Unit 52: Electrical Technology

NQF Level 3: BTEC National

Guided learning hours: 60

Unit abstract

Electricity is used in a wide range of applications, such as manufacturing, healthcare, transport and entertainment. All of these are reliant on electrical technology in one form or another. For example, for someone to be able to visit a holiday destination, go to a music festival or download the latest track by their favourite performer, numerous electrical activities and concepts must be coordinated.

Electrical technology provides the link between science and its application. It is underpinned by a range of enabling technologies and concepts such as materials science, energy efficiency, environmental impact, geological characteristics and design.

This unit provides an introduction to ways in which electricity is produced, the options we have about how and why we produce it, and the disposal of related bi-products. The unit considers how the electricity that has been produced is then moved to where the customer (end-user) needs. It also examines the materials used and whether alternatives exist or could be found.

Learning outcomes

On completion of this unit a learner should:

1 Know the methods used to produce electrical energy

2 Know the inherent electrical and magnetic properties of conductors, insulators and magnetic materials

3 Understand the physical arrangements of supply, transmission and distribution equipment

4 Understand the use of electrical energy to support applications of electrical technology.

Unit content

1 **Know the methods used to produce electrical energy**

Electromagnetic generation: characteristics and principles of operation of alternating current (AC) and direct current (DC) generators eg relative motion between conductors and magnetic fields, production and regulation of AC using field/slip-ring control, production of DC using commutators and brushgear; features of different types of electrical power generating stations and their energy sources eg coal, gas, oil, nuclear, hydro electric, pumped storage, wind farms, tidal, biomass

Solar panels: developments in photoelectric cells eg photo-electric effect, PN-junction for basic photocell, need for use of converters to convert to alternating current source; small and large scale applications of solar panels eg roadside furniture such as school crossing warning signs, domestic/commercial roofing

Electro-chemical cells and batteries: construction, applications and disposal; primary and secondary eg lead/acid, alkaline, nickel-iron (NiFe), nickel-metal-hydride (NiMH), nickel-cadmium (NiCad), lithium

2 **Know the inherent electrical and magnetic properties of conductors**, **insulators and magnetic materials**

Conductors: properties eg conductivity, resistivity, tensile strength, rigidity; electrical applications of solid conducting materials eg copper, aluminium, steel, brass, carbon, soil (for Earth continuity); applications of liquids and gases eg electrolytes, fluorescent and discharge lighting

Insulators: properties eg resistivity, maximum voltage capability, operating temperatures, mechanical strength; applications of solid, liquid and gas insulating materials eg poly-vinyl-chloride (PVC), butyl-rubber, glass, paper, oil, air

Magnetic materials: properties eg retentivity, coercivity, B-H curve, hysteresis, iron losses; electro-magnetic applications eg permanent magnets, electromagnets, soft iron, silicon steel, mu-metal, ferrites for use at audio and high frequencies

3 **Understand the physical arrangements of supply, transmission and distribution equipment**

Electrical generation: energy conversion methods eg generating plant and equipment (coal, gas, oil, nuclear, hydro electric, pumped storage, wind farms, tidal, biomass); by-products (useful and not so useful); speed governing and voltage regulation for supply standardisation

Electrical transmission: use of transformers for feeding into and out of the grid network, construction and operation of power transformers eg double-wound and autotransformers; construction and operation of switchgear and protection systems eg air circuit breakers, oil circuit breakers, fuses, over current and over voltage devices; transmission voltages eg 400kV, 275kV and 132kV and the reasons for using them; cross-channel/intercontinental links for electricity supply

Electrical distribution: ring and radial feeders; sub-stations; use of distribution voltages eg 33kV, 11kV; plant and equipment eg isolators, oil breakers, air breakers; three phase and single-phase distribution systems and voltages (400V and 230V); earthing arrangements

4 **Understand the use of electrical energy to support applications of electrical technology**

Applications of electrical technology: manufacturing eg automated processes, robotics, control systems; healthcare eg magnetic resonance imaging (MRI) scanners, operating theatre uninterruptible power supplies (UPS); entertainment eg sound and video systems, theme parks, music festivals; transport eg electric-trains, inner-city trams, electric cars, solar powered space travel

Grading grid

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all of the learning outcomes for the unit. The criteria for a pass grade describes the level of achievement required to pass this unit.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the characteristics and principles of operation of a DC electromagnetic generator P2 describe the characteristics and principles of operation of an AC electromagnetic generator P3 describe the operation and an application of a solar power source P4 describe the characteristic features of two different types of electro-chemical cells or batteries P5 describe the properties and a typical application of a solid and a liquid or gas electrical conductor P6 describe the properties and a typical application of a solid and a liquid or gas electrical insulator	M1 compare and contrast the features of three prime energy sources that are in general use for the production of electricity by mechanically driving an electromagnetic generator M2 explain the reasons for the use of a range of voltages in an electricity supply system.	D1 justify the use of different energy sources, including fuels and renewable sources, to provide a nation's electricity supply D2 explain and justify how a practical application of electrical technology could be improved by making effective use of available technologies.

Grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P7 describe the properties and an application of two different magnetic materials commonly used in electrical and electronic engineering P8 describe the arrangements and features of an electrical supply system from generation through to transmission and distribution to end users P9 describe two different applications of electrical technology and, for each of them, describe how electrical energy is used to enable them to function.		

Essential guidance for tutors

Delivery

The purpose of this unit is to give learners a feel for the breadth of the technologies used within electrical industries. Although the examples in the unit content often indicate a vast area of work, it is not intended that tutors cover all the material across the full range.

Selecting one or two themes to work with (eg conventional methods of generation and a more environmentally friendly method) should generate sufficient coverage to address all the assessment criteria.

At some time during their studies, learners would benefit from visits to a theme park or an industrial setting (eg car manufacturer, steel works, hospital, power station). Here, they would see electrical technologies in use and not just on a bench or on a whiteboard. Such visits allow learners to see equipment being put to proper use and discuss the technologies with employees, ask questions about alternatives, etc.

It might be possible to obtain a range of information from the internet, but this should never be relied on as the only source. Centres should also consider visits from local employers and engineers to talk about the technologies that they use now, what they used to use and what they plan to use in the near future. This would provide an excellent insight into the development of these technologies.

A walk around the local streets can also locate street furniture that makes use of electrical technologies — traffic lights, cameras, street lighting, signs and warnings, etc. This could provide the stimulus for further research, for example into the solar panels that are installed on top of some items such as school crossing patrol signs, vehicle speed-check installations, etc.

A further example of a possible visit might be to a wind farm/generator, which could fire learners' enthusiasm about researching the science and technologies underpinning its operation much better than a classroom lecture. It could also lead to a suitable project that could address D1 and D2.

Delivery of this unit does not necessarily need to follow the order of the content or criteria. The order of teaching and assessment will depend upon the resources available and the timing of any possible visits.

The unit lends itself adequately to a bottom up approach, starting with the basic methods of producing electricity then scaling this up to power generation, transmission, distribution and use. Alternatively tutors and learners could take a top down approach by investigating an application or two and working down to how the systems and components are put together. Learners could then investigate how electricity is produced to meet the needs of the application.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Assessment

As indicated above, although this unit could be delivered completely in class, the learning and assessment experience is much more relevant if the learners make use of the outside world and visit real applications of electrical technologies.

The pass criteria could be achieved through the use of written assignments and/or illustrated posters with relevant text boxes to describe the concepts covered, eg the characteristics and principles of operation of a DC electromagnetic generator.

For P1 (DC generator) and P2 (AC generator), motor vehicle/motorcycle parts are cheap and are a relatively safe resource that could be investigated and described. The larger items in power stations are just scaled-up models (figuratively speaking) with somewhat larger brush gear and coils, etc. Hence, an assignment could require learners to use such an easily obtainable device to help them describe the principles and operation of electromagnetic generation.

Learners could then use this simple model to illustrate the similarities and differences between these and larger machines when they consider the characteristics of a power station and its energy sources (eg a coal, gas, oil, nuclear, hydro-electric, pumped storage, wind farm, tidal, biomass) used to generate power commercially.

Solar cells (P3) can be found on a range of items including calculators and street signs, as well as small kits used by many college and school science departments. The learners' description of their operation should be limited to developments in photoelectric cells and a consideration of the action of the atoms in crystal lattice PN-junctions when subjected to illumination. An in-depth atomic theory explanation is not expected.

Cells and batteries take many forms and, although a wide range should be taught, learners only need to select two for P4. Liquid conductors and insulators (P5 and P6) could also be part of the learners' response to P4 if a wet cell such as lead acid were to be described. Reference could also be made to the potential hazard of topping up the cell with tap water if living in a hard water, high mineral content region. This would short out the plates and ruin the cell(s) whereas distilled or de-ionised water would not.

There is a wide range of other examples that could be examined for P5 and P6. For example, oil is a good insulator and is used on oil circuit breakers to quench the spark and prevent conduction. Fluorescent lights contain a variety of conductive gases and vapours requiring different arcing voltages and producing a range of colours. Overhead lines are insulated by air and any simple electric switch uses air as an insulator when in the 'off' position.

