A1: SOURCES OF ENERGY

Overview

These activities present an opportunity for teachers to introduce the concepts of **primary** and **secondary energy sources** to their students. The idea is for teachers to draw on what their students already know about energy, and then elaborate on that knowledge. By asking the right questions, teachers encourage their students to think about energy and to participate in the discussion. Some good lead-in questions might be: Where do plants get their energy from? So what is their energy source? Is this a **primary energy source**? What other **primary energy sources** are there? Can anyone suggest what a **secondary energy source** is? What are some examples of **secondary energy sources**?

Suggested approaches:

- Introduce some key terms such as **primary energy**, **secondary energy**, and **photosynthesis**. Establish what the students understand by these terms. Arrange the students into small groups and let them brainstorm about the theme of energy – What is it? Where does it come from? Can it be measured? Is there a connection between energy and food? After 6 – 8 minutes let each group summarise their results in poster form for reference afterwards.
- Some student groups may already have encountered the terms **primary** and **secondary energy sources** in another subject area. Ask them to tell you what they have learnt so that you can build on this. Have the students compile individual posters under the headings **What I know about energy sources** and **What I don't know about energy sources**. These can be revisited later.

NOTE:
Energy in Action is an online schools resource from SEAI.
If you're reading a printout and wish to view this online to access links, visit www.seai.ie/energyinaction

A1 ACTIVITY 1: PRIMARY AND SECONDARY ENERGY SOURCES

Background

The principle of the **Conservation of Energy** states that the total energy of a system cannot be created or destroyed, but can be transformed into different forms as well as being transferred from one object to another.

While energy from our nearest star, the Sun, enters and leaves our planet, the quantity of matter available on Earth is limited. Once used up, it cannot be replaced within a human timeframe. For this reason the Earth is considered an almost closed system.

The first step in this investigation is for the students to clarify what they understand by energy and its role in our lives. The next step centres on the role of the Sun as THE source of energy. Students explore what exactly is meant by a primary energy source and by a secondary energy source. Students are given a list of energy sources and challenged to classify them as primary and secondary, and to explain why some primary forms of energy are not included in the list (for example, it is difficult, if not impossible, to convert sound or lightning energies into useable secondary energy sources).

Equipment required – per group:

- A3-size sheets plus markers
- A list of the following questions (one per group)
  - ? ***Question 1 – What is the group's understanding of energy?***
  - ? ***Question 2 – Why is the Sun important to us on Earth?***
  - ? ***Question 3 – What is the group's understanding of primary energy sources?***
  - ? ***Question 4 – What is the group's understanding of secondary energy sources?***

  TWO SELF-REFLECTION EXERCISES (FOR HOMEWORK OR REVISION)
  - ✓ A1.1 Worksheet A: How can we categorise energy sources?
  - ✓ A1.1 Worksheet B: About energy sources

What to do:

1. Each group should appoint a recording secretary and a chairperson to present their findings to the rest of the class – the form of presentation (oral or poster) can be decided by each group.
2. Having agreed on a time for the discussion session (i.e. 15 minutes) each group should present their findings to the class.

   SOME SUGGESTED LEARNING OUTCOMES:

   ? ***Question 1 – What is the group's understanding of energy?***
   - Energy is the ability to do work, e.g. move something.

   ? ***Question 2 – Why is the Sun important to us on Earth?***
   - The Sun is THE original source of energy … all existing energy on earth emanates from it … nothing we do on Earth can increase this available energy (fossilised sunlight) ... this is the principle of the **Conservation of Energy**.

   ? ***Question 3 – What is the group's understanding of primary energy sources?***
   - Primary energy sources are those directly derived from the Sun, but the energy does not always take a form that is of use to us.

   ? ***Question 4 – What is the group's understanding of secondary energy sources?***
   - Energy is not always available in a form that is of use to us. Human intervention is required to transform the primary sources into energy sources that enable us to run our cars, heat and light our homes, run our music players, and charge our batteries. These forms of energy are secondary energy sources.

A1.1 Worksheet A: How can we categorise energy sources?

ENERGY SOURCE	PRIMARY	SECONDARY
Coal		
Hydro		
Nuclear		
Oil		
Rivers		
Solar		
Wood		
Wind		
Uranium		
Sun		
Geothermal		
Biomass		
Natural gas		
Radioactive minerals		
Electricity		

Challenge: Select a primary energy source not listed above and give a possible reason for its omission.

A1.1 Worksheet B: About energy sources

1. What is energy?

2. List the consequences of the Sun 'shutting down'!

3. a. List as many forms of energy as you can.

   b. From this list pick the ones you consider most useful.

4. Can you say why these are useful?

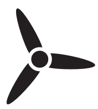
5. What do the following have in common: Wind, Coal, Biomass, Natural gas?

6. What do the following have in common: Uranium, Coal?

7. What do the following have in common: Solar panels, Geothermal power, Electricity?

8. What do the following symbols represent?


a


b


c


d


e


f


g

(See www.seai.ie/renewables)

9. How many differences can you find between primary sources of energy and secondary sources of energy?

A2: CHANGING ENERGY

Overview

The aim of the following activities is to help the students to understand visually how the different forms of energy are interrelated. They are useful both as teacher-led as well as student-led activities.

As the activity proceeds, the teacher poses probing questions for the students – What if…?, What do you think might happen if…? – leading them to an understanding of the different energies involved and how they are interlinked.

A2 ACTIVITY 1: THROWING PEBBLES introduces **gravitational potential energy** and kinetic energy. **A2 ACTIVITY 2: THE OBEDIENT BOTTLE** looks at **elastic potential** and **kinetic energies**. In **A2 ACTIVITY 3: THE POWER OF THE WIND — MAKING YOUR OWN GENERATOR** students construct a wind generator and use it to light an LED. **A2 ACTIVITY 4: EXPLORING THE WIND TURBINE** examines an alternative for generating electricity using a renewable source. **A2 ACTIVITY 5: THE ENERGY OF BOUNCE** examines the energies involved when balls bounce. How **gravitational potential energy** and **kinetic energy** change as a pendulum oscillates is examined in **A2 ACTIVITY 6: THE ENERGY OF SWING**.

A2 ACTIVITY 7: HEATING AND COOLING examines the simulation Energy Forms and Changes, which allows students to explore the energies involved in **heating and cooling** solids as well as examining some energy systems. **A2 ACTIVITY 8: THE ENERGY OF SKATING** examines another simulation Energy Skate Park: Basics, in which the students explore the **conservation of energy** by observing the results of changing both the shape and surface of a skater's track.

Suggested approaches:

- Before using any of these activities, a brainstorming session should take place to gather ideas that students have about different forms of energy – What is **kinetic energy**? Why is it so called? What is the origin of the word **kinetic**? Sometimes knowing the etymology of unfamiliar scientific words can make the understanding of them easier for students.
- A discussion should be facilitated to gather ideas and questions that students have about different forms of energy. Some useful questions to pose before the activity session might be, for example: What is **kinetic energy**? What is **friction**? The aim of both the brainstorming session and the discussion should be to enable the students to draw up a bank of questions to which they could find the answers as they carry out the various activities.
- There are a number of ways to use these simulations. They can be conducted in small groups or with the whole class together. Students could direct you as to what to do, and so present you with opportunities to ask questions of the class as a whole. As well as the simulations, the PhET website provides resource material for teachers to adapt to suit their own class situations.

A2 ACTIVITY 1: THROWING PEBBLES

Background

An effective introduction to **gravitational potential** and **kinetic energies** can be made through simply lifting and dropping pebbles onto an empty can. Some questions should be posed to the students: Which is easier to lift and to drop? Which pebble might make the greater dent?

The students may come to the conclusion that because a large pebble makes a greater dent than a small pebble when dropped from the same height, the large pebble must have a greater store of energy than the small one.

The activity can be expanded quantitatively by using force meters to calculate the **gravitational potential energy** involved, dropping the pebbles from different heights and comparing the resultant dents.

Equipment required:

- Selection of large and small pebbles
- Empty soft drink cans
- Tongs suitable for holding both large and small pebbles (optional)
- Newton meter with pan attached
- Metre stick/measuring tape

What to do:

1. Gather a variety of stones ranging from small pebbles to rocks (but no bigger than the can). If possible, have two similar collections, enabling one group to drop stones from one height and a second group from a different height.
2. Lift a little pebble and a large stone from the floor and place each on a table.
3. Lay an empty can on the floor near the table.
4. Drop the pebble so that it strikes the can.
5. Observe and record what happens.
6. Replace this can with another empty one.
7. Drop the large stone so that it strikes the can.
8. Observe and record what happens.
9. Compare both observations and comment.

EXTENSION ACTIVITY:

It may be appropriate to show the students that potential energy can be calculated using the following formula:

Potential Energy = mass x acceleration of gravity x height.

1. Lay an empty can on the floor.
2. Using the Newton meter find the weight of the pebble.
3. Holding the pebble in the tongs, measure and record its height above the floor.
4. Release the pebble and observe the result.
5. Calculate the potential energy using the formula above.
6. Using different pebbles repeat steps 1 – 5, measuring and logging the height from which the pebble is dropped and how it relates to the impact on the can.

