

## Unit 53:

## Utilisation of Electrical Power

<b>Unit code</b>	<b>R/615/1521</b>
<b>Unit level</b>	<b>5</b>
<b>Credit value</b>	<b>15</b>

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### Introduction

The supply, processing and usage of electrical energy is a leading preoccupation around the world today, with significant technical, economic, environmental and societal implications. Engineers have to engage seriously with this issue and need to be aware of the real and practical impact of their decisions.

The aim of this unit is to develop students' understanding of electrical power systems and power distribution, giving consideration to the advantages and disadvantages of alternative power sources.

Students will learn about the construction and characteristics of power transmission and distribution systems, including the interconnections of systems and their necessary protection. Students will also consider the economics of components, power systems and alternative energy sources, in line with emerging developments within the energy sector.

On successful completion of this unit students will be able to explain the demands, sources and construction of electrical power generation and distribution systems, review the interconnections of power systems and their necessary protection, identify the requirement for engineering activity and describe new and emerging methods to optimise energy usage.

## Learning Outcomes

By the end of this unit students will be able to:

1. Examine the demands, sources and construction of electrical power generation and distribution systems.
2. Explore the interconnections of power systems and their protection to explain the critical processes and the effects of failure and the importance of electrical safety.
3. Evaluate the effectiveness of forms of engineering activity to promote sustainable development, with consideration of the economics of components, power systems and alternative energy sources.
4. Discuss new and emerging methods to optimise energy usage, conversion and storage techniques.

## Essential Content

### LO1 **Examine the demands, sources and construction of electrical power generation and distribution systems**

*Demands of a power generation and transmission system:*

Total power demands of a defined country over a period of a working week, identifying average, minimum and maximum demands

Overall annual energy consumption of domestic, industrial, transport and other systems, identifying and quantifying energy losses

Extent of delivered energy that is in the form of electrical energy

Comparison between the demands of a G20 industrial economy with that of a Third World economy; analysis of the trends of energy supply and demand data to predict future energy requirements and budgets

Identification of the contribution to the energy supplied by each of the significant primary sources of energy of a defined country. Influence of long-term governmental policy on managing the energy budget

### LO2 **Explore the interconnections of power systems and their protection to explain the critical processes and the effects of failure and the importance of electrical safety**

*Construction of power generation and transmission systems:*

Comparisons between the distribution of power using DC and single-phase and polyphase AC transmission systems, amplitude and phase of voltages and currents in three-phase systems with resistive and complex loads

Power factor and power measurement techniques of AC systems, including identification of a range of loads and their respective power factors, consequences of loads with poor power factor and the advantages of applying power factor corrections

Calculation of power factor correction components

Recognition of the effects of perturbations and harmonics within AC systems and describing methods to measure and reduce harmonics

The need to protect the power distribution network from the effects of overload or damage, and identification of the requirements of a robust protection system

Evaluation of the impedance of an AC transmission line, its power losses and its effect on the power delivered to a load

Review safety procedures associated with power networks and techniques for the safe measurement of system parameters

Analysis of a power network with multiple generators, transmission lines and loads using power systems simulation software

**LO3 Evaluate the effectiveness of forms of engineering activity to promote sustainable development, with consideration of the economics of components, power systems and alternative energy sources**

*Sources of electrical energy:*

Efficiency, costs, security and environmental implications of energy production using coal, oil and natural gas

Definition of 'renewable' in relation to sources of energy

Evaluation of the efficiency, costs, security and environmental implications of energy production using renewable sources of mechanical kinetic energy, including wave, tidal, large- and small-scale hydro and wind

Evaluate the efficiency, costs, security and environmental implications of energy production using solar heating, solar photovoltaics, biomass, fuel cells and geothermal techniques. Current state of research into nuclear, fusion and fission energy and other novel forms of energy

**LO4 Discuss new and emerging methods to optimise energy usage, conversion and storage techniques**

*Techniques for optimising electrical energy generation:*

Techniques for optimising the generation of electricity in power stations and small-scale generators by using varied and distributed generation systems and managing the generation of power

*Techniques for optimising energy usage and conversion:*

Evaluating technologies and techniques for improving the efficiency or reducing the energy consumption of equipment in common use, including lighting, heating, transport and industrial processes

*Energy storage techniques:*

The need for energy storage techniques as part of an energy management programme, characteristics of short-term and long-term energy storage techniques and their connection to the power grid, including, hydro, battery, super capacitor, flywheel and thermal

Emerging battery technologies and battery management techniques

## Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
<b>LO1</b> Examine the demands, sources and construction of electrical power generation and distribution systems		<b>D1</b> Critically evaluate governmental policies for managing energy budgets in the long term, making justified recommendations
<b>P1</b> Examine the key aspects of a country's energy supply, demand and losses to create a balanced energy budget for the example	<b>M1</b> Apply reliable data to quantify past and current energy trends and predict future trends, having first established the reliability of data from a variety of sources	
<b>LO2</b> Explore the interconnections of power systems and their protection to explain the critical processes and the effects of failure and the importance of electrical safety		<b>D2</b> Critically evaluate the technologies for maintaining a high quality electrical supply to customers and demonstrate the advantages of applying these by computer simulation or otherwise
<b>P2</b> Explore the key aspects of three-phase power systems using distributed generators and loads and protection  <b>P3</b> Perform calculations and simulations on example systems, showing power losses and the advantages of applying power factor correction	<b>M2</b> Analyse and interpret the results of computer-based simulations of power networks	

Pass	Merit	Distinction
<b>L03</b> Evaluate the effectiveness of forms of engineering activity to promote sustainable development, with consideration of the economics of components, power systems and alternative energy sources		<b>D3</b> Critically evaluate novel forms of energy generation using recent, peer-reviewed
<b>P4</b> Evaluate the technology of renewable sources of energy, taking into account efficiency, costs, security and environmental implications	<b>M3</b> Illustrate the application of renewable energy sources to meet existing demands, taking into account efficiency, costs, security and environmental implications	publications, taking into account efficiency, costs, security and environmental implications
<b>L04</b> Discuss new and emerging methods to optimise energy usage, conversion and storage techniques		<b>D4</b> Critically evaluate novel forms of energy optimisation and
<b>P5</b> Discuss representative examples of existing and emerging methods of energy optimisation	<b>M4</b> Evaluate the environmental effects of applying known energy optimisation techniques	efficiency and their applications using recent, peer-reviewed publications

## Recommended Resources

### Textbooks

BAYLIS, C. and HARDY, B. (2012) *Transmission and Distribution Electrical Engineering*. Elsevier Science and Technology. Newnes.

BREEZE, P.A. (2014) *Power Generation Technologies*. 2nd Ed. Newnes.

### Links

This unit links to the following related units:

*Unit 41: Distributed Control Systems*

*Unit 44: Industrial Power, Electronics and Storage*