

Unit 28: Sustainable Energy

Delivery guidance

The focus of this unit is the comparison between fossil fuels and their renewable alternatives: their usefulness and relative environmental impacts.

Young people worldwide are concerned about the environmental impacts of fossil fuel energy generation, and the urgent need to both phase out consumption and switch to sustainable energy sources. This unit allows learners to learn about new sustainable energy technologies and their rapid uptake in our current economy, where there may be excellent job and career prospects in the coming decades. There are strong links between this unit and *Unit 10: Climate Change*.

Approaching the unit

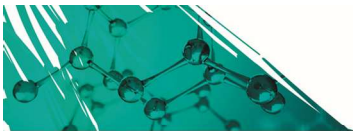
A range of delivery methods to engage all types of learners and learning styles can be used – for example:

- practical work on energy generation
- research work on energy generation, and the impact on the environment and health
- debates/discussion
- work experience placements
- visits (or virtual visits) from or to companies/organisations involved in energy generation, or from pressure/interest groups advocating alternative energy
- guest speakers from a local green technology company
- sharing resources, especially guest speakers and consideration of work placement opportunities with Unit 10
- small group work to research topics, followed by a presentation of facts to the rest of the class
- simulations and computer modelling
- videos, documentaries, newspaper articles and scientific articles to stimulate debate and contribute to knowledge and understanding.

Planning will be needed to arrange industrial visits, guest speakers and work placements.

As with all internally assessed units, all the unit content is mandatory and must be delivered during teaching and learning. The evidence for assessment need not cover every aspect of the unit content as learners will normally use particular examples, case studies or contexts in their assignments.

Centres should ensure that delivery of content is kept up to date, particularly where reference to regulation, legislation, policies and regulatory/standards organisations are part of the assessment requirements.



Learning aim A will require you to establish learner prior knowledge and understanding about fossil fuels (coal, crude oil and gas), their environmental impacts, renewable energy technologies, and their advantages and disadvantages. Learners need to understand the uses and importance of the by-products of coal (coal-tar).

Group work to investigate the environmental impacts of fossil fuels in relation to global warming, rise in temperature and sea level, increased risk of drought, heatwaves and intensity of storms and how these can lead to ecological disruption, will allow learners to demonstrate and acquire knowledge, understanding and interpersonal skills. Toxic air pollutants and their impact on health must be investigated and understood. Fracking to obtain oil and shale gas and its environmental impact must be investigated and understood.

Learning aim B, could start with an examination of the definition of sustainable and alternative energy production. Fossil fuels are unsustainable because, once burnt, their energy is lost forever, and the remaining reserves are finite – estimated in decades or centuries. Solar energy is sustainable because the sun is expected to continue in its current state for another five billion years.

The sustainability of nuclear energy is more complex. Nuclear fuels (e.g. uranium) are plentiful enough on earth to last for many millennia. However, the storage of radioactive spent nuclear fuel is proving an increasingly intractable problem, and so the sustainability of nuclear energy production is questionable. Learners will need opportunities to understand how to compare and evaluate the economic and operation efficiency of energy generation. Visits or virtual visits to different types of power stations, or online discussions with staff at power stations could be an interesting and stimulating vocational experience for learners. There are no practically assessed criteria for this unit.

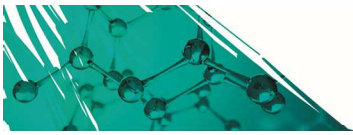
Learners could be encouraged to practically investigate the efficiency of some renewable energy sources, e.g. solar, water/wave, wind, biomass. This may help provide more robust evidence for this learning aim.

For Learning aim C Learners will require guidance to understand the social, environmental and financial advantages and disadvantages of the use of renewable energy and biofuels. Throughout the delivery of the unit, learners can collaborate through group discussions, presentations or debates. For example, learners could be split into small groups to research each these three factors for a given/chosen renewable energy form. Alternatively, each small group could be given/chose a factor and carry out research to the impact of the factor on each of the renewable energy technologies. They can then present their finding to the rest of the class. Throughout the delivery of the unit, learners can collaborate through group discussions, presentations or debates.