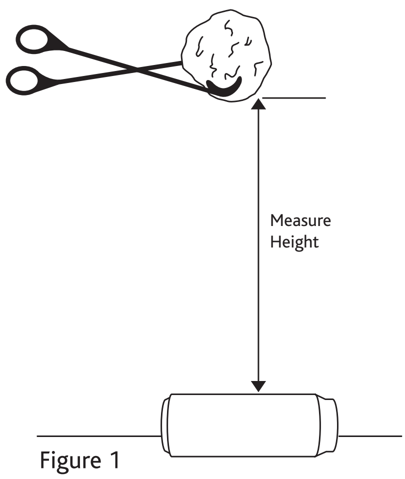


Figure 1

Using both the observation of the impact of the pebble on the can and its corresponding potential energy, what conclusion might you arrive at?

A2 ACTIVITY 2: THE OBEDIENT BOTTLE

Background

The **Obedient Bottle** or **Come Back Can** is a visual, explorative introduction to **elastic potential energy** and its conversion to **kinetic energy**.

When the cylinder is rolled, it acquires **kinetic energy**. As it slows down, this energy is transferred to the twisted elastic band inside in the form of **potential energy**. The twisted band's **potential energy** is then transferred back to the container in **kinetic energy** as it unwinds.

The energy transfer is due to a weight attached to the elastic band. This weight is pulled down by gravity, but it is also subjected to the twisting force from the elastic band. As long as the weight is greater than the twisting force on the band the elastic band will continue to twist. When the **kinetic energy** is mostly transferred to **potential energy** (to the elastic band) the bottle or can will stop rolling allowing the elastic band to untwist. However, because the weight is in the middle of the band only the end loops will unwind, causing the can to roll backwards.

This activity is useful for addressing some misconceptions such as: *Something not moving cannot have energy* (**potential energy** is energy **stored** in an object **due to position**); *An object has potential energy only when it is not moving* (**potential energy** depends on an object's **position**, whether it is moving or not); *The only type of potential energy is gravitational* (there are **other forms** of **potential energy**, such as **elastic potential energy** and **chemical potential energy**).

Suggested approaches:

- The **Obedient Bottle** may be carried out in two parts: before the session prepare the bottle or can. Have the bottle totally covered so that the students just see a cylindrical container. Gently roll it on the table for the students to see what happens – do not let them handle it. Continue rolling it as the students hypothesise as to what is happening. Depending on the class you may now decide to let them make their own Obedient Bottle so that they can test their hypotheses.
- Alternatively you may decide to let the students experiment with the prepared bottle, encouraging them to be observant and explain to you what they see and why the bottle behaves in this way.

Equipment required:

- Plastic bottle (any soft-drink size is suitable) with top, or a cylindrical, Pringles© tube-type container with a lid (again any size is suitable)
- Length of string – slightly longer than the length of whichever container is being used
- Metal nuts or washers (size depends on width of bottle/container)
- Two paper clips/two matchsticks
- Elastic bands
- Hook, such as a crochet needle (one can be fashioned using a large paperclip)
- Scissors or knitting needle, for boring holes in the container lids

What to do:

USING A CYLINDRICAL CONTAINER, E.G. A PRINGLES© TUBE

1. Carefully punch a hole in the centre of both the lid and the base of the container as shown in **A** below.
2. Slip the elastic band into the nut and tie a knot as shown in **B** below.
3. Using a paper clip or matchstick to keep it in place, insert the elastic band through the hole in the base as shown in **C** below.
4. Using the hook, pull the elastic band up to the top of the container and through the lid of the container as shown in **D** below.
5. Put the lid on the container and secure the elastic with the other matchstick or paperclip.
6. Cover the can completely with paper, ensuring that all signs of elastics and matchsticks are concealed. This will be the demonstration can prepared before class.

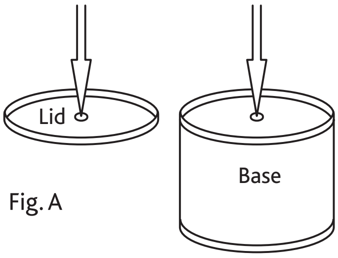


Fig. A

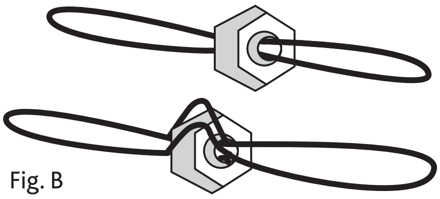


Fig. B

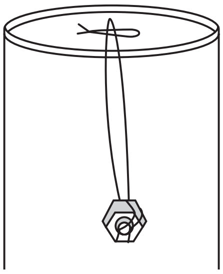


Fig. C

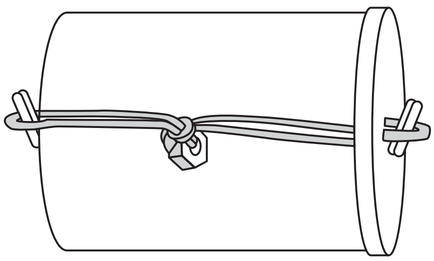


Fig. D

USING A CLEAR PLASTIC BOTTLE

1. Remove all labels from the bottle.
2. Carefully punch a hole in the centre of both the lid and the base of the bottle as shown in **A** above.
3. Slip the elastic band into the nut and tie a knot as shown in **B** above.
4. Make a neat cut in the side of the bottle to insert the elastic band with the nut.
5. Carefully attach one end of the elastic band with a paperclip or matchstick to the lid as in Figure **E**.
6. Pull the other end with the hook through the hole in the base. Secure it using the other paperclip or matchstick and seal with tape as shown in **E** above.
7. Check if the nut/washer is touching the side of the container. If it is then you will need to use a shorter elastic band.
8. If making two bottles, instead of a bottle and a can, conceal what is happening in the demonstration bottle by covering it with paper or painting the outside and covering the lid and base carefully with opaque tape.

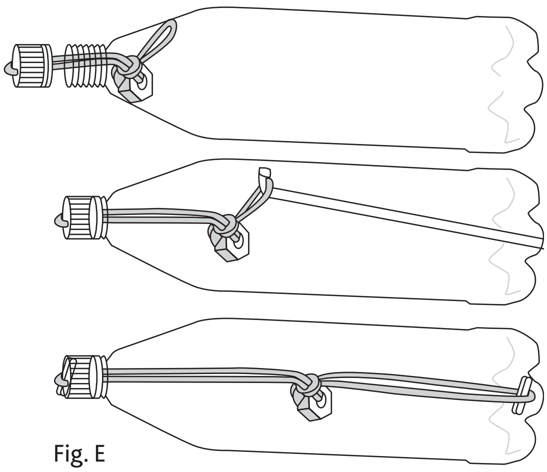


Fig. E

A useful video on the construction of the bottle is available at http://www.stevespanglerscience.com/lab/experiments/magic-rollback-can-sick-science.

Questions to promote discussion:

1. What do you expect to happen within the bottle/can if you roll it on a flat surface?
2. How could you observe and record it in action?
3. What happens when you roll the bottle/can?
4. Can you explain why?
5. How does this compare with your predictions?
6. What energies are involved?
7. What do you think might happen if there was no nut?
8. Does the position of the nut make a difference to the behaviour of the bottle/can?
9. How do you think the bottle would roll if the nut was positioned as shown in Figure 2?

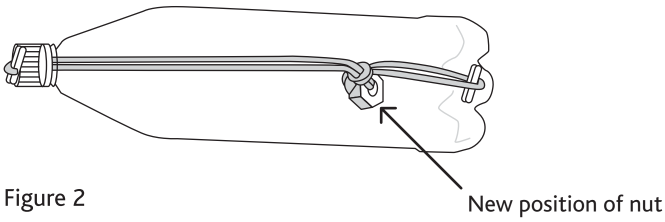


Figure 2

Click here to explore an interesting interactive site for the students in preparation for the remaining questions.

10. What do you expect will happen if you roll the bottle on an inclined surface?
11. Are there any other forces in action if you use an inclined surface?
12. Does the rise of this inclined surface make a difference to the outcome?

A2 ACTIVITY 3: THE POWER OF THE WIND — MAKING YOUR OWN GENERATOR

Background

In this activity, students investigate how the power of the wind can be harnessed to generate electricity.

Students build their own wind generator. The propeller is connected to a Lego motor with an LED. When the blades of the propeller move, energy is fed to the connected motor. The motor converts **rotational energy** into **electrical energy** to make the light go on.

By going through these steps themselves, students experience first-hand the process of feeding one kind of energy (**motion**) into a generator, and getting another (**electricity**) out. The experience helps them to visualise the concepts of **energy conversion** and the **conservation of energy**, and to appreciate the power of the wind. When the propeller moves, they can see what a simple rotation can achieve. A little propulsion will cause the LED to light up, indicating that sufficient energy has been harnessed.

