Topic Overview

Background and suggested aims

Aims

- To develop an understanding of energy within the confines of the curriculum appropriate for year 7-9 pupils
- To appreciate the range of energy resources (fossil fuels, renewable energy etc.) that are and the limitations of such resources
- To develop and understanding of the hazards of energy generation, from pollution to declining availability of resources
- To appreciate the distinction between conservation of energy, which is a law of nature, and the preservation of our energy resources
- To appreciate that as energy resources decline, there is pressure to access new sites in areas of outstanding natural environment
- To discuss some of the vague and non-scientific terms using 'energy' and to clarify misunderstandings and pseudo-science

Lesson summary

Lesson	Content summary	National curriculum links	Activities
Lesson 1: Types of energy	Introduction to types of energy and the question 'what is energy?'	**Changes in systems:** energy as a quantity that can be quantified and calculated; the total energy has the same value before and after a change	Brainstorming types of energy Energy bingo – identify types of energy
Lesson 2: Energy Circus	Identifying energy conversions	**Energy changes and transfers:** other processes that involve energy transfer: changing motion, dropping an object, completing an electrical circuit, stretching a spring, metabolism of food, burning fuels. Changes in systems: comparing the starting with the final conditions of a system and describing increases and decreases in the amounts of energy associated with movements, temperatures, changes in positions in a field, in elastic distortions and in chemical compositions	Demo: energy circus for types of energy
Lesson 3: Energy conservation	Use of the word 'conservation' in different contexts	**Changes in systems:** energy as a quantity that can be quantified and calculated; the total energy has the same value before and after a change	Discussions

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Lesson summary cont.

Lesson	Content summary	National curriculum links	Activities
Lesson 4: Energy resources	Renewable and non-renewable energy resources definitions and examples	**Energy:** fuels and energy resources.	Discussions UK Gov statistical spreadsheet references
Lesson 5: Woolly energy	Uses of the word energy in pseudo-scientific contexts	**Scientific attitudes:** pay attention to objectivity and concern for accuracy, precision, repeatability and reproducibility; understand that scientific methods and theories develop as earlier explanations are modified to take account of new evidence and ideas, together with the importance of publishing results and peer review	Examples, reading and studying websites

Background

This topic builds on the standard year 7 curriculum topic of energy. Some novel ways of approaching the material are suggested, allowing links to other subject areas to be developed. In particular, students should see links to geography in the discussion of energy resources and environmental impact. At the end of the topic, there is the chance to explore how word usage in science is generally more precise than in everyday language and how in some contexts terminology from science is used to make claims appear scientific when in fact they are not acceptably evidence-based.

Teacher background knowledge

Physics teachers will have the requisite knowledge of forms of energy, energy transfers, energy resources and conservation of energy. However, they may not be familiar with perspectives presented in geography, including the geopolitical issues involved. Several internet sites and referenced below, where teachers can augment their knowledge and use selected highlights with the students.

Cross-curricular links

There are links to geography in discussing the availability of energy resources and the polluting impact of their use, both in terms of chemical emissions and the impact on the natural environment of their extraction. Some discussion of the controversy surrounding fracking is appropriate (see the companion topic in Chemistry).

Tentative links can be drawn with philosophy. Issues relating to pseudoscience are addressed along with loose language in the context of energy ('healing energy', for example but also 'I've got no energy today'). Another worthwhile point that can be developed surrounds the definition of what energy is. At a fundamental level, arguably we do not know what energy is, but we know how it behaves and the rules that govern its properties. As a primary aspect of nature, this might be the best that we can hope for until some more fundamental understanding develops.

Student background knowledge

This is a topic that is generally covered early in the year 7 curriculum, and so there is no required prior content. However, any exposure that students have had to different forms of energy is helpful. However, be aware that confusions might have developed: it is common to confuse energy and force, for example. Some background knowledge, or learning from geography, regarding types of energy resource is useful along with some awareness of environmental change and its link to energy generation.