Assessment model

Learning aim	Key content areas	Recommended assessment approach
<p>A Explore the environmental impact of continued use of fossil fuels</p>	<p>A1 Uses of coal and the by-products of coal, crude oil and natural gas</p> <p>A2 Environmental impact of fossil-fuel use</p>	<p>A report detailing the sources and environmental impact of the continued use of fossil fuels, to include:</p> <ul style="list-style-type: none"> • amplified greenhouse effect through increased atmospheric concentration of carbon dioxide • release of nitrogen oxides, sulphur dioxide • emissions of soot and other particulates • land degradation • water pollution and generation of wastewater • fracking.
<p>B Explore the generation of electricity from alternative fuel sources</p>	<p>B1 Renewable energy</p> <p>B2 Nuclear energy</p> <p>B3 Efficiency of energy production</p>	<p>A portfolio of evidence that explores alternative energy sources, to include:</p> <ul style="list-style-type: none"> • how photovoltaic panels convert the sun's energy into electricity • how wind energy is produced • how waves and tides are utilised to produce energy • capture and uses of geothermal energy • production of nuclear energy • efficiency of energy sources.
<p>C Compare the social, environmental and financial benefits and advantages of the use of renewable energy with the disadvantages</p>	<p>C1 Advantages of generating electricity from renewable resources</p> <p>C2 Disadvantages of generating electricity from renewable resources</p>	<p>A report that explores, evaluates and compares the advantages and disadvantages of increasing use of renewable energy sources. The report will include:</p> <ul style="list-style-type: none"> • the social, environmental and financial benefits of using solar, wind, hydroelectric, biomass and geothermal sources • the social, environmental and financial disadvantages of using solar, wind, hydroelectric, biomass and geothermal sources.



Assessment guidance

This is an internally assessed unit with a maximum of three summative assignments – one for each learning aim. Authorised assignment briefs are available for the unit and demonstrate the holistic, distinction-first approach that is required to encourage learners to access all criteria.

Once learners are working on assignments that will be submitted for assessment, it is essential they work independently to produce and prepare their evidence.

For learning aim A, learners must produce a report that describes sources of oil, coal and natural gas and how they are extracted. The impacts on human health and the environment of the use of fossil fuels must be described, and, to access higher grades, explained and evaluated.

Learning aim B focuses on renewable energy. Learners must describe the technologies used to generate renewable energy, including nuclear energy and the advantages and disadvantages of nuclear fuels. To access higher grades, the efficiency of the different renewable sources must be compared and evaluated. Learners could present their evidence as a portfolio of evidence which may contain written reports, slide presentations, leaflets etc. If learners give a spoken talk on their slide presentation and take questions from the audience afterwards, it could be videoed and used as evidence.

For learning aim C, learners must produce a report that describes the social, environmental and financial advantages and disadvantages of the use of renewable energy and biofuels. To access higher grades, the report must demonstrate that they are able to compare and evaluate the benefits and detrimental effects of the increased use of solar, wind, hydroelectric, biomass and geothermal power.



Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 28: Sustainable Energy

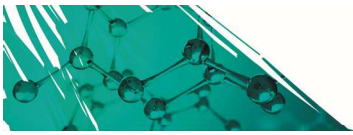
Introduction

- Establish prior knowledge of the topics in this unit by giving learners the unit content/simplified unit content and splitting them into pairs or small groups to map their current understanding. Learners could produce mind maps or have a topic list of simplified unit content to identify current knowledge in terms of 'good understanding', 'heard of it' or 'no understanding'. It may be expedient to do this for each learning aim separately, as you are due to deliver them, rather than covering all three at the start of the unit.
- Stress the need for a wide range of sustainable energy sources because they are less energy-dense than fossil fuels, meaning no single source is enough, so a wide variety of sources must be used to maximise energy supply and minimise the risk of breaks in supply (blackouts). Another critical issue is the storage of renewable energy, as the energy supply is often inconsistent.
- Critical thinking skills can be developed by asking learners to consider and discuss, for example: What is the meaning of the word 'sustainable'? How does it apply to energy? Is nuclear energy sustainable or not? What is the cost of switching to sustainable energy, compared to the environmental costs of global warming linked to fossil fuel use? Do the benefits outweigh the disadvantages/drawbacks?