Students then use their acquired skills and knowledge to investigate the questions posed in **A2.3 WORKSHEET C: THE POWER OF THE WIND — WHAT DO YOU THINK?**

Suggested approaches:

- The following link contains a wealth of information on wind energy:
  EPA Wind Energy – Powering the Future.
- As a lead-in, students could be set a short research project on wind energy before constructing their own windmill. The following links may be useful:
  Wind Energy Activities
  SEAI's Wind Energy information.
- Before construction the students could watch the video on the following links:
  https://vimeo.com/20705049 – English version
  http://vimeo.com/28864041 – Irish version

Equipment required:

- 9V Lego motor or similar, with matching cable
- LED with connecting leads
- Aluminium can
- Ruler
- Permanent marker or CD pen (to write on can)
- Scissors
- Glue gun
- Sandpaper
- Protective gloves (for cutting the can)
- Support rod for windmill
- Hand fan or hairdryer (low watt preferable)

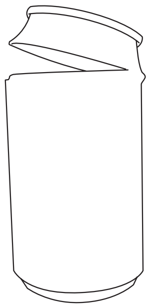


Figure 3: Cutting the top from the can

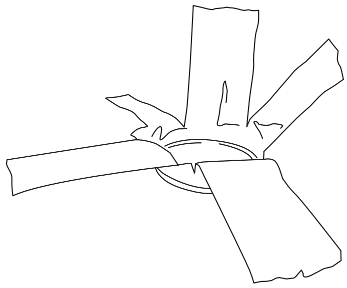


Figure 4: Cutting the blades

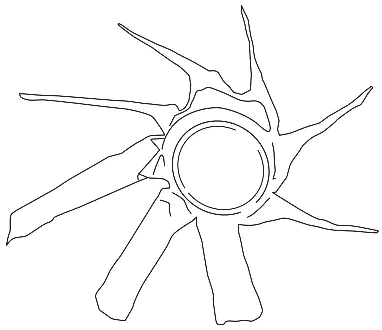


Figure 5: Angling the blades

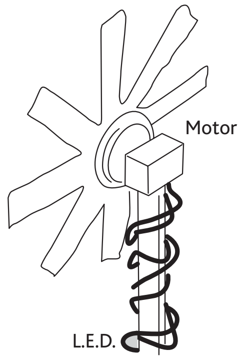


Figure 6: Assembled windmill

What to do:

1. Measure and note the circumference of the can.
2. Wearing the protective gloves, cut the top off the can.
3. Use the marker to make three evenly spaced lines in the side of the can – these will be the blades for the propeller.
4. Cut along the lines.
5. Fold down and carefully angle the blades.
6. Using the glue gun attach an 'axle' for the motor onto to the top of the can and attach the motor to it.
7. Set up a support rod for the motor-windmill structure and connect the LED as shown in the Figure 6.
8. Gently fan the blades. As they move, the LED should light, indicating that electricity is being generated. Investigate using the hairdryer or fan and vary the distance of the blades accordingly.

Having constructed and used the windmill the students are now presented with various questions. Using **A2.3 WORKSHEET C: THE POWER OF THE WIND — WHAT DO YOU THINK?** the class can be divided into groups with each group assigned some questions from the worksheet that they could be asked to investigate. They can then be asked to present their findings to the class. In **A2 ACTIVITY 4: EXPLORING THE WIND TURBINE** students examine the commercial aspect of investing in wind farms.

There is also a version of this activity on page 66 of Science on Stage 1 & 2, available at http://www.scienceonstage.ie/resources/SOS1&2_booklet_Ireland.pdf.

A2.3 Worksheet C: The Power of the Wind — What do you think?

1. Does it matter how many blades there are on the generator?
2. How many blades are on wind turbines in Ireland?
3. To make the generator spin faster, would we increase or decrease the number of blades on it?
4. Would the speed of the wind turbine change if the blades were at different angles?
5. How could you generate more electricity using this generator?
6. Describe what types of energy are involved in this system.
7. Does the type of material from which the blades are made affect the system?
8. There are many people who object to the installation of wind turbines as generators of electricity. Give three reasons for objection.
9. Are there many wind farms in Ireland? How are they used and who mainly uses them?
10. What is the benefit of using wind to generate electricity rather than burning fuels such as coal, peat or oil?
11. How much electricity is generated by wind in Ireland compared to the quantity of electricity generated by fossil fuels?

A2 ACTIVITY 4: EXPLORING THE WIND TURBINE

Background

The aim of this investigation is to examine one alternative for generating electricity using a renewable source. Students may be familiar with the **dynamo** used on a bike or the decorative LEDs which are often attached to the spokes or the valves. However, they may not make a conscious connection between movement and the generation of electrical energy. The previous investigation – **A2 ACTIVITY 3: THE POWER OF THE WIND — MAKING YOUR OWN GENERATOR** – is a good lead-in to this activity.

What to do:

1. If appropriate, recap on the investigation **A2.3 WORKSHEET C: THE POWER OF THE WIND — WHAT DO YOU THINK?** using it as a lead-in to research into wind turbines, their uses, advantages, etc.
2. Use a roleplay approach as this contentious issue lends itself well to this method.
3. Divide the class into three groups – **A**, **B** and **C**,

   Group A is to present the case for the erection of a wind turbine/wind farm,

   Group B is to oppose such an idea, whilst

   Group C represents the general public who, having listened to both cases, then votes on whether to accept, reject or request more information indicating what might need clarification, etc. If appropriate, two or three students from this group could be assigned the role of reporters who would then write up an article/write a radio script/present a TV clip for general presentation to the class, or even the school community.
4. The two groups presenting their cases should be given a timeline for that presentation plus time for questions from the audience.

Resources:

- The Sustainable Energy Authority of Ireland (SEAI) site gives detailed background information about the history of wind energy, attitudes in Ireland to wind farms, best practice guidelines, the technologies of wind energy, detailed insights into wind farm development and some case studies.
- Click here for information on a community-owned wind farm, Tipperary Energy Agency.
- Click here for a report on the significance of noise from onshore wind farms.
- A teacher's guide to a virtual laboratory on wind power can be accessed by clicking here.
- The howstuffworks website has a series of articles on wind power.

A2 ACTIVITY 5: THE ENERGY OF BOUNCE

Background

This activity is a great way to open a discussion about the energies involved in **bouncing**, and to demonstrate the principle of the **Conservation of Energy**.

Before the ball is dropped, it has **potential gravitational energy**, which will cause it to rebound when it hits the ground. Some of this energy is **converted** to **heat energy** and **sound energy**, so it loses **momentum** and will not rebound to the original height.

Students can film the action and then replay it in slow motion to observe bounce patterns. Following that, students could consider why in tennis, squash, rugby and basketball, the ball is often repeatedly bounced before the player uses it.

After the activity students can consolidate and further their learning by answering **A2.5 WORKSHEET D: THE ENERGY OF BOUNCE**.

Equipment required:

- Two basketballs – one fully inflated and the other partially inflated
- A selection of smaller balls – table tennis ball, squash ball, tennis ball
- Measuring tape or supported screen marked at intervals, or a data logger and motion sensor
- Worksheet – **A2.5 WORKSHEET D: THE ENERGY OF BOUNCE**

Suggested approaches:

- If the class has internet and viewing access, show this short SEAI video to inspire a class discussion before carrying out the activity. Alternatively, you could watch this video and replicate the presentation for your class.
- You might discuss with the class whether some balls bounce better than others, or what it is like to ride a bike with a flat tyre. Click here to view a useful webpage with information and ideas on teaching a class about air pressure and force.

What to do:

1. Give the fully inflated ball to one student, and the partially inflated ball to another, and ask them both to drop the balls from the same height.
2. Compare the bounce of both balls by observing return bounce heights.
3. Bounce the balls and let them continue for a number of rebounds. By having a marked screen behind the balls, it should be possible to measure the successive rebounds. The activity could also be videoed and reviewed frame by frame.
4. Now move on to **A2.5 WORKSHEET D: THE ENERGY OF BOUNCE** – the class could complete the worksheet together or individually.

ALTERNATIVE

You might wish to use the worksheet during the activity, rather than after it. It could be used to guide the lesson, with actions carried out to find the answer to each question. In this way students can focus on the activity without needing as much teacher input.

FURTHER LEARNING

For teachers wishing to elaborate further on this theme, there is an appropriate activity on page 13 of *Physics on Stage 3: Demonstrations and teaching ideas*, and available free online by clicking here.

In this more advanced lesson, a student is asked to demonstrate what happens when one small ball is placed on top of the basketball and both are dropped together. The class is asked to observe and consider the following questions:

- What happens on the rebound?
- Is there a difference depending on which of the small balls is placed on top of the basketball?

A2.5 Worksheet D: The Energy of Bounce

1. What happens to both balls when they are dropped from a height?

 ____

2. Which ball bounces higher, the partially inflated ball or the fully inflated ball?

 ____

 ____

3. Which ball applies more pressure on the ground? Explain!

 ____

 ____

4. The law of the Conservation of Energy says that

 ____

 ____

5. Fill in the blank and circle the correct answer:

 Before the ball is dropped, it has ________________ energy. We know this because the ball is/isn't moving but is about to fall.

