OUR FUTURE.ENERGY

ENERGY RESOURCES PROJECT

A COLLABORATIVE PROJECT

BY

OURFUTURE.ENERGY AND

THE ASSOCIATION FOR SCIENCE EDUCATION

The Association for Science Education
Promoting Excellence in Science Teaching and Learning

OUR FUTURE.ENERGY

OurFuture.Energy is an online education resource for 11-16 year olds, informing young people of the importance of energy in our daily lives, the basic science behind it and the challenges we face in balancing our energy use and supply to meet demand. Featuring articles, games, animations and videos, all offering an engaging and relatable insight into the energy sector. Supported by major organisations across the energy sector, from oil and gas, nuclear and renewables.

https://ourfuture.energy

The Association for Science Education (ASE) is the largest subject association in the UK. It is an active professional learning community that has been supporting all those involved in science education from pre-school to higher education for over 100 years; members include teachers, technicians, tutors and advisers.

It is a Registered Charity with a Royal Charter, owned by its members, independent of government and therefore a powerful voice for science education. ASE continues to make a positive and influential difference to the teaching and learning of science throughout the UK and further afield. Membership offers lots of unique benefits.

http://www.ase.org.uk/

OUR FUTURE.ENERGY

Energy resources project

Introduction

Energy resources are a key feature of the secondary curriculum and concepts link to other curricular areas within science and the wider curriculum. Exploring energy resources provides students with an insight into their future, as the world's energy mix is likely to look very different in the coming decades as we tackle the challenges of climate change, a growing world population, and the need to connect over a billion people who currently don't have access to electricity.

The *OurFuture.Energy (OFE)* website has a wealth of information, ideas and approaches to the complex issues surrounding the energy industry. Young people of today are the energy consumers and decision makers of the future and it is essential that they have the scientific literacy to make well-informed decisions about energy policy, supply and use. These lesson resources are intended to provide students with a focus through which to explore the resources on *OurFuture.Energy* website collaboratively and largely independent of the teacher. They also provide an opportunity for peer teaching and for students to practice presentation skills. They are designed to provide customisable lessons for teachers, with an open-ended approach for students.

Project aims

- To increase students' awareness of energy issues that they will face during their lifetime, through exploration and evaluation of OFE and other web resources, and through discussion and argument
  with others;
- To provide students with a stimulating and informative exploration of energy issues;
- To evaluate possible local, national and global solutions to energy issues; and
- To explore and stimulate interest in STEM careers related to the energy industry.

Overview of the resources

The resources comprise:

- A teacher guide
- A PowerPoint presentation supporting lesson delivery
- Student guidance comprising:
- Student briefing cards with optional research guidance
- Organising your group
- Top tips for effective collaboration
- PowerPoint presentation guidance and a sample poster presentation to model '*What A Good One Looks Like (WAGOLL)*'

Approaches to delivery

The materials are intended to be used in different ways according to local circumstances. For example, there are suggestions for different lesson structures dependent on class size, student ability and motivation, and students may be offered a choice of presentation formats.

A: All student groups are guided to explore one or more different categories over the course one, two or three lessons. Students present findings as a scientific poster, PowerPoint presentation, cartoon strip or sales brochure

B: Different student groups explore one group of energy resources and use the information to prepare a presentation or poster to peer-teach others in the class

It is suggested that groups comprise three or four students, depending on their ability and motivation. Groups could choose the research focus, or you may prefer to assign this. It may be preferable to assign research foci, as some have fewer 'key questions' for students to address and fewer 'suggested information sources'.

Students can work collaboratively to agree roles within the group, or you may prefer to assign roles: for example, which key questions each student researches, who should be responsible for creating the final presentation and how the presentation will be undertaken.

Suggested student research foci

The top eight suggested research foci provide a good match to the 14-16 curricula for the four nations. The remaining three suggested research foci provide a less good match, but are included because they provide important careers information, enrichment and additional interest.

STUDENT RESEARCH FOCUS	CATEGORY
Oil and gas today	Non-renewable resources
The future of fossil fuels	Non-renewable resources
Nuclear power	Non-renewable resources/renewable
Solar power	Renewable resources
Wind power	Renewable resources
Water power	Renewable resources
Geothermal power	Renewable resources
Electricity as a resource	General
Innovative approaches to renewable energy	General
Future energy	General
Careers in the energy industry	Careers

Suggested presentation formats

Presentation formats suggested include a scientific poster, PowerPoint presentation, cartoon strip and sales brochure, and examples of '*What A Good One Looks Like (WAGOLL)*' are included in the suite of lesson resources. Students may present their work to small groups of peers or to the full class, by PowerPoint presentation or through displaying scientific posters. The purpose of the presentation is for development and practice of peer teaching and oracy, and reinforcement of learning gained from the information-gathering and evaluation phase.