Learning aim A: Explore the environmental impact of continued use of fossil fuels

A1

- Show learners, or ask them to identify, physical samples of low-risk products derived from fossil fuels, e.g. naphthalene, soaps, plastics, petroleum jelly, fertilisers.
- Deliver a presentation on the uses and by-products of coal, crude oil and natural gas. Alternatively, learners could work in small groups to research and present information on the by-products.
- Pictures of open cast mining, an oil refinery, gas platforms, on land 'nodding donkey' gas extraction, a fracking site, power stations, carbon fibre products, water filters, kidney dialysis machines, etc. could be used as a tutor-led discussion on uses of fossil fuels and their importance to our lives.
- You should emphasise that not all fossil fuels are burned to produce energy (and carbon dioxide). They are also used as raw materials for manufacturing useful products; this does not directly add carbon dioxide to the atmosphere.
- An expert-led visit to an oil refinery would show learners how crude oil contains many components with a wide variety of uses. A visiting speaker could be an alternative. It is worth considering using IT possibilities for a virtual meeting/tour using JoinMe, Facetime, Skype, etc.
- An expert-led visit to a gas, oil or coal-fired power station would show learners how energy is generated on a large scale by these high energy density fuels.
- Use videos of power stations and oil refineries where visits are not possible.



A2

- The environmental impacts of fossil fuel usage could be investigated by field studies, for example by estimating the percentage lichen cover on trees, rocks and walls, or where lichens are adversely affected by sulphur dioxide pollution.
- Give learners data, scientific reports or news reports linking respiratory illness and air pollution, or encourage them to carry out research to find them. Discuss and evaluate them as a tutor-led class activity.
- Give learners, or encourage them to access, secondary data about levels of CO₂, methane, water vapour, global temperature, melting ice caps, rising sea levels, etc. to analyse and discuss.
- Use documentaries or news reports on flooding, drought, heatwaves, fires, storms and ecological disruption as stimulus material for learners to carry out research and present information back to the class.
- Encourage learners, in pairs or small groups, to research toxic air pollutants, as listed in the unit content. There needs to be an opportunity to feed back and discuss the impact they have or may have on human health and the environment.

Learning aim B: Explore the generation of electricity from alternative fuel sources

B1 and B2

- Introduce this learning aim with a run-through of alternative fuel sources (renewable energy sources, wind, solar, hydro, biomass, tide/wave, nuclear). Learners could use small whiteboards to indicate examples of renewable energy sources. You can then collate this information.
- Ask learners to carry out simple experiments to generate electricity using small solar cells and small wind turbines. Kits are available from reputable school science equipment suppliers.
- Present learners with, or encourage them to access, secondary data from textbooks, websites and documentary science films about the use of renewable energy sources (wind, solar, hydro, biomass, tide/wave, nuclear) in different parts of the world.
- Learners could work in pairs/small groups to describe the specific technology for one renewable energy source, and how it works. They should produce a list of advantages/disadvantages of that source. They should then present their findings to the rest of the class to ensure all wind, solar, hydro, biomass, tide/wave, nuclear technologies have been covered.
- Encourage learners to form small groups to debate the advantages/disadvantages of each energy source.
- Have learners compile a list of 'for and against' views about the use of nuclear energy. Organise a debate.
- Visiting speakers/debates on TV about the use of nuclear energy and renewable sources could be accessed for learners to watch and then debate and share their views.
- Have learners investigate commercial wind, solar, hydro, biomass, tide/wave, nuclear sources of energy generation which feed into the electricity grid, locally, nationally and/or globally.
- If possible, learners could participate in an expert-led visit to a power station. You could use videos as an alternative.

B3

- Give a tutor-led presentation on Levelised Cost Of Energy (LCOE).



- Discuss the efficiency of the different energy sources listed in B1 and B2 unit content. Consider cost factors such as construction, operation and maintenance, fuel, technology, and design and environmental damage. Learners can research these in small groups and feed back to the class. Clarify and establish understanding.

Learning aim C: Compare the social, environmental and financial benefits and advantages of the use of renewable energy with the disadvantages

C1 and C2

- Introduce this learning aim with a group discussion on the advantages and disadvantages of generating energy from renewable resources – biofuels, solar energy, wind energy, hydroelectric energy, tidal and wave energy must be researched. (Some of this may have been included as part of work for learning aim B.)
- Working in small groups, learners could produce a Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis for each energy source concerning financial and environmental issues. They should consider factors such as:
 - job creation
 - initial investment costs/operational costs
 - clean energy generation versus operating costs
 - efficiency
 - inconsistent supply
 - environmental impact to land and wildlife, use of pesticides, use of water and associated risk
 - noise pollution/visual impact
 - ease of storage (biomass).