To cover P7, learners could consider electrical relays, motors, generators or similar devices that rely on electromagnetism. For example the soft iron formers of transformers and motors or a radio tuner's use of ferrite core inductors. Some devices use permanent magnets, which could also be described to address P7.

P8 requires learners to describe the arrangements and features of an electrical supply system to cover the key aspects of the content. This will include the generation method, transformer construction, types and operation including single wound (autotransformers) and double wound voltages and distribution method. Learners might also include the finer details of distribution such as an electronics workshop having isolating transformers on bench supplies and reasons why they are used.

P9 provides an opportunity for learners to apply their knowledge by considering complete real-world applications. Examples could include lighting systems, sound systems or systems including motion (ranging from a model containing an electric motor to the electrification of the rail network). The Docklands Light Railway and some airport transport systems have no driver and an investigation of these systems could allow learners to work on an area in which they may be interested and learn through the application of electrical technology. This should take learners into such aspects as electromagnetic effects and sensors for control, computer control, or the requirement for emergency or uninterrupted power supplies (UPS).

To achieve a merit, learners should be able to differentiate between the mechanical prime movers of electromagnetic generators (M1), ranging from nuclear, coal and gas to wind and wave power and water storage such as that used at Dinorwic in Wales. Things to compare and contrast could include cost, response time, maximum demand, pollution, environmental issues including appearance, hazards (and perceived hazards), locality of employees, life span of the project and post-service decommissioning.

While reporting on a supply system (P8), learners could address M2 by explaining why a range of voltages is used such as 15 to 25kV at the generators and up to 400kV for transmission, and the reasons for other voltages (eg 33kV, 11kV and 3.3kV down to 400/230 volts) for light industrial and domestic end users.

To address D1 learners need to produce a thorough justification of why a nation might use a range of different energy sources. This could include (as a source and focus for the learner's own justifications) suitably referenced third party comments from parliamentary reports, Greenpeace opinions, local opposition groups and the projected impacts on national and global economies. Other considerations could include the future of different methods and fuels, lifespan of equipment and the actual fuel, cost of fuel production, hazards and environmental impact assessments.

D2 provides an opportunity for learners to develop the ideas of P9, the applications of electrical technology. The main difference between P9 and D2 is that learners are expected to provide suggestions for improvements to many aspects of effectiveness and efficiency of a chosen application. The suggestions made, and their explanations and justifications, should be feasible and possible. This could include an evaluation of the learner's ideas by a third party/engineer in that chosen industry. The learner could then make effective use of this through further reflection and subsequent development of their own work by following the professional feedback.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit provides some of the underpinning knowledge for the SEMTA Level 3 NVQ in Electrical and Electronic Engineering.

The unit can be linked to *Unit 5*: *Electrical and Electronic Principles*, *Unit 35*: *Principles and Applications of Electronic Devices and Circuits* and *Unit 53*: *Electrical Installation*.

Essential resources

Centres will need simple models or alternators/dynamos from motor vehicles to demonstrate AC and DC generation.

Because cells and batteries can be hazardous, videos/DVDs or pictures are recommended to illustrate these along with manufacturers' data.

Indicative reading for learners

Guru B and Hiziroglu H — *Electric Machinery and Transformers* (Oxford University Press, 2000) ISBN 0195138902

Kiameh P — *Power Generation Handbook* (McGraw-Hill Publishing, 2002) ISBN 0071396047

Key skills

Achievement of key skills is not a requirement of this qualification but it is encouraged. Suggestions of opportunities for the generation of Level 3 key skill evidence are given here. Tutors should check that learners have produced all the evidence required by part B of the key skills specifications when assessing this evidence. Learners may need to develop additional evidence elsewhere to fully meet the requirements of the key skills specifications.

Communication Level 3		
When learners are:	**They should be able to develop the following key skills evidence:**	
• carrying out research into the characteristics and principles of operation of electromagnetic generation, energy sources, etc • preparing descriptions of the features and principles of operation electromagnetic generation, energy sources, etc.	C3.2	Read and synthesise information from at least **two** documents about the same subject. Each document must be a minimum of 1000 words long.
	C3.3	Write **two** different types of documents each one giving different information about complex subjects. One document must be at least 1000 words long.

Information and communication technology Level 3		
When learners are:	**They should be able to develop the following key skills evidence:**	
• searching for information on electrical technology principles and applications • preparing and presenting reports on electrical technology principles and applications.	ICT3.1	Search for information, using different sources, and multiple search criteria in at least one case.
	ICT3.2	Enter and develop the information and derive new information.
	ICT3.3	Present combined information such as text with image, text with number, image with number.