It is suggested that PowerPoint presentations are limited to five minutes per group, and there are no more than three presentations in a lesson. It would be particularly beneficial to have a combination of poster presentations and PowerPoint presentation to provide variety. Students should be required to apply learning from the presentations in the final phase of learning.

Project structure overview

These are suggested phases and timings. It is expected that these will be modified to suit the curriculum, time available, class sizes and abilities.

PHASE	TIMING	DESCRIPTION	FEATURES
1	20 mins	Introduction	Explanation of the purposes of the project: • To consider key questions, develop opinions and form conclusions relating to energy resources Organisation of groups.
2	60 - 90 mins	Research	• Research for relevant information • Evaluate and select information • Prepare information to share
3	30 - 60 mins	Presentations	• Present and share information
4	20 - 30 mins	Debate (optional activity)	• Exploration of ideas from different groups based on *OurFuture.Energy* 'Debate' pages
5	60 mins	Application of learning (optional activity)	• To design the 'best' energy solution for a local, regional or national area • To develop opinions and form conclusions relating to energy resources

Phase 1: Introduction

This sets the scene for students and makes explicit the purpose of the work, through sharing learning objectives and curriculum links (See Appendices A to D).

Share and discuss learning objectives with students, explaining the links between the project and the curriculum. It is also worthwhile to show relevant newspaper articles, especially if they are relevant locally.

The suggested learning outcomes for the project are:

- To research and select relevant information about energy resources;
- To use information to create a presentation that answers key questions about energy resources;
- To present findings to peers through a poster presentation or PowerPoint presentation;
- To debate national and global energy issues based on ideas and evidence gained through research;
- To apply ideas and evidence about energy resources to suggest local national or global energy solutions; and
- To increase awareness of careers within the energy industry.

Phase 2: Information gathering and evaluation

Students work in groups of about three to gather and evaluate information about the energy industry based on a research focus. They are guided to explore key pages on the *OurFuture.Energy* website relevant to their focus through '*student briefing cards'*. Research foci are selected by the teacher to ensure coverage of the topics appropriate to the curriculum.

The '*student briefing cards'* have a series of suggested '*key questions'*. Depending on student ability, these can be reduced in number. It may be appropriate to suggest *OurFuture.Energy* website pages that support the key questions. The '*student briefing card'* copy master is designed to produce double-sided cards with suggested website pages on the reverse side to the *'key questions'*. Students evaluate the relevance of information from the web pages they explore, selecting the most important for inclusion in their presentation.

Phase 3: Presentation

Presentation formats suggested are a scientific poster, PowerPoint presentation, cartoon strip or sales brochure. Students may present their work to small groups of peers or full class by PowerPoint presentation or through poster display. The purpose of the presentation is to develop and practice peer-teaching and oracy. It also serves to reinforce learning gained from the information-gathering and evaluation phase.

Phase 4: Debate (optional)

The *OurFuture.Energy* website contains a number of *'Debate'* articles intended to stimulate discussion and reinforce learning from the peer-teaching phase.

DEBATE ARTICLE	OVERVIEW
DEBATE: Is 1 Earth Enough?	Explores whether the Earth has enough resources to support our growing population and increasing demands on nature. Key questions relate to how we can measure our ecological footprint and how we can reduce it.
DEBATE: Electric Everything!	Explores the need for a diverse energy mix of current sources of energy, along with innovation in new sustainable and low carbon alternatives. A key question is how we can achieve this in the UK.
DEBATE: Save energy, waste energy	Explores the pros and cons of processes that are accepted as 'energy-saving', such as pumped storage schemes and recycling. A key question relates to whether such processes are worthwhile.
DEBATE: Fracking: Yes or No?	Explores the fracking process and why it is controversial. A key question is whether the UK should back or ban fracking.
DEBATE: Let's Work Together: COP21	Explores the 21st Conference of the Parties (or "COP") of the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations body that is responsible for climate. Key questions relate to the importance and effectiveness of such conferences.