Useful internet sites

Energy Resources

https://www.nationalgeographic.org/topics/resource-library-energy-resources/?q=&page=1&per_page=25 National Geographic resources page with a focus on energy resources from the perspective of geography

https://www.bbc.co.uk/bitesize/guides/z3pppv4/revision/1 BBC Bitesize page with useful data on energy resources with a geographical perspective. It is worth showing some of the maps of resource distribution.

https://www.bbc.co.uk/bitesize/guides/zxc2sg8/revision/1 BBC Bitesize section discussing energy production and consumption. Useful material here which re-enforces connections with geography, but from a political and economic perspective not simply geophysical.

https://en.wikipedia.org/wiki/Energy_development

Energy healing

https://www.asbestos.com/treatment/alternative/energy-therapies/

https://www.timothypope.co.uk/what-is-energy-healing/

https://www.mindbodygreen.com/0-23890/what-everyone-should-know-about-energy-healing.html

https://en.wikipedia.org/wiki/Energy_medicine

Activities

The following notes are based on lessons of ~ 50 mins duration. The teacher is free to re-arrange content in a manner that best suits the curriculum context and the students involved.

Lesson 1: Types of energy

A good way to start the lesson is by 'brain-storming' forms of energy that the students may have heard about already. Use a board or software equivalent to compile a list based on their answers. Expect some pupils to suggest energy resources, such as coal, oil etc. rather than forms of energy. Add these to the list but in a separate column and work around to the idea that these are either just different forms of chemical energy or rely on different forms of energy (e.g. windmills rely on movement energy). Point out that the topic of energy resources is an important one that will be re-visited in a later lesson.

Energy Bingo: place at various points around the lab a collection of images showing various forms of energy e.g. a light bulb, a car in motion, a burning wood fire, a bowl of breakfast cereal, overhead power lines, a hamburger, a rocket, a stretched bow, a megaphone being used, a climber scaling a wall or mountain etc. Each illustration has a number. Students, in pairs, are provided with a 'bingo card' showing a table with different forms of energy (light, movement, thermal, chemical, electrical, movement, elastic, sound, gravitational etc.). They move around the lab writing the number on the image next to the form of energy that they have identified in the image. A prize can be issued for the group with the most correct answers. It is useful to delay the traditional energy circus until after this exercise, as the circus can re-enforce the learning, but also as the situations set up in the lab can be used to develop the idea of energy transformations.

Having discussed various forms of energy, and depending on the ability level of the group, you can tentatively explore the question "what is energy?". Point out that listing the various forms of energy is not answering that question. Listing the different types of plant does not directly address the question "what is a plant?". An alternative analogy to explore would be "what is money?", which comes in different forms: coins, notes, cheques, cards, electronic transfers etc. Another good analogy which might be more easily discussed with some groups is the question "what is a game?". In each case, reasonably sound answers can be given to the question, but in order to do so more fundamental concepts have to be drawn upon (e.g. cells and photosynthesis, or exchange of goods and services). It is *not* suggested that you need to explore these ideas in detail with the pupils. Be guided by the ideas that they suggest as to their level of understanding.

In the case of energy, it is not easy to produce a basic definition. A standard definition along the lines of 'energy is the capacity to do work', is of dubious scientific benefit and constructed more to provide some answer than to develop fundamental ideas. Unpacking such a statement to understand what is meant by work, capacity and how this relates to energy shows what little benefit is developed from this definition. The situation is similar to that surrounding the question "what is mass?" and the standard answer 'the amount of matter in an object' which can be seen as raising more questions than it answers and is of little value in terms of developing new lines of thought. It is good to point out to classes that there are some mysteries left in science, especially when it comes to fundamental aspects of nature. Even though we do not have a tidy definition of what energy is (largely, as definitions in physics specify things in terms of more fundamental aspects of nature, and there is nothing more fundamental than energy …), we know enough about how it works and what it does to be able to carry out good science. Arguably, an operational definition of this sort is all we can expect.

Lesson 2: Energy circus

The core of this lesson is the traditional energy circus. Set up around the lab a range of different stations. Each one contains a short demonstration of energy transfers.

Suggestions include:

1. A lit candle (with accompanying appropriate safety warnings)
2. A wind-up car if available
3. A ramp or similar down which a car or a ball-bearing can roll
4. A battery-powered electric motor at the edge of a bench and set up to lift a small weight from the floor
5. A photocell connected to a voltmeter, with a black card to cover the cell and a torch to provide direct light
6. A small turbine connected to fan blades and a hairdryer to provide 'wind'; the turbine can be connected to a small light in order to demonstrate that it is producing electricity.