6. When the ball is falling, it has ________________ energy. While the ball is falling it has its maximum ________________ energy.

7. Circle the correct answer!
 After the ball hits the ground, does it:
 (a) return to the original height?
 (b) not bounce at all?
 (c) return to half the original height?

8. Explain your answer to question 7.

 ____

 ____

9. Fill in the blanks:

 After the ball hits the ground, its ________________ energy is converted to other forms of ________________. When the ball hits the ground it makes a ________________. Sound is a form of ________________. Therefore we can say that some of the ________________ energy is converted to ________________ energy. After continuous bouncing the ball begins to heat up. This is caused by ________________ between the ball and the ground. Heat is a form of ________________. Therefore, we can say that some of the kinetic energy is converted to ________________ energy. Finally, when the ball is bounced close to your feet you feel ________________ from the floor. This is caused by some of the ball's ________________ energy being converted to ________________ energy.

A2 ACTIVITY 6: THE ENERGY OF SWING

Background

The pendulum is a simple machine for transferring **gravitational potential energy** to **kinetic energy** and back again. This activity centres on the conversions between **kinetic potential energy** and **gravitational potential energy** as a pendulum swings back and forth.

When the pendulum is at the highest point of its **swing** it has no **kinetic energy** but at that moment its **gravitational potential energy** is at its maximum.

As the pendulum swings downwards, the **gravitational potential energy is transferred to kinetic energy**, causing the pendulum to **accelerate**.

At the lowest point of the swing the **kinetic energy** is at a maximum and **gravitational potential energy** is at a minimum.

The pendulum **swings** upwards until it reaches the top of its **swing**. At this stage the **kinetic energy** is at a minimum whilst the **gravitational potential energy** is at a maximum.

This cycle continues, **but the energy does not remain the same**. Each swing becomes lower as some energy is used as the pendulum overcomes air resistance – **friction**.

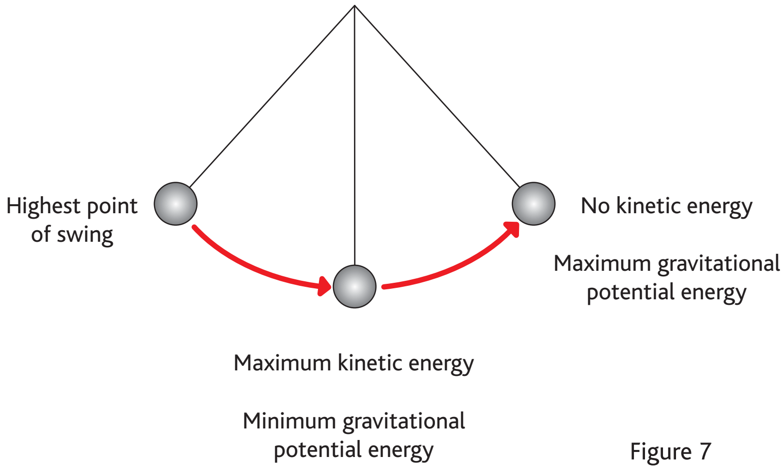


Figure 7

Equipment required:

- Retort stand
- Squash ball or similar
- Small cup-hook or a thumb-tack attached to a piece of string
- Sellotape
- Newton's cradle (optional)

What to do:

1. Set up the Newton's cradle. Ask the class if anyone can tell you what will happen if you pull back one of the balls and then release it. After collecting predictions, pull back a ball at one end of the Newton's cradle, and release it. Compare observations with predictions. Ask the class to predict what would happen if you pulled back two balls and released them. If a Newton's cradle is not available a video of this activity is available here.
2. After watching the video the following activity can be carried out. Fix the cup-hook or attach the thumb-tack to the squash ball using Sellotape. Using the string, suspend the ball from the retort stand.

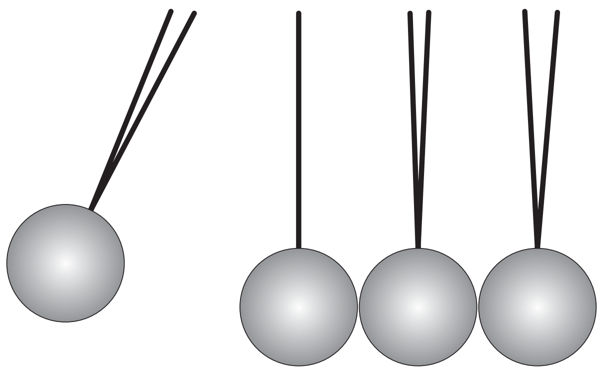


Figure 8

ENERGY IN ACTION
ACTIVITIES FOR JUNIOR CYCLE

3. Pull the ball back a distance and ask a student to hold their palm at that point, as shown in Figure 9.

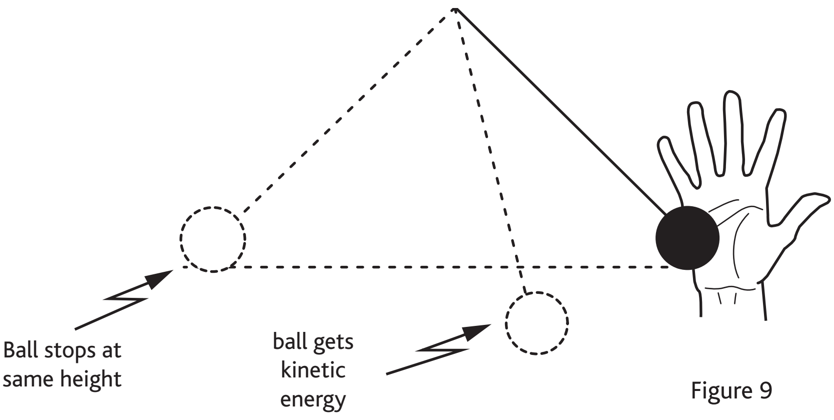


Figure 9

4. Release the ball and observe it as it oscillates. Remind the student not to move their hand.
5. As the ball swings back and forth it is behaving like a pendulum. Prompt discussion by asking questions such as – Can you think of where you may have seen a pendulum in action? How about if you are on a swing? What about a trapeze artist?

What next:

- It may have been a while since students sat on a swing. Ask them to think back on what it was like to swing. Ask them to consider the following questions:
  - ? ***How would someone on a swing reach a good height without anyone pushing them?***
  - ? ***What would they do to make themselves swing faster and higher?***
  - ? ***What energies are involved in this process?***
- Click here for a short video on swings – it might be useful to show after the students have offered some explanations on the swing questions above.

A2 ACTIVITY 7: HEATING AND COOLING

Background

This activity allows students to explore the **heating** and **cooling** of a brick, a lump of iron and water. It is a lead-in to an exploration of various **energy systems** – **mechanical**, **electrical**, **thermal** and **chemical** – and creates an opportunity for students to observe **energy flows**.

This activity relies on access to the PhET simulations from the University of Colorado, Boulder, USA. The simulations are interactive and have the added bonus of being available in different languages. The simulation Energy Forms and Changes contains a comprehensive teacher's guide and a list of suggested ideas. It can be used with a projector to share the screen with the class; either the students may direct the action while the teacher makes suggestions, or vice versa.

What you need:

There are three ways to run PhET simulations:

a) Run them online in class, or;

b) Install all the simulations onto a drive thus eliminating the need for an internet connection to run the simulations, or;

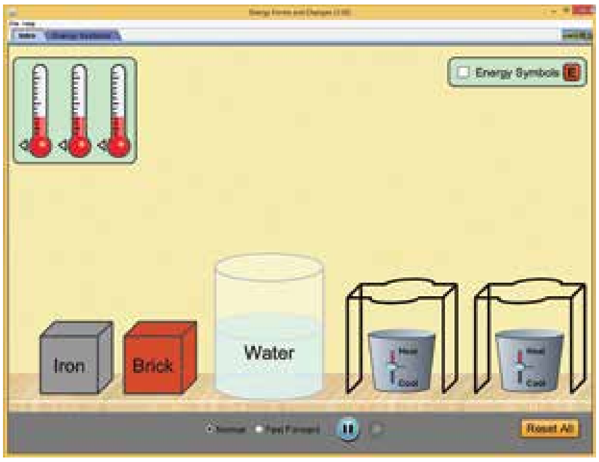
c) Download the simulations needed, again eliminating the need for an internet connection to run the simulations.

