Embedding Renewable Energy in the Curriculum

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Renewable energy and energy conservation have key roles to play in humanity's efforts to tackle the pressing global challenges of climate change, pollution and resource depletion. As a theme, renewable energy is an excellent way to teach STEM subjects and stimulate cross-curricular project work.

Lack of awareness of its technical intricacies can be a challenge to embedding it in the curriculum. There is a need to allocate time and resources for teachers to master both the theory and practice of renewable energy technologies and to develop a coherent work scheme.

Key Stage 3 Science Curriculum Unit	Illustrative topics in renewable energy
7I Energy resources	Fossil fuels, renewable energy sources and their environmental impacts. The Sun as the ultimate source of most of Earth's energy resources.
7J Electrical circuits	Simple circuits incorporating solar cells, rechargeable batteries, etc. Series and parallel connections of solar cells in a PV panel.
7K Forces and their effects	Utilisation of buoyancy in wave power converters. Forces acting on turbine blades in flowing air or water.
7L Solar system and beyond	Effects of Earth's tilt, spin and orbit on Sun path, day length and seasons. Effects of the Moon, Sun and Earth's spin on tidal times and ranges.
8I Heating and cooling	Conductive, convective and radiative heat transfer in solar collectors. Use of insulation, spectrally selective coatings, etc. to reduce heat losses. Convection in thermosyphon water heating systems, Trombe walls, etc. Radiative heat transfer from Sun to Earth through the vacuum of space.
8K Light	Reflection from mirrors in concentrating solar collectors and heliostats. Refraction in (Fresnel) lenses in concentrating solar PV arrays. Solar spectrum. Colours of materials. Spectral reflectance of chlorophyll.
9C Plants and photosynthesis	Production of biomass from carbon dioxide, water and sunlight. Artificial photosynthesis and dye-sensitised solar cells.
9D Plants for food	Energy from waste. Energy crops. Anaerobic digestion. Biofuels
9F Patterns of reactivity	Corrosion of metals. Bi-metallic corrosion. Corrosion inhibitors.
9H Using chemistry	Combustion of fuels. Chemical reactions in batteries and fuel cells.
9I Energy and electricity	Energy transfers and transformations in renewable energy systems. Electricity generation and its environmental impacts. Electrical generators, circuits and batteries in renewable energy systems. Energy use. Energy efficiency. Energy flow (Sankey) diagrams.
9K Speeding up	Measurement of air and water flow speeds in the environment. Streamlining. Aerofoils. Forces acting on turbine blades in flowing fluids.
9L Pressure and moments	Water pressure ('head') in hydroelectric and tidal barrage power schemes. Use of pneumatic and hydraulic systems in wave and tidal power devices. Turning effects (moments) of forces acting on turbines in flowing fluids.

Table 1.

As with other technical subjects (e.g. electronics, systems and control, etc.), some schools may be apprehensive about embedding renewable energy in their curricula. However, the beauty of a cross-curricular theme is that you can start with the topics with which you're already familiar and develop your knowledge, experience and confidence step by step.

Key Stage 3

Much of the basic theory of renewable energy systems can be presented in KS3 Science. Although the detailed specifications of the former (2000) Key Stage 3 National Curriculum have been superseded by the much more flexible 'level descriptions', 'key concepts', 'key processes' and 'curriculum opportunities' of the revised KS3 National Curriculum (2008), many schools may still be using schemes of work based on the old specifications. Table 1. identifies appropriate opportunities to cover various renewable energy topics within the former KS3 Science curriculum.

The main purpose of the recent curriculum reforms and new approaches to assessment is to encourage innovation, creativity and enterprise at KS3. Cross-curricular KS3 STEM initiatives now have the opportunity to flourish. One such initiative is the new Nuffield Sustainable Futures topic. Though renewable energy doesn't feature prominently in the introductory and enabling 'Pods', it can be the focus of 'Exploring a question' in Pod 5. For example, Cris Edgell reports that, in last summer's pilot of Nuffield Futures, "One group's challenge was to investigate whether the school could provide its own renewable energy to power the hydroponic greenhouse".

Collaboration across subjects

QCDA's Inspired engineering case study (see Hot Links) relates how Chris Williams at Eckington School, Derbyshire was keen to improve cross-curricular links between science, mathematics, geography, and design and technology. He designed a project that developed students' skills across these subjects through the curriculum dimensions of creativity, enterprise and sustainability. The students' challenge: to design a solar buggy based on Solar-Active's solar car kit.

The project was a collaborative effort from the outset, with staff from the science, maths, geography, and design and technology departments working together to develop the programme. As one Year 8 student explained: "The task was to act as solar detectives to look at the background to solar energy, construct a solar-powered buggy, test how effective the buggy was and then to communicate findings to friends, parents, teachers and judges." Working in groups of four, the students tested and refined their designs, experimenting with design features to make the buggy go straight and travel quickly, taking into account wheel sizes, drag and mass. After ten weeks of hard work, the project culminated in a presentation to an audience of friends, parents, teachers and judges. The teams raced their buggies and explained their research using PowerPoint presentations. The winners, 'Go Green', went on to represent the region in the BA CREST awards final in London, where they won second prize for engineering.