Phase 5: Application of learning (optional activity)

This is an activity intended for enrichment and extension. Students are challenged to design the 'best' energy solution for a local, regional or national area. The first part of the activity explores what is meant by the 'energy trilemma: sustainability, accessibility and security', through exploring 'energy mix' pages on *OurFuture.Energy* website. Students are provided with data about installation costs and energy output for different energy resources, and work in groups to apply ideas they have formed about security, accessibility and sustainability to decide on the best solution.

This activity can be tailored to student ability and interest. For example, some students might like to consider a town or village, others a county or country. The activity will support students in developing opinions and forming conclusions relating to energy resources.

Appendix A: Scotland Curriculum for Excellence

N3 CHEMISTRY MANDATORY KEY AREAS	SUGGESTED LEARNING ACTIVITIES
Fuels and energy	Has Scotland won the natural lottery? A debate on Scotland's natural resources. Environmental impact of carbon dioxide can be demonstrated by practical work to show how global warming occurs. Learners could investigate processes associated with reducing the environmental impact of hydrocarbons by society such as carbon capture, uses of detergents in oil spills and how plastics are recycled.
Fuels and energy	Different types of biomass can be burned and the amount of energy released can be compared. Types of biomass can include samples collected from field trips and the surrounding area as well as recycled waste within the school (e.g. paper, cardboard, sawdust). Learners produce a leaflet promoting advantages or disadvantages of a local biomass plant. Models of wind turbines and solar cells can be used to compare the amount of energy produced and identify some of the difficulties associated with maintaining the energy production.
Fuels and energy	Investigation of electricity production in Scotland and creation of a poster or PowerPoint summarising different locations and the method of electricity production. Learners investigate the cost of electricity and costs associated with developing alternative energy sources. Practical to demonstrate products of sugar and methanol combustion. Samples burned and products drawn through a test tube containing cobalt chloride paper and a second test tube containing lime water.

Appendix A: Scotland Curriculum for Excellence cont.

N4 CHEMISTRY MANDATORY KEY AREAS	SUGGESTED LEARNING ACTIVITIES
Acids and bases: Sources of carbon dioxide in the atmosphere	Learners will investigate sources of CO_2 in the atmosphere including the burning of fossil fuels and cement manufacture. Carbon/global footprints may be discussed at this point. A good resource for this is Education Scotland's 'Schools Global Footprint'. Online resources are available on LTS schools global footprint index.
Sources of non-metal oxides, particularly carbon dioxide, sulfur dioxide and oxides of nitrogen, and their effects on the environment	Learners can study the effect of CO_2 on global warming by charting the temperature of plastic bottles filled with air, water vapour, CO_2 (and possibly methane) exposed to a heat source over time. The effect of increased temperature on the ability of the oceans to absorb extra CO_2 as well as the effect of reduced pH on shells could also be investigated. A suitable resource can be found at the Royal Society of Chemistry website called 'Sea Change'. Learners can be introduced to other non-metal oxide pollutants and can investigate the effects of lower pH on cress seed growth, limestone or marble. These investigations can be accessed on the Education Scotland website.
Fuels Fossil fuels Some reactions release energy from fuels	Video clips on the formation of fossil fuels and fractional distillation can be found on the website. A methane explosion can be demonstrated using the ratio of 1part methane to 2 parts oxygen. This can also be shown by an 'exploding can' demonstration as detailed in the book *101 Classic Chemistry Demonstrations* published by the RSC. Demonstration of fractional distillation using synthetic crude oil. Further details on this can be found through the SSERC website.

Appendix A: Scotland Curriculum for Excellence cont.

N4 CHEMISTRY (cont.) MANDATORY KEY AREAS	SUGGESTED LEARNING ACTIVITIES
Fuels Complete and incomplete combustion Use of catalytic converters to reduce carbon monoxide emissions Reducing carbon emissions	The products of combustion can be shown through a demonstration of burning a hydrocarbon and drawing the products of combustion through a test tube with cobalt chloride paper surrounded by an ice bath and through another test tube with lime water. The products of incomplete combustion can be shown by heating a beaker of water using the safety flame of a Bunsen burner.
Fuels Impact on the environment of burning fossil fuels including the effect on the carbon cycle	

Appendix A: Scotland Curriculum for Excellence cont.