Opportunities for feedback to the rest of the class and tutor input will be required to ensure the breadth and depth of the unit content are fully covered.

- Ask learners to consult news media to keep abreast of the latest developments. The current trajectory seems to be that the cost of renewable energy production is falling, and its production is increasing exponentially, but overall energy production continues to increase, and fossil fuel energy production continues to increase, i.e. renewables are not replacing fossil fuels but contributing to overall energy consumption.
- Have learners consider and distinguish between energy sources in the following terms:
 - adding ancient carbon as CO₂ to the atmosphere (fossil fuels: carbon positive)
 - returning recently trapped carbon to the atmosphere, but trapping it immediately with new plant growth (biomass energy production: carbon neutral)
 - generating energy without combustion, and not contributing any net carbon to the atmosphere (direct solar, wind, hydroelectric: carbon negative).
- Ask learners to produce a concept map to show the different types of renewable energy sources, including their advantages and disadvantages in relation to social, environmental and financial factors.



Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- Unit 8: Contemporary Issues in Science
- Unit 10: Climate Change
- Unit 15: Diseases and Infections
- Unit 24: Pollution and Waste Management
- Unit 25: Water Quality
- Unit 27: Ecosystems.

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International L3 Qualifications in Applied Science. Check the Pearson website (<http://qualifications.pearson.com/endorsed-resources>) for more information as titles achieve endorsement.

Textbooks

Can Renewable Energy Sources Power the world? Free Learning from the Open University (Open University/OpenLearn, 2015) ISBN 9781473025134 (.kdl) / 9781473025868 (.epub)

An Introduction to Sustainable Energy: Free Learning from the Open University (T206 Energy for a sustainable future) (Open University/OpenLearn, 2016). ISBN 9781473016583 (.kdl) / 9781473008908 (.epub)

Energy Resources – Solar Energy: Free Learning from the Open University (Open University/OpenLearn, 2016) ISBN 9781473016026 (.kdl) / 9781473008342 (.epub)

These resources are excellent for this unit because: (i) they cover the prime content of this unit at a level appropriate to 16–19-year-old learners, (ii) they are short and succinct, (iii) they have an international focus and (iv) they are available as free e-books.

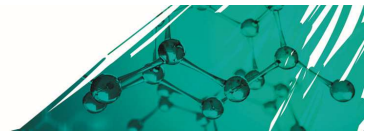
Journals

Biological Sciences Review eMagazine (Hodder Education, Dynamic Learning) ISBN 9781510470323

Chemistry Review eMagazine (Hodder Education, Dynamic Learning) ISBN 9781510470439

Physics Review eMagazine (Hodder Education, Dynamic Learning) ISBN 9781510470804

These three journals are specially tailored to 16–19-year-old science learners. They contain accessible articles on all aspects of science, including sustainable energy. For example, the February 2020 edition of *Physics Review* has an article on solar-powered ground source heat pumps as a method of heating a building without the use of fossil fuel, while the February 2020 *Chemistry Review* has an article on the photochemistry of methane removal from the atmosphere.



Videos (YouTube)

'Why renewables can't save the planet | Michael Shellenberger | TEDxDanubia' – the speaker in this video highlights the downsides of solar, wind and hydroelectric power in California. Instead, he advocates nuclear power. This video could be used to stimulate debate.

'Sustainable energy: New energy innovations to make the future brighter – Compilation' – this video is a showcase describing new sustainable energy products by various international companies.

Websites

Visit the First Solar Inc. website. First Solar is an international alternative energy firm specialising in solar energy. It manufactures solar modules for the solar industry and it develops complete solar projects for utilities, power companies and commercial entities.

Visit the Statkraft website; Statkraft (literally: 'State Power') is Norway's leading provider of hydroelectric power.

Visit the UK Sustainable Energy Ltd website. This is a private company of consulting engineers involved in numerous case studies of installing, for example, biomass heating for municipalities in the UK.

Visit the Vestas Wind Systems A/S website. Based in Denmark, Vestas is the world's largest manufacturer of wind turbines.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling students to access them through the school/college intranet.