Provide pupils with a worksheet that lists each station with boxes for 'energy is converted from .... to ....'. Some students will not be sure where to start the chain of energy conversions. In the case of the wind-up car, for example, is the energy the movement of you winding it, the elastic energy stored in the car, the muesli energy stored in your body that allows you to wind it, or something else? In the case of the candle, it could be energy related to the match that lit it, the movement of the person lighting the match etc. Use such questions as opportunities to congratulate students on raising such issues and point out that there are often interconnected links in a chain of events, and if explored fully could potentially take us right back to the Big Bang! In answer to this, students may express concern regarding examinations or tests – not knowing where to start the chain in answer to a question. Reassure them that in an examination question it will be a simple example and that they should start with the most obvious form of energy within the device itself (e.g. the elastic energy in the car, the chemical energy in the candle).

The idea of friction will almost certainly come up in one context at least. Indeed, friction may have been suggested as a form of energy in the previous lesson's brain-storming session. Be clear that friction is not a form of energy (students often confuse forces and energies), but that it can cause an energy change, most often from movement energy into thermal energy.

Close off the lesson with a discussion of the various examples. Develop the idea that energy changes are a key aspect of nature. Challenge the pupils to think of something happening in nature that does not involve an energy change. Note that there are two varieties of energy change:

- An energy **transformation** from one form to another
- An energy **transfer** from one object to another which can happen separately, or together. Use their examples to explore these two options.

Lesson 3: Energy conservation

Lesson 2 explored the idea that energy can be changed from one form to another and move from one object to another. Recap these ideas and challenge the pupils to consider what rules might be involved. Address and explain the idea of conservation of energy: the total amount of energy in the universe never changes. Some students might ask how we can possibly know that this is true, which is an excellent opportunity to suggest that if the rule works for every energy change, then it must work for the universe as a whole: in any energy change, the total amount of energy remains the same. It is worth referring back to the energy circus and the energy transformations that they identified in the previous lesson. Point out that in some cases it might appear that energy is 'lost' (e.g. the wind-up car, the ramp etc.), but in fact the conversion of energy into thermal energy (and sometimes sound and light) accounts for the missing amount. If the curriculum calls for it, Sankey diagrams could be introduced at this stage, in which case some of the subsequent discussion suggested here for this lesson would be best postponed to the following lesson. You can also take the view that a more in-depth discussion of renewable and non-renewable resources would be better before the next lesson, depending on the level of prior pupil knowledge.

Ask pupils to jot down any phrases they can think of where either the word 'conservation' or 'conserved' is used (correctly). If they are coming up blank, direct them towards environmental concerns. Give them a couple of minutes to discuss, and then bring ideas together. Hopefully you will get at least two versions along the lines of:

"we need to conserve our energy"

"wildlife conservation is important"

or similar.

In the first case, ask them why that is an issue; after all, we have a rule that says energy is conserved! Bring back the idea of energy **resources** from the first lesson. Conserving our energy really means 'preserving our energy resources'. Equally, an aspect of wildlife conservation is the preservation of endangered species. The learning opportunity here is that words with precise scientific definitions sometimes have wider meanings in everyday language. Students need to appreciate the difference. (Another good example of the same issue is *power*. The American President is a powerful person, but probably does not convert energy rapidly …) Using language with precision in this way serves to make ideas clearer. In particular, the distinction between forms of energy and types of energy resource is important. Left unaddressed, misunderstandings about the scientific meaning of energy conservation could fester and block further development at a later stage.

Lesson 4: Energy resources

Depending on the level of prior knowledge, all or part of this lesson should be devoted to:

- Renewable and non-renewable resources: good definitions are:
  Renewable – energy resources which can be replaced over a realistic time scale (biomass), or which exist in such abundance we are never realistically going to consume them (sunlight and all forms derived from it, geothermal)
  Non-renewable – energy resources that cannot be replaced over a realistic timescale
- Types of energy resource and how they are categorised (see above)
- Pollution created by consuming energy resources
- Environmental impact of extracting energy resources.

Re-emphasise from the previous lesson (or develop for the first time) the distinction between *conservation of energy* (a law of nature that is always followed) and *preserving energy resources* (running out of stores of energy). Consuming an energy resources does not cause energy to vanish from the universe, but it can convert it into a form that is useful (thermal to generate electricity) and into a form that is not useful (thermal that is lost into the surroundings) and once this conversion has happened, it cannot be fully reversed. Some students might appreciate the point that once thermal energy is lost to the surroundings, it spreads out so much that it cannot be used to generate electricity etc.