N3 PHYSICS MANDATORY KEY AREAS	SUGGESTED LEARNING ACTIVITIES
Energy Sources Identify different energy sources Classify renewable and non-renewable sources Describe advantages and disadvantages to society/ environment of different energy sources	Renewable and non-renewable energy sources (including responsible use) Benefits and problems associated with each type Advantages and disadvantages of 'green' transport such as hybrid vehicles, biofuels, and hydrogen fuel cells etc. 'Best' location for harnessing different types of renewable energy Current study/research/testing of new ways to harness renewable energy Environmental issues associated with renewable energy Energy supply and demand
Energy Transfer Conduction of heat Convection of heat Radiation of heat	Examples of convection — gulf stream, weather systems, gliders,sea breezes Best methods for reducing rate of heat transfer in a variety of situations, for example heat loss from a house, animal survival Eco-friendly house, e.g. 'Sun City' homes in Dundee, the Glasgow House

Appendix A: Scotland Curriculum for Excellence cont.

N4 PHYSICS MANDATORY KEY AREAS	SUGGESTED LEARNING ACTIVITIES
Generation of electricity Knowledge of advantages and disadvantages of different methods of electricity generation. Knowledge of the potential role of different methods of electricity generation in future sustainable energy supply. Awareness of the concept of energy efficiency and energy efficiency issues related to generation distribution and use of electricity. Knowledge of energy transformations and basic components of power stations.	Research energy supply and demand projections from current data. Research different energy sources. Prepare a plan for a Scottish island to be self-sufficient in electricity from natural resources. Research generation and transmission losses. Discuss the implications of distribution methods — overhead cables versus underground cables. Carry out investigations into generation of electricity, for example, dynamo, and methods of passing a magnet through coil of wire. Compare input and output energy for power stations using different energy sources. Research or investigate the factors affecting the electrical output from a range of sources, for example solar cells or wind turbines. Research microgeneration such as home-based solar panels, wind turbines or hydro-electricity. Observe a demonstration of model power lines

Appendix A: Scotland Curriculum for Excellence cont.

N4 PHYSICS (cont.) MANDATORY KEY AREAS	SUGGESTED LEARNING ACTIVITIES
Nuclear radiation Knowledge of natural and artificial sources of nuclear radiation and associated medical and industrial applications. Consideration of the pros and cons of generating electricity using nuclear fuel. Comparison of risk due to nuclear radiation with risk due to other environmental hazards (e.g. global warming) and the management of these risks.	Discuss the arrangement of neutrons, protons and electrons in an atom. Research into sources and effects of nuclear radiation including natural sources (e.g. radon) man-made sources (e.g. plutonium), their effects on living things (e.g. leukaemia) and their effects on non-living things (scintillation, sparks between high voltages)

Appendix A: Scotland Curriculum for Excellence cont.

N5 PHYSICS MANDATORY KEY AREAS	SUGGESTED LEARNING ACTIVITIES
Electrical power Use an appropriate relationship to solve problems involving energy, power and time.	Investigate power loss using model power transmission lines.
Use appropriate relationships to solve problems involving power, potential difference (voltage), current and resistance in electrical circuits.	Research into society's reliance on radioactivity for a range of medical and industrial applications, including energy sources. Discuss or debate the risks and benefits of radioactivity in society.
Nuclear radiation Awareness of applications of nuclear radiation.	Discuss or debate the biological effects of radiation. Research the significance of half-life in medical and industrial applications. Research current applications and developments of fission and fusion reactions to generate energy.

Appendix B: Welsh Curriculum

N5 PHYSICS
KS3 SCIENCE: HOW THINGS WORK

Appendix B: Welsh Curriculum

KS3 Science: How things work

Pupils should use and develop their skills, knowledge and understanding by investigating the science involved in a range of contemporary devices/machines and evaluate different energy resources and possibilities.

They should be given opportunities to study:

5. how renewable and non-renewable energy resources are used to generate electricity and the implications of decisions made about their use
6. technologies under development, which may lead to more efficient use of energy resources or using them in new ways, *e.g. hydrogen-powered cars, using cooking oil/gasohol, as replacements for diesel/petrol.*

WJEC GCSE:

1.2 GENERATING ELECTRICITY (Physics) and 3.2 GENERATING ELECTRICITY (GCSE Science: Double Award)

Overview

This topic begins by looking at the advantages and disadvantages of renewable and non-renewable technologies for the generation of electrical power. It discusses the need for the National Grid as a nationwide electrical distribution system and the use of step-up and step-down transformers in the transmission of electricity from the power station to the home.