Suggested approaches:

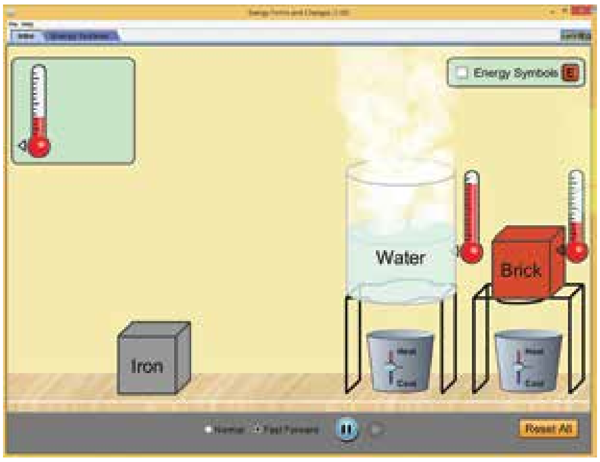
- This link: https://phet.colorado.edu/en/simulation/energy-forms-and-changes will take you directly to the simulation.
- Showing simulations on the whiteboard makes it possible for all the students to participate. Students can guide either the teacher or other students in the actions taken. Using the simulations this way helps to ensure that the whole class are seeing the same thing and allows the teacher to address any possible misconceptions as they come up.

Preview

i. The first simulation is **an introduction to energy**. It shows how energy is **added** or **removed** through **heating** and **cooling**.



PhET Interactive Simulations
University of Colorado
http://phet.colorado.edu



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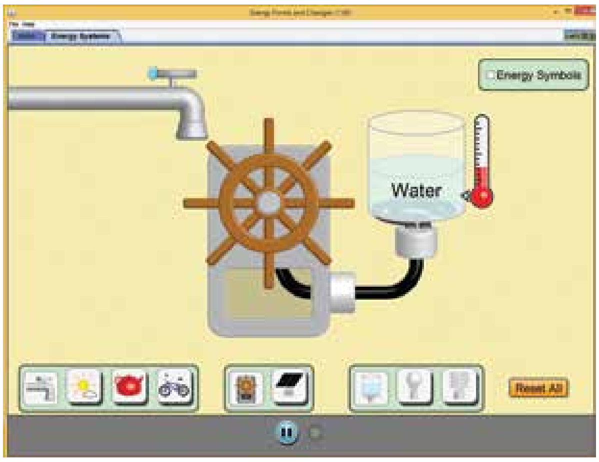
ii. The second exercise simulates an investigation into **energy flow** and **energy changes** in various **energy systems**.



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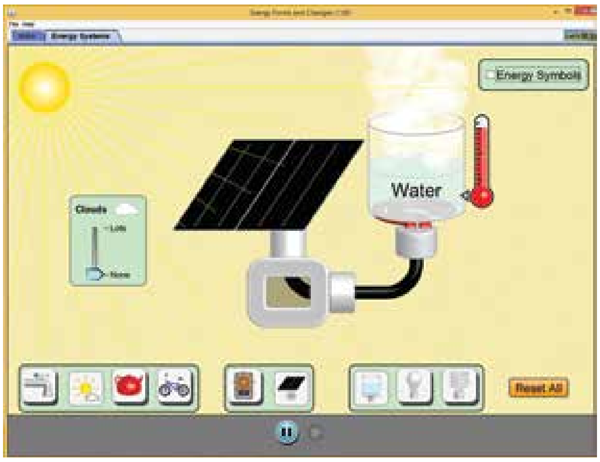
http://phet.colorado.edu



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http://phet.colorado.edu

A2 ACTIVITY 8: THE ENERGY OF SKATING

Background

This activity also makes use of PhET simulations from the University of Colorado, Boulder, USA. The simulations are interactive and have the added bonus of being available in different languages. The simulation Energy Skate Park contains a comprehensive teacher's guide and helpful suggestions, and can be used as a whole-class activity led by either the students or the teacher, or as an activity where the class is divided into groups.

The simulation uses a skateboarder to explore the **conservation of energy** and different types of energy. As well as using different types of tracks there is a graphic representation of the **energy changes**.

What you need:

There are three ways to run PhET simulations:

a) Run them online in class, or;

b) Install all the simulations onto a drive thus eliminating the need for an internet connection to run the simulations, or;

c) Download the simulations needed, again eliminating the need for an internet connection to run the simulations.

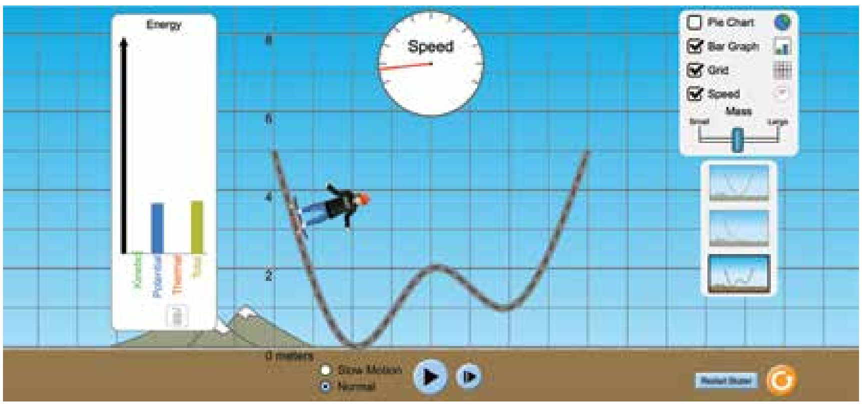
Suggested approaches:

- This link: https://phet.colorado.edu/en/simulation/skate-park-basics leads directly to the simulation.
- Showing the simulation on the whiteboard makes it possible for all the students to participate. Students can guide either the teacher or other students in the actions taken. Using the simulation this way helps to ensure that the whole class are seeing the same thing and allows the teacher to address any possible misconceptions as they come up.

Preview

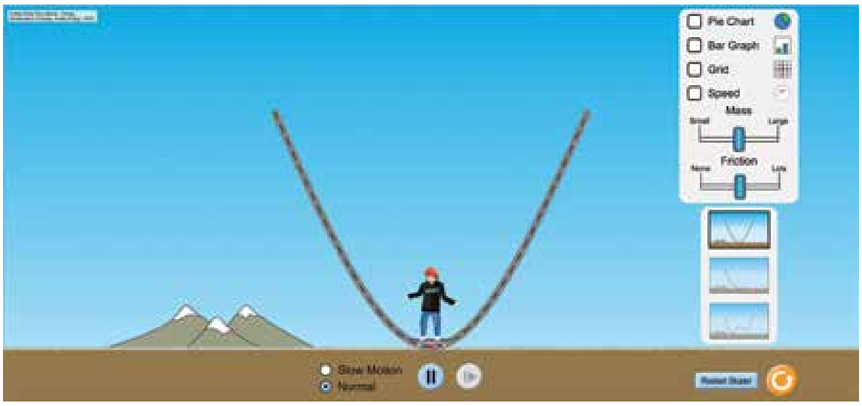
There are three activities in this simulation:

1. The first exercise in an **introduction to the energies involved in skating**. Students can examine the skate path on the three different tracks either in slow motion or at normal speed while at the same time viewing the various energies involved on a graph that displays **height**, **mass** and **speed**. The students can use this simulation to discover how **changing the mass of the skater alters the energies involved**.



PhET Interactive Simulations
University of Colorado
http://phet.colorado.edu

2. The second simulation shows the effect of **friction** on the skater. There are **two variables** – the **track shape** and **friction**. The action is viewed within a graph that displays these variables.



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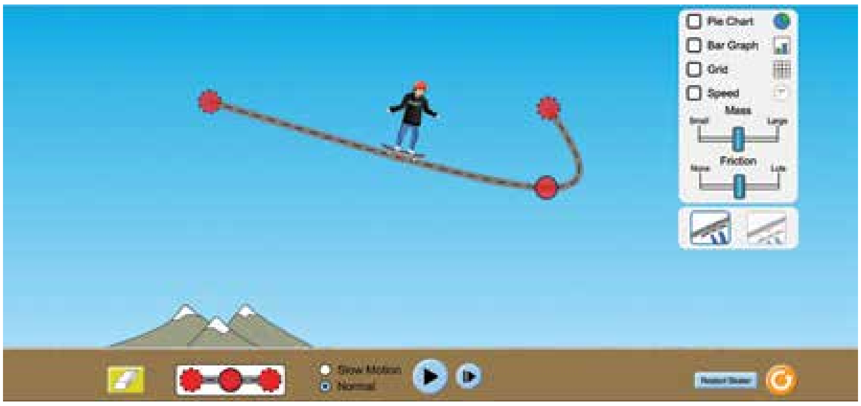
3. The third simulation allows students to design and virtually build their own tracks. They then use these to explain the **conservation of energy**.



PhET Interactive Simulations
University of Colorado
http://phet.colorado.edu

A3: ENERGY AND SUSTAINABILITY

Overview

Everything we need for our survival and wellbeing has always depended directly or indirectly on sustaining a careful management of the natural environment. This need for sustainability has always been addressed, e.g. the rotation of crops is essential to managing the quality of the soil, moving grazing animals is needed to allow vegetation to recover. On the other hand, the damage caused in the American Midwest by the 'dust bowl' storms of the 1930s was partly due to deep soil ploughing resulting in the destruction of the grasses that trapped moisture and prevented the loss of top-soil. Failure to manage a sustainable balance between cash crops and food has contributed to poverty in many countries. There is an even greater focus now on sustainability for the following reasons: rapid population growth, economic growth and the consequential consumption of our natural resources.