Preserving our energy resources is not just a matter of trying to find new (renewable, or more efficient) ways of generating electricity, it is also about reducing our consumption. Interestingly, the demand for electricity in the UK has fallen in recent years. The drive to embrace more efficient forms of energy consumption (LED lighting, for example) has been a significant factor. An interesting piece of project work for the pupils would be to research this aspect, and perhaps generate posters advertising the effectiveness of more efficient lighting in stabilising demand. Of course, lighting is just one aspect of this, perhaps the aspect students will be most familiar with, but the general drive to produce more efficient devices has had an impressive impact.

Cross-curricular links can be developed here with geography by looking at environmental impact of extraction, where in the world various fossil fuels are mined (if you have discussed nuclear power, then uranium as a resource and where that is extracted is a useful topic to discuss). The various websites referenced previously give ample resources and information to help develop this perspective.

The maps and charts relating to energy production and consumption from: https://www.bbc.co.uk/bitesize/guides/z3pppv4/revision/1 can be especially useful.

Lesson 5: Woolly energy

Start this lesson by writing or projecting onto the board:

"I have no energy today …".

If you wish to be slightly theatrical about it, you can slump into a chair and sigh …

Now challenge the pupils to examine that statement in order to discern what it actually means. Ask them to consider times when they have felt the same. What would be the consequences to a person if they really had *no* energy? Try recasting the statement in the form:

"I feel really tired/run down/lacking motivation/unable to focus/sad/depressed/blue etc."

While this is quite a harmless misuse of a specific term, suggest that there are other contexts in which ostensibly scientific language is being used in a manner that is either manifestly not scientific, or at least unproven.

Here is one useful example taken from an easily accessible website:

"The one thing that is undoubtedly universal amongst all of us is energy. It is the pervasive force that allows for life to exist and flourish, yet our westernized minds are often reluctant to embrace it as something that should be considered in medicine."

From https://www.gaia.com/article/5-methods-for-energy-healing

Ask the students to discuss the statement in groups (to facilitate this, it could be provided to them on cards). The aim should be to find any examples where scientific language is being used *wrongly*, and anywhere it is being used *imprecisely*. What is the author(s) of the quotation trying to convince us about? The website could be projected onto the board so that students can see the context for the statement.

After this group discussion, ask for feedback from the groups and open up for comments. Ensure that the paragraph's conflation/confusion between *energy* and *force* is noted and challenged. This is a common misunderstanding amongst students and the public at large. The aim of this exercise is not to make fun of the website and its authors, but to point out that scientific language is being used wrongly/imprecisely. At some point in their future, either the students themselves or family or friends will face important decisions about their health and treatment. If such decisions are to be made effectively, then clear language must be used, the distinction made between scientifically proven and unproven and the role of hopes and expectations (the placebo effect) must be understood.

Another useful quotation is:

"Healing techniques, of which there are many different disciplines, are an effective natural aid to self-healing. By removing negativity, giving light healing energy to the client and balancing the energy centres, unhealthy negative energy can be lifted and dispersed by the Energy Healer, helping the energy centres to return to a more balanced functioning."

From https://www.timothypope.co.uk/what-is-energy-healing/

This could also be provided to the students on cards for them to discuss. Key phrases in this quote are:

- light healing energy
- energy centres
- unhealthy negative energy
- Energy Healer.

Examine each of them in turn. Challenge students to identify any dangers in using scientific language in this way. Again, what is the author(s) of the paragraph trying to convey to the reader? Does the word 'client' in the paragraph suggest anything? You can also discuss the phrase "effective natural aid to self-healing" and what it reveals about the rest of the paragraph.

It may be that some of the students have family or friends who have undergone treatments of this type. It is also possible that they may have a family member who is a practitioner. Emphasise that the exercise is not directly about the validity of energy healing as a treatment, but about the use of scientific language in an incorrect / imprecise manner which might confuse some people. The danger of not challenging such practice is that it potentially weakens judgement by relaxing the standards expected. It is possible to imagine some truly dangerous contexts in which people might set out to deliberately create the impression of scientific expertise in order to deceive people for monetary gain or some other purpose. Additionally, significant life decisions could be influenced by language that suggests a degree of precision or an evidence base that is not justified for the claims concerned.

[1] See UK Government statistical data spreadsheet