Learners should be able to demonstrate and apply their knowledge and understanding of:

(a) the advantages and disadvantages of renewable energy technologies (e.g. hydroelectric, wind power, wave power, tidal power, waste, crops, solar and wood) for generating electricity on a national scale using secondary information

(b) the advantages and disadvantages of non-renewable energy technologies (fossil fuels and nuclear) for generating electricity

(c) the processes involved in generating electricity in a fuel based power station

Appendix B: Welsh Curriculum cont.

N5 PHYSICS (cont.)
KS3 SCIENCE: HOW THINGS WORK

(e) the need for the National Grid as an electricity distribution system including monitoring power use and responding to changing demand

(h) efficiency, reliability, carbon footprint and output to compare different types of power stations in the UK including those fuelled by fossil fuels, nuclear fuel and renewable sources of energy

1.4 THE EVER-CHANGING EARTH (Chemistry) and 2.4 THE EVER-CHANGING EARTH (GCSE Science: Double Award)

Overview

This topic explores the structure of the Earth and the composition of the atmosphere, looking at changes in both over time. They gain an understanding of how a balance of processes maintains the composition of the atmosphere and the effects upon this of human activity.

(g) the environmental effects and consequences of the emission of carbon dioxide and sulfur dioxide into the atmosphere through the combustion of fossil fuels

(h) the measures used to address the problems of global warming and acid rain

2.5 CRUDE OIL, FUELS AND ORGANIC CHEMISTRY (Chemistry) and 5.5 CRUDE OIL, FUELS AND ORGANIC CHEMISTRY (GCSE Science: Double Award)

Overview

This topic provides an introduction to the skills and knowledge, including the representation and naming of organic structures, needed in organic chemistry. The formation and fractional distillation of crude oil, cracking and polymerisation are explored and the products of each process explained. **Higher tier learners will be introduced to the concept of isomerism**. Learners should be able to write word and balanced symbol equations for combustion, cracking, addition and fermentation reactions and symbol equations representing polymerisation.

(a) crude oil as a complex mixture of hydrocarbons that was formed over millions of years from the remains of simple marine organisms

(b) the fractional distillation of crude oil

(c) fractions as containing mixtures of hydrocarbons (alkanes) with similar boiling points

Appendix B: Welsh Curriculum cont.

N5 PHYSICS (cont.)
KS3 SCIENCE: HOW THINGS WORK

(d) the trends in properties of fractions with increasing chain length and the effect on their usefulness as fuels

(e) the global economic and political importance and social and environmental impact of the oil industry

(f) the combustion reactions of hydrocarbons and other fuels

(h) the combustion reaction of hydrogen and its use as an energy source including its advantages and disadvantages as a fuel

(v) the uses of ethanol as a solvent and as a fuel and the social, economic and environmental factors that affect the development of bioethanol fuel

Appendix C: Northern Ireland Curriculum Links

N5 PHYSICS (cont.)
KS3 SCIENCE: HOW THINGS WORK

Northern Ireland KS3 SCIENCE AND TECHNOLOGY: Science

The minimum content is set out below.

The statutory requirements are set out in **bold** and additional guidance appears in plain text. *All examples are in italics.*

Pupils should have opportunities, through the contexts opposite, to:

- **develop creative and critical thinking in their approach to solving scientific problems;**
- **research scientific information from a range of sources;**
- **Forces and energy**
  - **Forces and energy transfer**
  - **Using electricity**

(Objective 1): Developing pupils as Individuals

Pupils should have opportunities to:

- **Explore physical, chemical and biological effects on personal health,** for example, *inherited characteristics, exercise and nutrition, misuse of chemicals, loud sound etc.* **Personal Health**

(Objective 2): Developing pupils as Contributors to Society

Pupils should have opportunities to:

- **Explore some ethical dilemmas arising from scientific developments,** for example, testing of new chemical products for weapons development, growing genetically modified crops etc. **Ethical Awareness**

Opportunities must also be provided to explore issues related to:

- **Citizenship** Consider factors that need to be taken into account when assessing statements that claim to be based on scientific research into issues affecting society, for example, *the nature, quality and source of the data etc.*

Appendix C: Northern Ireland Curriculum Links cont.