In **1972 The United Nations General Assembly** convened at the **United Nations Conference on the Human Environment**, or the Stockholm Conference. This conference introduced environmental concerns into the formal political development sphere, focusing on human interactions with the environment. Among the key resolutions were that Earth's capacity to produce renewable resources should be maintained and that non-renewable resources should be shared and not exhausted.

To rally countries to work and pursue sustainable development together, the **UN General Assembly** established the **Brundtland Commission** in **1983**. The Commission published *Our Common Future*, also known as the *Brundtland Report*, in **1987**. The report aimed at promoting a sustainable development path, and recapturing the spirit of the **Stockholm Conference**. The document coined, and defined the meaning of, the term 'sustainable development' i.e. to maintain 'developments that meet the needs of the present without compromising the ability of future generations to meet their own needs.'

The limit of our resources is illustrated by the first two activities – **A3 ACTIVITY 1: VISUALISING: WHY SUSTAINABILITY? IS THERE ENOUGH LAND FOR EVERYONE?** and **A3 ACTIVITY 2: VISUALISING: WHY SUSTAINABILITY? HOW MUCH FRESHWATER IS THERE?**

Suggested approaches:

- Before introducing any of the activities, pose the following questions to the class:
  - ? *Is there an **energy crisis**?*
  - ? *If so, what does this mean?*
  - ? *What do the words **sustain** and **sustainability** mean?*
  - ? *Apart from the Sun, what energy resources do we have on planet Earth?*
  - ? *Which of these resources are essential for living?*
  - ? *How can we replenish these resources?*
  - ? *How long would it take to replenish these resources?*
- Alternatively, divide the class into groups and assign one of the above questions to each group. Record the responses for future reference. These questions should lead the students to understand that when resources like oil or coal have been depleted, there is no way they can be created again. The time spent need not be too long as the overall aim is to show that a number of our energy resources are indeed finite, i.e. should a crop fail or seeds be destroyed then there is no agency outside Earth to replace them.
- Let the students draw up a list of what they consider to be an **energy crisis** and how it might be addressed.

- Challenge them to list examples of **energy conversion applications** in everyday living and ask them which of these could be considered **energy efficient**.
- Former president of Ireland, Mary Robinson, founded the **MARY ROBINSON FOUNDATION: CLIMATE JUSTICE** which facilitates action on **climate change**. Challenge the students by posing the following questions for discussion:
  - ? *What exactly is **climate justice**?*
  - ? *Why was the Mary Robinson Foundation set up?*
  - ? *How are people affected by **climate change**?*
  - ? *How do we contribute to **climate change**?*
  - ? *How should we contribute to **climate change**?*
  - ? *What impact could a **rising population** have on **energy resources**?*
- Another approach would be for the students to carry out the two activities and then use them to generate discussions on: land ownership vs. usage, population demands, the conservation of water, the role of ethics in society, how lifestyle changes might make land sufficiency easier (eating less meat, eating seasonal foods, composting to replenish the soil, etc.).

Resources:

- The Mary Robinson Foundation website provides access to a number of fascinating studies and videos. Encourage your class to browse the website, or summarise some of the information for them.
- Click here to download the Principles of Climate Justice.
- This link contains a wealth of information generated by SEAI for the One Good Idea project.
- The SEAI website has a useful outline of how **a sustainable energy community** works.
- The USA Environmental Protection Agency website provides a simple introduction to the terminology and facts about climate change.
- Click here for a graphic presentation of the population status in 2050 to show in class.
- Click here to download a short booklet on population and water resources.
- **Trócaire** has a great website on climate change and the effects it has on people in the poorer parts of the world. Click here to access their education resources.
- For examples of ways to live sustainably, show the Eco Eye TV programme on Sustainable Communities in class.

A3 ACTIVITY 1: VISUALISING: WHY SUSTAINABILITY? IS THERE ENOUGH LAND FOR EVERYONE?

Background

It can be difficult for students to understand sustainability as it relates to their everyday lives. The following activity uses a map of the world and an apple to demonstrate visually why urgent management of our energy resources is so important.

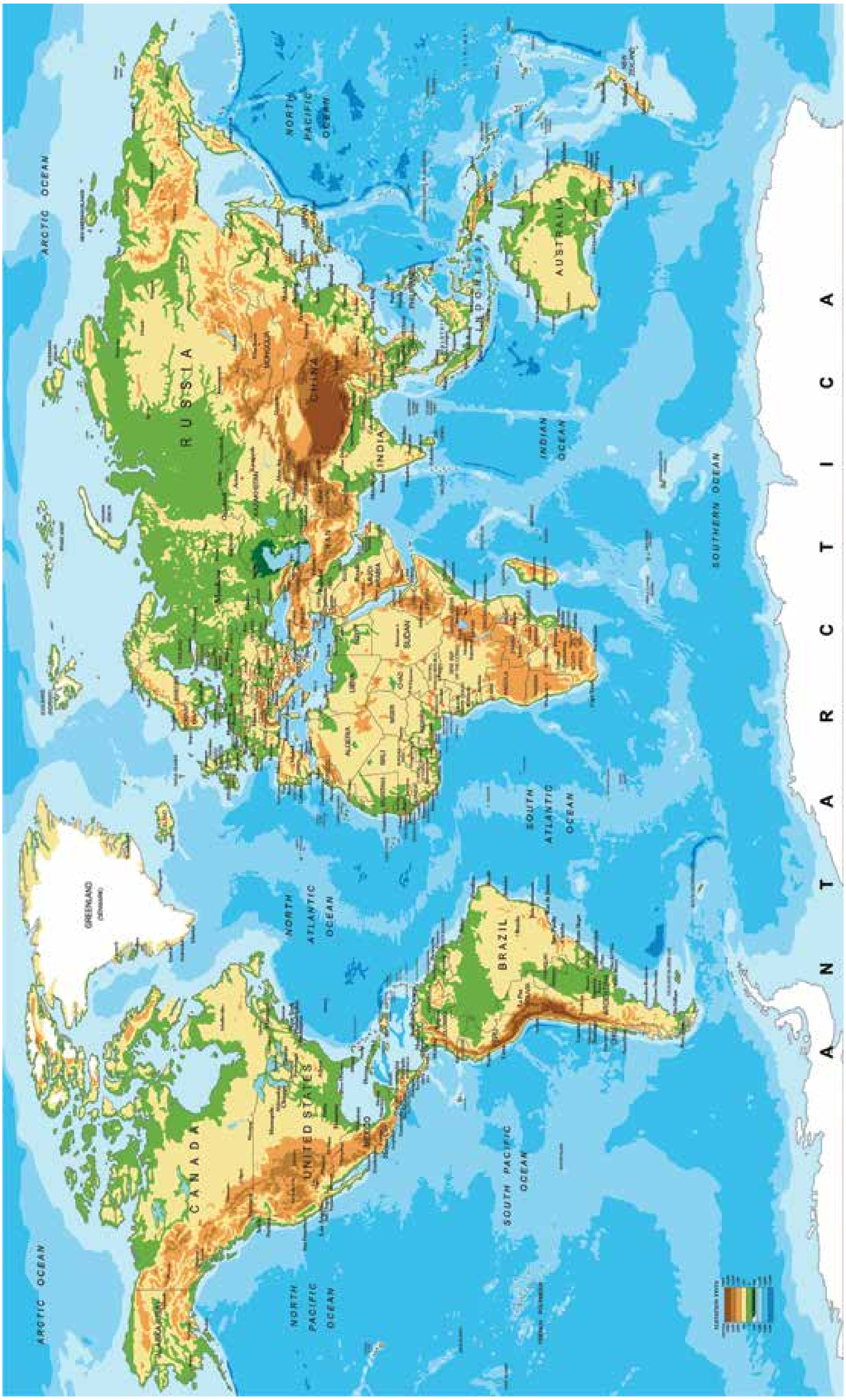
The apple is divided into segments representing water and land (arable, habitable, etc.), and these areas are marked off on the map.

Equipment required:

- Melon (for a class demonstration) or one apple per pair of students – the fruit represents the Earth
- Knife
- Map of the world (marking the topographical features if possible)

What to do:

1. Print out copies of the map below and give one to each pair of students, or a large class size map will suffice.
2. Explain to the class that the fruit represents the planet Earth.
3. Divide the apple or melon into quarters.
4. Set three of these quarters aside, explain that they represent all the water on Earth and will be revisited later. Mark all the water areas on the map.
5. Explain that the remaining quarter of the fruit represents the land, then divide this segment into half giving you two one-eighth pieces of the world (half of a quarter).
6. Explain that one of the eighths represents land which is inhospitable (i.e. not suitable for people to live on). Set it aside. Mark on the map what land you would consider inhospitable, for example, mountains, deserts…
7. Referring to the already marked map, ask the class if there is much land which is not marked?
8. Divide the second eighth into four equal pieces. Explain that three of these pieces represent poor areas for producing food: areas covered by buildings, roads, cities, factories, 'out-of-town' shopping centres, etc.
9. Carefully peel the skin off the last eighth. Explain that the skin represents all the arable land on the surface of the Earth.
10. Ask the class if they have any comments on the amount of land in the context of the Earth's population? Is there enough to sustain a growing population?
11. Return to the three quarters that were set aside (in step 4 above) – explain that though these represent all the water on the planet, not all the water is potable. Ask the class to look at the map and, if possible, to estimate how much of the water is potable.