Although this cross-curricular project appeared seamless to the students, there were distinct benefits for each department involved: covering sustainability and energy sources for science and geography; application of geometry and data handling skills for maths; and reinforcing the design process for design and technology. The students showed a pleasing ability to transfer their knowledge between subject areas and developed skills in communication, problem solving and tackling problems collectively.

Eckington School has been setting their Year 8 students solar buggy challenges since 2003. The students have refined the buggies with larger wheels, more solar cells, and colourful and aerodynamic bodywork. The school has also collaborated with other schools to run challenge days. These have been successful in building contacts for teachers and students. The kits are often loaned out to schools to run their own STEM days and are enthusiastically received. The small gears tend to go astray, but the kits are otherwise remarkably durable considering the use they've had by hundreds of teenagers.

A number of UK secondary schools have embedded solar energy activities based on the solar car kit into their Key Stage 3 schemes of work because they've been so impressed with the results and feedback from their students. For instance, students at Shelly College's STEM Challenge event in Huddersfield were amazed at how robust and efficient the flexible PV cells are, their cars worked even in torrential rain! The event enabled students to appreciate how easily a product design can be modified to improve its performance.

The UK has long been a world leader in innovative engineering of wave, tidal and wind power systems, e.g. the LIMPET Oscillating Water Column device, Pelamis wave energy converter, Stingray tidal generator, Seaflow marine current turbine, and several pioneering vertical axis wind turbines. Building and testing working models of such devices could be a stimulating theme for KS3 practical work.

Key Stage 4 and beyond

Opportunities for covering renewable energy topics at Key Stage 4 vary widely across the GCSE syllabi. OCR's GCSE Gateway Science B and Physics B specifications are particularly renewables-friendly. For instance, both include a detailed consideration of home energy conservation, and experimentation with PV cells, solar collectors and wind turbines.

A detailed guide to using solar energy teaching resources to meet new KS4 sustainability and curriculum targets, as required by various UK examination boards, is available at www.solar-active.com/guide.pdf (The guide also addresses the requirements of the revised KS3 National Curriculum, including internal assessments, 'Can Do' tasks and 'How Science Works'.)

In GCSE D&T: Systems and Control Technology, photovoltaic systems could provide a focus for the coursework, which accounts for 60% of the overall assessment.

In the GCSE Engineering Double Award, renewable energy systems could be included across all three of its equally weighted units:

- Design and Graphical Communication;
- Engineered Products;
- Application of Technology.

The 14-19 Engineering diploma is set out as four themes, for which renewable energy could provide the context:

- The Engineered World;
- Discovering Engineering Technology;
- Engineering the Future;
- Analytical Methods for Engineering (Level 3 only).

It is a large qualification – equivalent to five GCSEs at Level 1, seven GCSEs at Level 2 and 3.5 A-Levels at Level 3. The Level 3 diploma will be accepted for university entrance in the same way that A-Levels are, but will also provide a more solid preparation for students who wish to enter the world of work directly.

ABC Awards offer Level 2 and Level 3 qualifications in sustainable energy, including Sustainability and the Renewables Industry, Converting Biomass into Fuel and Energy, and Converting Wind into Energy.

National Skills Academies for Power (NCAP) and Environmental Technologies (NSAET) are currently being established to address the growing skills shortages in those sectors and help train tomorrow's 'low carbon' workforce.

Post-16 students can study The Open University's T123 Sustainable Scotland and T173 Engineering the future modules through its Young Applicants in Schools and Colleges Scheme (YASS).

The future is green

With both the QCDA and diplomas facing an uncertain future, there may be curtailed or fresh opportunities for curriculum innovation and creativity. What is certain is that growing concern about climate change, pollution and resource depletion will push energy conservation and the large-scale exploitation of renewable energy sources ever higher up the political agenda. Renewable energy has a bright future, which will naturally stimulate interest in this fascinating subject and its associated employment opportunities.

Hot Links

ABC Awards: www.abcawards.co.uk/sustainability.php

National Skills Academy for Environmental Technologies: www.summitskills.org.uk/Skills-Academy/477

National Skills Academy for Power: www.power.nsacademy.co.uk

Nuffield Futures: www.nuffieldfoundation.org/futures

OCR GCSE Gateway Science: www.ocr.org.uk/qualifications/type/gcse_2011/

QCDA Inspired engineering: http://curriculum.qcda.gov.uk/key-stages-3-and-4/case_studies/casestudieslibrary/case-studies/Inspired_engineering.aspx

Solar-Active Curriculum Guide: www.solar-active.com/guide.pdf

Young Applicants in Schools and Colleges Scheme: www.open.ac.uk/yass

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Further Information

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