N5 PHYSICS (cont.)
KS3 SCIENCE: HOW THINGS WORK

(Objective 3): Developing pupils as Contributors to the Economy and the Environment

Pupils should have opportunities to:

- **Identify how skills developed through science will be useful to a wide range of careers,** for example, jobs involving animal welfare, building and construction, education, electrical work , engineering, environmental management, financial services, food and farming, forensics, information and communications technology, journalism, plumbing, technology, pharmaceuticals, medicine etc. **Employability**

- **Investigate a product of economic importance to determine the science behind it,** for example, explore a successful local product, and generate ideas for a product of their own etc. Investigate a product to determine best value, for example, compare performance and cost of an economy and branded product, consumer product testing etc. **Economic Awareness**

- **Investigate the effects of pollution,** for example, water, air, land, sound etc. **and specific measures to improve and protect the environment**, for example, *renewable energy, efficient use of resources and waste minimisation etc.*

Northern Ireland Draft GCSE Curriculum Links: Physics

Energy

In this section, students examine the various forms of energy and apply the Principle of Conservation of Energy to a range of situations. They study the difference between renewable and non-renewable energy resources, along with their impact on the environment. Students also study the concepts of work, power, kinetic and gravitational potential energy. They examine heat transfer and its importance in a range of applications.

CONTENT	LEARNING OUTCOMES
Renewable energy resources	**Students should be able to:** 1.4.5 explain that renewable energy is defined as energy that is collected from resources that will never run out or which are naturally replenished within a human lifetime; 1.4.6 evaluate examples of renewable energy such as sunlight, wind, hydroelectricity, tidal, waves, wood and geothermal heat; and 1.4.7 demonstrate knowledge of the effects on the environment of using renewable energy resources, such as habitat destruction and visual pollution. 1.4.8 explain that: • a non-renewable energy resource is one that has a finite supply and it will run out some time; and • fossil fuels such as oil, natural gas and coal are considered non-renewable because they cannot be replaced within a human lifetime 1.4.9 demonstrate knowledge that nuclear energy based on fission is also non-renewable since supplies of uranium will not last forever; 1 4.10 demonstrate an understanding of the effects on the environment if using non-renewable energy resources, such as acid rain and global warming

Northern Ireland Draft GCSE Curriculum Links: Physics cont.

Energy

In this section, students examine the various forms of energy and apply the Principle of Conservation of Energy to a range of situations. They study the difference between renewable and non-renewable energy resources, along with their impact on the environment. Students also study the concepts of work, power, kinetic and gravitational potential energy. They examine heat transfer and its importance in a range of applications.

CONTENT	LEARNING OUTCOMES
Nuclear fission	**Students should be able to:** 1.5.20 describe nuclear fission in simple terms and be aware that it is a form of energy used in the generation of electricity (fission equations are not required); 1.5.21 demonstrate knowledge that: • for fission to occur, the uranium nucleus must first absorb a neutron and then split into two smaller nuclei, releasing energy and several neutrons; and • these fission neutrons go on to cause further fissions, creating a chain reaction; 1.5.22 discuss and debate some of the political, social, environmental and ethical issues relating to the use of nuclear energy to generate electricity, demonstrating an understanding that: • while the use of nuclear power produces employment opportunities for many people, many are still concerned about living close to nuclear power plants and the storage facilities used for radioactive waste; • incidents at nuclear power plants in Ukraine and Japan have caused huge economic, health and environmental damage to the area surrounding the power plant; and • although nuclear fission does not release carbon dioxide, the mining, transport and purification of the uranium ore releases significant amounts of greenhouse gases into the atmosphere.

Northern Ireland Draft GCSE Curriculum Links: Physics cont.

Energy

In this section, students examine the various forms of energy and apply the Principle of Conservation of Energy to a range of situations. They study the difference between renewable and non-renewable energy resources, along with their impact on the environment. Students also study the concepts of work, power, kinetic and gravitational potential energy. They examine heat transfer and its importance in a range of applications.

CONTENT	LEARNING OUTCOMES
Nuclear fusion	**Students should be able to:** 1.5.23 describe nuclear fusion in simple terms and be aware that it is the source of a star's energy 1.5.24 demonstrate an understanding: • of the potential of nuclear fusion to solve the world's energy needs, provided the technological difficulties of fusion reactors can be overcome; • that the isotopes of hydrogen, deuterium and tritium are widely available as the constituents of sea water and so are nearly inexhaustible; and • that fusion doesn't emit carbon dioxide or other greenhouse gases into the atmosphere as its major by-product is helium, an inert, non-toxic gas 1.5.25 recall that: • fusing nuclei together in a controlled way releases four million times more energy per kg than a chemical reaction such as the burning of coal, oil or gas; and • fusing nuclei together in a controlled way releases four times as much as nuclear fission reactions per kg; 1.5.26 explain that: • there are many difficulties to overcome before nuclear fusion provides electricity on a commercial scale and it may be another 50 years before that happens; and • nuclear fusion reactors will be expensive to build, and the system used to contain them will be equally expensive because of the very high temperatures needed for the nuclei to fuse; 1.5.27 demonstrate an appreciation of the work being carried out at the ITER project (International Thermonuclear Experimental Reactor) and an understanding that such research requires international co-operation.