ARCTIC OCEAN
NORTH PACIFIC OCEAN
RUSSIA
CHINA
INDIA
INDONESIA
AUSTRALIA
INDIAN OCEAN
SOUTHERN OCEAN
SUDAN
SOUTH ATLANTIC OCEAN
GREENLAND
NORTH ATLANTIC OCEAN
BRAZIL
CANADA
UNITED STATES
MEXICO
SOUTH PACIFIC OCEAN
ARCTIC OCEAN
NORTH PACIFIC OCEAN
A N T A R C T I C A

A3 ACTIVITY 2: VISUALISING: WHY SUSTAINABILITY? HOW MUCH FRESHWATER IS THERE?

Background

This activity complements **A3 ACTIVITY 1: VISUALISING: WHY SUSTAINABILITY? IS THERE ENOUGH LAND FOR EVERYONE?** The measures used are approximate ones but still within the same ratio frame and should illustrate how scarce freshwater is and why we need to be careful using it. The difficulty is in understanding, and appreciating, that the quantity of water on Earth is actually finite – there is no agency outside Earth waiting to replenish it – all our water is continually being recycled in various forms.

Equipment required:

- Empty container with a four-litre capacity, or
  Four containers with a one-litre capacity each if a single container with a four-litre capacity is not available
- Two beakers, each with at least a 100 ml capacity
- Pipette and filler, or a large volume syringe
- Blue food dye
- A small amount of table salt
- Map of the world (marking the topographical features if possible)

What to do:

1. Print out copies of the map above and give one to each student, or use a large map for the whole class.
2. Fill the container with approximately four litres of water. Explain that this represents the total amount of water on Earth.
3. Using a pipette or a syringe, remove 90 ml of water, transfer it to one of the 100 ml beakers and set it aside.
4. Add a few pinches of salt to the water left in the large container. Explain that this water now represents the oceans, i.e. water not suitable for immediate human usage. (You can explain that some countries are investigating desalination processes but it is very expensive both financially, and in terms of energy consumption.)
5. Return to the 90 ml set aside (in step 3). Add a few drops of the blue food colouring to this water. Explain that this water represents freshwater…
6. **BUT** that not all this water is accessible. Using the pipette remove about 80 ml of the water and put it out of reach. This represents water trapped in glaciers or too deep underground to be accessible.
7. Explain that what remains in the 100 ml beaker represents the amount of water available for daily use by the entire planet, e.g. agriculture, potable water, industry, freshwater ecosystems.
8. Explain that forecasts indicate that the world population will reach 9.6 billion by 2050 but the quantity of water available for daily use will still be represented by the quantity left in the 100 ml beaker. Ask the question, Why is this?

A4: EXPLORING OCEAN AND TIDAL ENERGIES

Overview

One of the **EU 2020 goals** is to raise the share of energy produced from renewable sources to **20%** by **2020**.

Renewable energy sources accounted for almost **12%** of the **EU-28's gross inland energy consumption** in 2013. **This is almost one quarter of EU energy production**. Renewable energy production in the EU is growing at a rate of over **6% per year**. In 2013 Ireland's share of renewable energy in the final consumption was **7.8%.**

Over **97% of all the water on Earth is contained in the oceans**. However, it is saltwater, thus undrinkable for humans. Desalination might be the answer but this process is very energy intensive. Perhaps the fact that only **about 5% of the oceans have been explored** may be one of the reasons why the use of the ocean as a potential renewable source of energy is just beginning. Current research presently concentrates on harnessing tidal, and wave, energy. Both sources have their respective advantages and disadvantages. **Exploring Ocean and Tidal Energies** enables students to explore both of these energies – the advantages, disadvantages and ethical issues involved in developing each of these energies.

A4 ACTIVITY 1: FARADAY'S EUREKA MOMENT is an activity that introduces the students to the principle of electromagnetic induction and shows that electricity can be generated using a magnet and a coil of wire.

A4 ACTIVITY 2: WHAT MOVES? looks at how Faraday's principle is still being used in power plants to generate electricity.

In **A4 ACTIVITY 3: ENERGY FROM THE SEA**, students explore the emerging new technologies that use waves from the ocean to generate electricity.

Earth's non-renewable resources, particularly oil, are running out. Transport is one of the greatest consumers of energy, and currently relies predominantly on oil. **A4 ACTIVITY 4: EXPLORING ELECTRIC VEHICLES (EVS)** looks at an alternative transport programme being led by SEAI in the Aran Islands.

Suggested approaches:

- Ask the class to think about the following questions:

  ? ***What would a typical weekend be like if there was no electricity?***

  (Ask members of the class to tell you what they are doing this weekend. Point out all the ways in which it would be different without electricity.)

  ? ***How dependent are we on electricity?***

  The questions serve to highlight our **dependence** on electrical energy and to help students to understand how the issue of **renewable energy relates to them**.

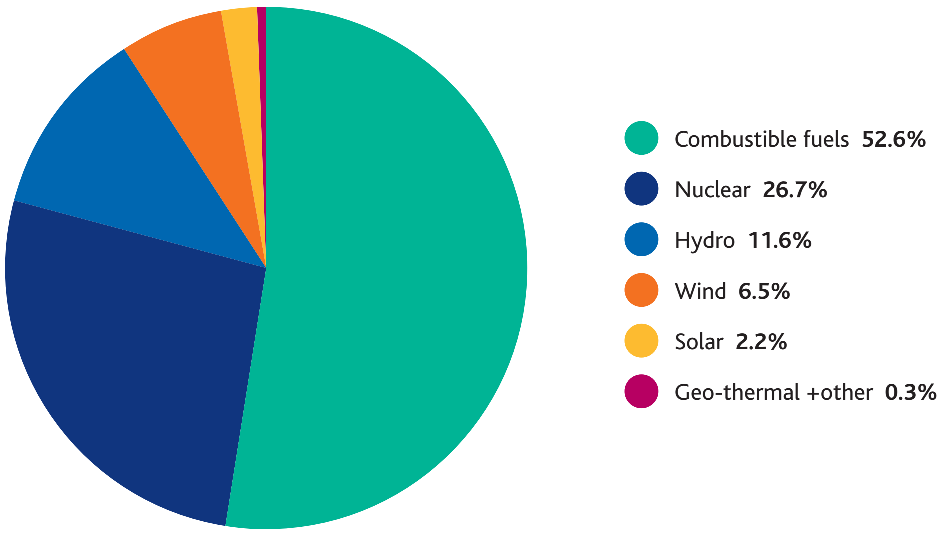
- Start by getting the students to list the various primary and secondary resources used to generate electricity. Then hand out the following, and ask the students to link the percentage of electricity generated (column A) to the sources that generate it (column B).

A: Percentage of Electricity	B: Generated by
6.5%	Hydro
52.6%	Wind
0.3%	Geothermal and others
2.2%	Combustible fuels
11.6%	Nuclear
26.7%	Solar

Source: Eurostat (online data code:nrg_105a)

When this is completed, show them the following chart.

A short discussion may take place comparing their results with those represented on the actual pie chart.



Source: Eurostat (online data code: nrg_105a)

A4 ACTIVITY 1: FARADAY'S EUREKA MOMENT

Background

In **1831 Michael Faraday** discovered that moving a magnet in and out of a coil of wire produced what he called a **wave of electricity**. He found that this **wave of electricity** only occurred as the magnet was moving in and out of the coil. This was a new discovery – electricity without the need for a battery!

Faraday had discovered the principle of **electromagnetic induction**, which is still the basis for generating electricity. The aim of this activity is for the students to replicate Faraday's original experiment in order to appreciate how ocean and tidal movements are used to generate energy.

Equipment required:

- Strong neodymium magnet
- Solenoid of at least 1,000 turns
- LED
- Crocodile clips and leads

What to do:

1. Connect the LED across the solenoid.
2. Quickly bring the neodymium towards the solenoid as shown.
3. Ask the class what they noticed about the LED.
4. Let the neodymium quickly slip through the solenoid and take note of the appearance of the LED.
5. Ask the class to identify when the LED lights up and what they conclude from their answer.

