the children to make a list of how they use energy every day in school and to record what type of energy the school uses for light, heat, equipment. *Electricity, coal, oil, biomass other?*

Collect and distribute the monthly energy bills for the previous school year (Think about electricity, gas, oil). In groups ask the children to examine a range of these monthly energy bills to find out the answers to the following questions:

- During what month were the energy bills the highest/lowest? Can you explain why this might have been so?
- Can you calculate the total cost of electricity/gas/oil the school had to pay this year?
- Calculate the total cost of energy for the school year?
- Calculate the average energy consumption per month.
- Calculate the average energy consumption per day.

Activity: How much energy do we use at home?

This activity is to be carried out at home. Ask the children to ask their parents/guardians to show them their energy bills (electricity/gas/oil/fuel for car) bills (for the past year if possible). The children ask their parents / guardians to answer the questions below regarding how much energy they use at home.

Questions for parents and children to answer together

- During what month was the energy bill the highest/lowest? Can you explain why this might have been so?
- What energy bill was the highest? *Electricity/gas/oil*
- Calculate the weekly cost of petrol/diesel for your family car.
- What is the total cost of energy for the year?
- Calculate the average energy consumption per month.
- Calculate the average energy consumption per day.

Drawing conclusions

Discuss energy usage at home and in school and ask the children what they have learned.

Much of the energy we use comes from non-renewable resources which are damaging our environment.

Decreasing the amount of energy we use is not only better for the environment but also saves money in terms of energy costs.

Lesson 3: Energy Saving

Learning outcomes

Children develop their understanding about the many ways to conserve energy. They are provided with opportunities to devise and implement strategies to save energy in their everyday lives, both at home and in school.

Resources

Matching game cards, Paper, pen, graph paper.

Skills development

Scientific: Observing; Inferring; Hypothesising; Recording and Communicating; Problem Solving; Collaborating.





Set the context

Discuss with the children that in addition to reducing our reliance on non-renewable energy sources, it is essential that we decrease the amount of energy we use. Whenever energy is saved, the demand for non-renewable sources of energy is reduced. This reduction also saves money on energy bills. When the burning of fossil fuels is reduced this also results in lower emissions of carbon dioxide, which has a positive impact on reducing the effects of global warming. Everyone must take action to reduce the amount of energy we are using every day.

Group discussion

Ask the children to develop a definition of energy conservation. They share and discuss their group definitions with the whole class. *Energy conservation is the smart use of energy resources resulting in reduced energy costs.*

Activity: Drawing activity

Divide the children into pairs. Distribute a card with a picture that is illustrative of wasting energy. For example, a picture card might show a rubbish bin filled with a variety of waste materials. Each pair must discuss their picture and then draw a contrasting conserving energy picture that illustrates how energy could be saved. For this picture for example, they might draw a recycling bin. Other examples of wasting energy pictures that could be used could include a bath full of water, tv on standby, thermostat, refrigerator door open, etc. Each pair will then report back to the class stating how energy was wasted and how it could be conserved.

Activity: Saving Energy in the School

Teacher Note

Across Europe buildings lose about 40% of the energy that is used. Most of this energy is produced by burning fossil fuels in power plants which create a lot of pollution. Children need to think of ways to ensure that all energy used in the classroom is used wisely and effectively. In groups children brainstorm ways the school could save energy. A final list of ten energy saving strategies to be implemented are agreed on. Children must devise ways of calculating whether or not the changes will have an impact on the amount of energy that is used.

Suggested approach to help the children with this task

- a. *Calculating reductions in electrical/gas/oil consumption:* Children read the meter (electricity/gas/oil) every day for a week. The following week children implement changes and read the school meter every day. Children should record their readings in a table. They then compare readings and discuss the results

- b. *Recording long term impact of energy saving strategies:*

- Compare current energy bill with the previous energy bills.
- What other factors should be considered? Temperature of month; Days not in school; amount of day light, etc.

- c. *Recording and presenting findings.*

Present results of savings on a graph. Discuss results with the class and head of the school

Question to promote discussion

- How much energy did we save?
- What day did we save the most energy?
- Can you think of other ways we could save energy at school? *Solar Panels; Large windows facing the sun; Compost and recyclable bin inside the classroom; Bicycle rack outside; Fluorescent light bulbs.*

Activity: Saving energy at home

Children are encouraged to work with their parents / guardians to identify ways that they could conserve energy at home. Initially they could discuss ways that they currently waste energy in their homes: e.g

- *Leaving the television on when you are not in the room.*
- *Having a bath instead of a shower.*
- *Leaving the tap running while brushing your teeth.*
- *Open a window when the heat is on.*

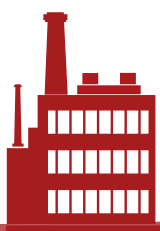
Conserving energy at home action plan

Ask the children to work with their parents / guardians to read and record the readings on their meters (electricity/gas/oil) for a week. They then work together to devise and implement five energy saving strategies at home. They record meter readings each day the following week and discuss changes (if any) in their energy consumption.

Drawing conclusions

Hold a whole class discussion on what they have learned about saving energy at home and in school.

Energy conservation is when we do something to reduce the amounts of energy we use, such as turning off lights, cycling to school, etc. Conservation of energy will reduce energy costs and help reduce the pollution caused from burning fossil fuels.





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**The SUSTAIN project has produced three handbooks
on sustainable development issues**

Energy

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