Northern Ireland Draft GCSE Curriculum Links: Chemistry

Energy

In this section, students examine the various forms of energy and apply the Principle of Conservation of Energy to a range of situations. They study the difference between renewable and non-renewable energy resources, along with their impact on the environment. Students also study the concepts of work, power, kinetic and gravitational potential energy. They examine heat transfer and its importance in a range of applications.

CONTENT	LEARNING OUTCOMES
Organic chemistry	**Students should be able to:** 2.5.5 recall that crude oil is a finite resource and is the main source of hydrocarbons and a feedstock for the petrochemical industry; 2.5.6 describe and explain the separation of crude oil by fractional distillation; 2.5.7 describe the fractions as largely a mixture of compounds of formula CnH2n+2 which are members of the alkane homologous series and recall the names and uses of the following fractions: • petrol used as a fuel for cars; • kerosene as a fuel for aircraft; • diesel as a fuel for cars and trains; and • bitumen used to surface roads and roofs 2.5.8 explain that cracking involves the breakdown of larger saturated hydrocarbons (alkanes) into smaller more useful ones, some of which are saturated (alkenes); 2.5.28 demonstrate knowledge that the combustion of fuels is a major source of atmospheric pollution due to: • combustion of hydrocarbons producing carbon dioxide, which leads to the greenhouse effect causing sea level rises, flooding and climate change; • incomplete combustion producing carbon monoxide (toxic) and soot (carbon particles), which cause lung damage; and • presence of sulfur impurities in fuels, which leads to acid rain damaging buildings, vegetation and killing fish

Appendix D: English Curriculum links

Reference: Biology, Chemistry and Physics GCSE subject content (DFE-00352-2014) and Combined Science GCSE subject content (DFE-00351-2014)

Please note that there are four suites of specifications provided by AQA, Edexcel and OCR, which were derived from the DFE subject content documents. Please refer to the specifications for more detailed subject matter guidance.

Combined science and physics

Conservation, dissipation and national and global energy sources:
describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro-electricity, the tides and the Sun), compare the ways in which they are used and distinguish between renewable and non-renewable sources;
explain patterns and trends in the use of energy resources.

Physics only

Induced potential, transformers and the national grid:

- explain how the effect of an alternating current in one circuit in inducing a current in another is used in transformers and how the ratio of the p.d.'s across the two depends on the ratio of the numbers of turns in each

Nuclear fission and fusion

- recall that some nuclei are unstable and may split, and relate such effects to radiation which might emerge, to transfer of energy to other particles and to the possibility of chain reactions
- describe the process of nuclear fusion and recall that in this process some of the mass may be converted into the energy of radiation.

Combined science and chemistry

Life cycle assessment and recycling:

- describe the basic principles in carrying out a life-cycle assessment of a material or product
- interpret data from a life-cycle assessment of a material or product
- describe a process where a material or product is recycled for a different use, and explain why this is viable
- evaluate factors that affect decisions on recycling.

Fractional distillation of crude oil and cracking:

- describe and explain the separation of crude oil by fractional distillation

Appendix D: English Curriculum links cont.

Carbon dioxide and methane as greenhouse gases:

- describe the greenhouse effect in terms of the interaction of radiation with matter
- evaluate the evidence for additional anthropogenic causes of climate change, including the correlation between change in atmospheric carbon dioxide concentration and the consumption of fossil fuels, and describe the uncertainties in the evidence base
- describe the potential effects of increased levels of carbon dioxide and methane on the Earth's climate and how these effects may be mitigated, including consideration of scale, risk and environmental implications.

Common atmospheric pollutants and their sources:

- describe the major sources of carbon monoxide, sulfur dioxide, oxides of nitrogen and particulates in the atmosphere and explain the problems caused by increased amounts of these substances.