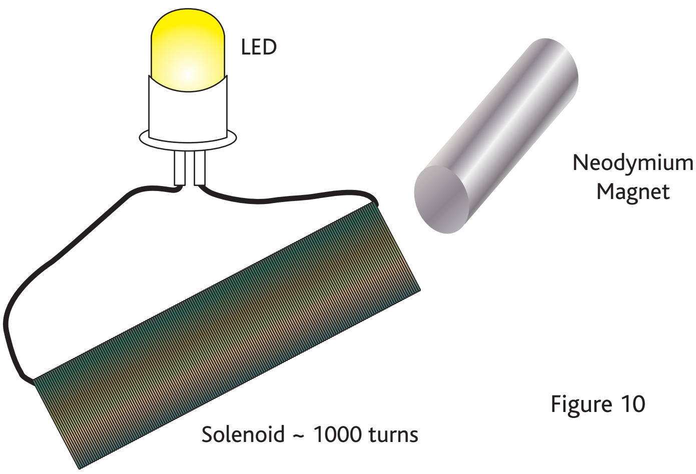


Figure 10

ALTERNATIVE ACTIVITY

Equipment required:

- Strong bar magnet or barrel neodymium magnet
- Galvanometer (an instrument that detects electric current)
- Insulated copper wire
- Cardboard tube
- Crocodile clips plus leads
- Sandpaper

What to do:

1. Wrap the wire around the cardboard tube to form a solenoid.
2. Scrape both ends of the wire clear using sandpaper.
3. Connect the solenoid to the galvanometer.
4. Quickly bring the magnet towards one end of the solenoid and observe the galvanometer.
5. Withdraw the magnet and observe the deflection of the galvanometer's needle.

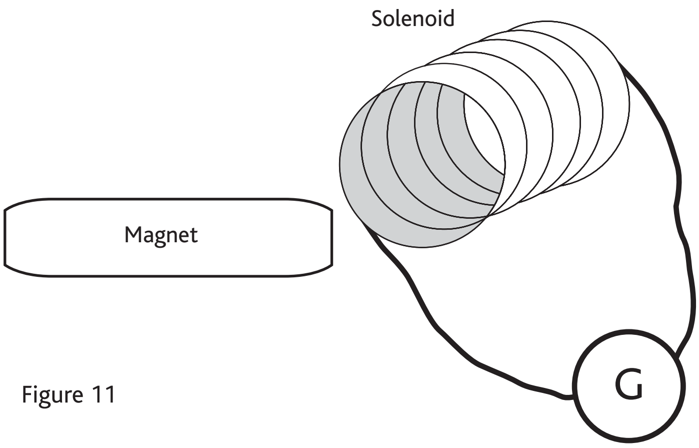


Figure 11

In your own words write a brief summary of the activity and explain why it is considered to be one of the most important experiments ever carried out.

A4 ACTIVITY 2: WHAT MOVES?

Background

Faraday used the principle of **electromagnetic induction** to construct the **dynamo**, which could be considered the forerunner of modern power generators. The principle of **electromagnetic induction** is still fundamental to all energy generators. Having carried out Faraday's classic experiment the next step is to explore **how this principle is present** in many of the ways in which **primary** and **secondary sources** are used to address energy needs.

What to do:

1. Arrange the students into teams and assign each team one of the following electrical energy generators:
   a) Coal burning generators
   b) Natural gas burning generators
   c) Nuclear power plants
   d Wind farms
   e) Hydro power generators
2. In the case of each of the generators consider the following:
   - ? ***What primary source is used?***
   - ? ***Is the primary source freely available?***
   - ? ***If it is not freely available, is it available locally?***
   - ? ***If it is not available locally, from where can it be obtained?***
   - ? ***How is the primary source used to generate electricity?***
   - ? ***How are each of the following used to generate electricity?***
     i) Steam turbines
     ii) Gas combustion turbines
     iii) Water turbines
     iv) Wind turbines

- What environmental issues might be associated with your assigned generator? How are they addressed?

Each team will decide how to present their responses (e.g. poster, oral, PowerPoint presentation, pamphlet). Encourage them to be creative and imaginative.

A4 ACTIVITY 3: ENERGY FROM THE SEA

Background

As the non-renewable energy resources are dwindling, the demand for energy is increasing. Despite over 97% of the Earth being covered by water, using it as a primary source of energy has not really been exploited until now. **Ocean energy** is also referred to as **marine energy**. The movement of the oceans creates a vast store of kinetic energy – waves, tides, temperature differences – all of which can be used to generate electricity. The rhythmic nature of the oceans is more reliable for generating electricity than the unpredictable and random nature of wind.

Suggested approaches:

- Ask the students to compare the advantages of solar energy with those of wind energy. What might the disadvantages be – Is wind energy always available? How can it be used to generate electricity? What about solar energy, can we depend on it? What about the seasons? Could it be too hot for solar panels to work? (You might like to show this video to help the discussion http://www.livescience.com/39409-new-sun-reflecting-london-skyscraper-melts-cars-video.html). Do the advantages outweigh the disadvantages?

  The following video is an excellent introduction to wave energy, https://www.youtube.com/watch?v=bEfrtAOMuvk.
- How many advantages can the students list for developing ocean energy? What is the source material? What might some of the disadvantages be? Are there any ethical issues to consider – for example, what about marine habitats? Which should have priority, our need for energy or marine life?
- The two sheets – **A4 ACTIVITY 3 (I) DISCUSSION POINTS: WIND VERSUS SUN** and **A4 ACTIVITY 3 (II) DISCUSSION POINTS: WHY GO TO THE SEA?** – could be used as guidelines for debating the issues, providing students with the opportunity to carry out their own research and then present their arguments.

Resources:

1. https://www.youtube.com/watch?v=Tsyx1qhzy08

   This short video describes how waves are created in the test laboratory at Cork University.
2. http://www.oceanenergyireland.com/Planning

   This is a short introduction to converting tidal power into electricity.
3. http://www.oceanenergyireland.com/TestFacility

   This site looks at the Atlantic Ocean as a power source.
4. http://www.oceanenergyireland.com

   This is a short video making the case for developing ocean energy.

A4 ACTIVITY 3 (I) DISCUSSION POINTS: WIND VERSUS SUN

1. Is wind energy always available?
2. Is it possible to predict how much energy the wind will generate in any given place at a given time?
3. Is energy lost in storage?
4. How can wind energy be used to generate electricity?
5. Can we depend on the quantity of energy generated by the sun in any given place?
6. Is it ever too dark for solar panels?
7. Is it ever too cold for solar panels?
8. Is it ever too hot for solar panels?
9. How can solar panels be used to generate electricity?
10. List some disadvantages of using wind energy.
11. List some advantages of using wind energy.
12. List some disadvantages of using solar energy.
13. List some advantages of using solar energy.
14. List some advantages of solar energy over wind energy.
15. List some advantages of wind energy over solar energy.
16. What is the role of ethics in research?

A4 ACTIVITY 3 (II) DISCUSSION POINTS: WHY GO TO THE SEA?

1. List some advantages for Europe in developing ocean energy.
2. List some advantages for Ireland in developing ocean energy.
3. Which energy sources are harnessed when using the ocean as an energy generator?
4. List some possible disadvantages of using the ocean to generate energy.
5. What is the role of ethics in research?
6. What effect could using the ocean have on marine habitats?
7. Our need for energy could compromise marine life — which should have priority?
8. What ethical issues might need to be considered before embarking on harnessing ocean energy?

A4 ACTIVITY 4: EXPLORING ELECTRIC VEHICLES (EVS)

Background

Petrol and **diesel** have been the principal transport fuels ever since the invention of the **internal combustion engine** in the late nineteenth century. This tradition relies on **fossil fuels** and creates **CO_2**. Today we are looking for alternatives. **Battery powered motors** already exist, but the limited achievable travel distance means that electric cars are not yet rivalling **petrol** or **diesel** cars in terms of practicality or performance.

Since the first safe prototype, a **lithium ion battery**, was built in 1985, the replacement of petrol or **diesel** powered vehicles with electric alternatives has become increasingly likely.

In this activity students **compare and contrast** an **electric car** with a **petrol** or **diesel** one.

Suggested approaches:

- Ask students to brainstorm about their understanding of electric cars in groups. A summary of ideas could be written up for further reference.
- Show the Science Squad video available on the SEAI site. After seeing the video the students can revisit the earlier discussion and see how the video affects their original findings.

What to do:

1. Divide the class into three groups:

   Group A is the sales group. The members must devise a campaign to sell an electric car like the LEAF and present a sales pitch to the class.

   Group B is another sales group. They are selling traditional cars and must draw up a number of arguments against electric cars in favour of petrol driven cars. They must present a sales pitch focusing on the advantages of traditionally powered cars over electric vehicles.

   Group C is a client group. The members do not know whether to buy an electric car or a traditional car. They must draw up a list of questions for the sales groups.

2. Using the SEAI programme Aran Island Electric Vehicle as their case study, and drawing on other **resources**, each group should write a summary of the programme, describing it from their assigned viewpoints.

   The groups should present their cases to the class within a given time frame, and this should be followed by a questions-and-answers session.

3. The groups can disperse, and a final discussion can take place where students give their individual opinions about electric vehicles and the teacher evaluates the presentations with the class.

Resources:

- The Aran Island Electric Vehicles webpage is essential to the task.
- Click here for a pdf booklet on the Aran Islands Electric Vehicles programme.
- The ESB webpage on electric cars could prove useful.
- Click here for RTE coverage of electric cars, including the Aran Island project.