

# Unit 44: Industrial Power, Electronics and Storage

<b>Unit code</b>	<b>M/615/1512</b>
<b>Unit level</b>	<b>5</b>
<b>Credit value</b>	<b>15</b>

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## Introduction

This unit presents a wide-ranging introduction to the field of existing and renewable energy systems. There are many alternative sources of energy (some 'green') which can be converted to an electrical form, providing energy for transport, heat/cooling and lighting, as well as energy for various industrial processes and applications.

Power electronic converters are an essential component of renewable and distributed energy sources, including wind turbines, photovoltaics, marine energy systems and energy storage systems. It is necessary to gain a clear understanding of, and be able to examine, the technical implications of providing sustainable electrical energy to meet the energy demand of the future.

The unit will also explore the potential impacts of climate change and why more, and different forms of, sustainable energy sources are required together with the need for energy efficiency measures.

By the end of this unit students will be able to examine the technological concepts behind providing a sustainable electrical energy supply for the future. They will also be able to describe how the fundamental technical and economic processes and drivers at play in the electrical power industry affect the selection and use of energy sources.

## **Learning Outcomes**

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

1. Evaluate energy demand to determine the technology and methods of energy production.
2. Discuss current energy efficiency measures, technologies and policies specific to the building and transportation sectors.
3. Analyse the control techniques of power electronics for renewable energy systems.
4. Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid.

## Essential Content

### LO1 Evaluate the energy demand to determine the technology and methods of energy production

#### *Energy demand:*

Historical energy production, energy consumption, environmental aspects and global warming

The need for energy systems and global energy demand over the short to long term

Environmental effects associated with energy generation and consumption

Practicality, benefits, drawbacks and effectiveness of renewable energy sources

Overview of renewable energy technologies (wind, solar, bio, hydro, geothermal) and the associated costs

Future energy trends, scenarios and sustainable energy sources

### LO2 Explore current energy efficiency measures, technologies and policies specific to the building and transportation sectors

#### *Energy auditing, management, costs, requirements, bench marking and optimisation:*

Energy management, planning, monitoring, policy, ecology and environment

#### *Energy and buildings:*

Overview of the significance of energy use and energy processes

Internal and external factors on energy use and the attributes of the factors

Status of energy use in buildings and estimation of energy use in a building

Standards for thermal performance of building envelope and evaluation of the overall thermal transfer

Measures and technologies to improve energy efficiency in buildings

*Energy and electric vehicles:*

Electrical vehicle configurations, requirements, and circuit topology; electric and plug in hybrid vehicles

Policies, measures and technologies to support more sustainable transportation

Use of Matlab/Simulink or alternative appropriate software to model, simulate and analyse the energy efficiency of a typical standard house or electric vehicle

**LO3 Analyse the control techniques of power electronics for renewable energy systems**

*Control techniques:*

Environmental aspects of electrical energy conversion using power electronics

Introduce design criteria of power converters for renewable energy applications

Analyse and comprehend the various operating modes of wind electrical generators and solar energy systems

Introduce the industrial application of power converters, namely AC to DC, DC to DC and AC to AC converters for renewable energy systems

Explain the recent advancements in power systems using the power electronic systems. Introduction to basic analysis and operation techniques on power electronic systems

Functional analysis of power converters' main topologies

Use of Matlab/Simulink to model, simulate and analyse the dynamic behaviour of a simple renewable energy system

**LO4 Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid**

*Impact of renewable resources:*

Safe and secure operation of a simple power system

Standalone and grid connected renewable energy systems

Introduction to smart grid, features, functions, architectures, and distributed generation. Grid interactive systems, grid tied systems, inverters, and application of its devices

Smart homes, power management, smart grid, intelligent metering

Communication technologies and power electronics modules for smart grid network, importance of power electronics in smart grid, for example energy storage (electrical, chemical, biological, and heat), and the future of smart grid

Use of Matlab/Simulink to model, simulate and analyse the dynamic behaviour of a standard smart grid.

## Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
<b>L01</b> Evaluate the energy demand to determine the technology and methods of energy production		<b>D1</b> Critically evaluate the performance of a renewable energy system and the technologies used in energy efficiency improvement
<b>P1</b> Investigate current energy sources, demand and their impact on the environment  <b>P2</b> Examine the benefits and effectiveness of renewable energy sources  <b>P3</b> Explore renewable energy technologies and their costs	<b>M1</b> Determine the use of energy sources to assess their global impact on energy demand  <b>M2</b> Evaluate the effectiveness and drawbacks of renewable energy systems for short and long term energy demands	
<b>L02</b> Explore current energy efficiency measures, technologies and policies specific to the building and transportation sectors		
<b>P4</b> Discuss current energy efficiency measures  <b>P5</b> Determine the main factors that impact on energy use and efficiency in a building  <b>P6</b> Discuss the technologies that could be used to support more sustainable transport	<b>M3</b> Apply modelling of energy management in a building or electric vehicle using Matlab/Simulink (or equivalent)  <b>M4</b> Evaluate the selection of suitable technologies to improve energy efficiency in a building or electric vehicle	<b>D2</b> Analyse the dynamic performance of a power electronic converter for a given renewable energy source and calculate the energy and cost savings against conventional power sources, including consideration for development and installation costs

Pass	Merit	Distinction
<p><b>L03</b> Analyse the control techniques of power electronics for renewable energy systems</p>		<p><b>D3</b> Critically evaluate the dynamic performance of integrating renewable energy sources to the smart grid network using a standard industrial based software, such as Matlab/Simulink software (or equivalent)</p>
<p><b>P7</b> Analyse the applications of power electronics in renewable energy applications</p> <p><b>P8</b> Determine the industrial application of power electronic converters</p> <p><b>P9</b> Analyse the power electronic converter topologies and their principles of operation</p>	<p><b>M5</b> Simulate a simple power converter for a typical renewable energy system using a standard software package such as Matlab/Simulink (or equivalent)</p> <p><b>M6</b> Critically analyse the use of the power converter selected above for a renewable energy application</p>	
<p><b>L04</b> Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid</p>		<p><b>D4</b> Critically analyse the impact of renewable energy sources and their integration to the grid using a standard industrial based software such as Matlab/Simulink (or equivalent)</p>
<p><b>P10</b> Investigate the safe operation of a smart power system</p> <p><b>P11</b> Investigate the principle of operation of standalone and grid connected renewable energy systems</p> <p><b>P12</b> Discuss the features of a smart grid network</p> <p><b>P13</b> Determine the importance of power electronics in smart grid and energy storage</p>	<p><b>M7</b> Analyse how power electronic converters are used in smart grid networks</p> <p><b>M8</b> Evaluate the issues associated with integrating renewable energy sources to the grid</p>	

## Recommended Resources

### Textbooks

ABU-RUB, H., MALINOWSKI, M. and AL-HADDAD, K. (2014) *Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications*.

John Wiley & Sons.

EKANAYAKE, J. and JENKINS, N. (2012) *Smart Grid Technology and Applications*.

John Wiley & Sons.

RASHID, M.H. (2013) *Power Electronics: Circuits, Devices and Applications*.

4th Ed. Pearson.

TWIDELL, J. and WEIR, T. (2006) *Renewable Energy Resources*. 2nd Ed.

Taylor & Francis.

### Links

This unit links to the following related units:

*Unit 51: Sustainability*

*Unit 53: Utilisation of Electrical Power*