Unit 5011: Industrial Power, Electronics and Storage

Unit Code: J/651/0865

Level: 5

Credits: 15

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.

On successful completion of this unit, students will be able to learn about the technological concepts behind providing a sustainable electrical energy supply for the future, the fundamental technical and economic processes, and drivers at play in the electrical power industry and how they affect the selection and use of energy sources.

Learning Outcomes

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

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

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

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

LO4 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 non-renewable and 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

Sustainable buildings, 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, SWOT analysis.

Energy and electric vehicles:

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

Policies, charging infrastructure, grid implications, measures, and technologies to support more sustainable transportation, SWOT analysis

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, distributed generation, grid integration and implications. Grid interactive systems, grid tied systems, inverters, and application of its devices

Smart homes, power management, smart grid, intelligent/smart 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

Discuss in groups popular and latest models of integrating a diverse range of renewable resources to the grid.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Evaluate the energy demand to determine the technology and methods of energy production		
P1 Evaluate the energy demand of a specific scenario or case study by identifying the required technology and methods of energy production with reasoning or consideration of alternatives.	**M1** Determine the effectiveness and drawbacks of renewable energy systems for short- and long-term impact on energy demands.	**D1** Justify the most suitable technologies and methods of energy production for the local area, backed by relevant data or research.
LO2 Explore current energy efficiency measures, technologies, and policies specific to the building and transportation sectors		
P2 Explore energy efficiency measures, technologies, and policies in the building and transportation sectors suggesting alternatives.	**M2** Provide detailed SWOT analysis of various energy efficiency measures, technologies, and policies in the building and transportation sectors.	**D2** Conduct an impact analysis of current and emerging energy efficiency measures, technologies and policies in the building and transportation sectors, with insightful recommendations or predictions for future developments.

Pass	Merit	Distinction
LO3 Analyse the control techniques of power electronics for renewable energy systems		
P3 Analyse the control techniques of power electronics for a given renewable energy system, applying understanding of the key concepts and practices.	**M3** Provides an analysis of the control techniques of power electronics for renewable energy systems, demonstrating a clear understanding of the theoretical principles and practical applications, including identification of strengths and weaknesses of various techniques.	**D3** Conduct an in-depth impact analysis of the control techniques of power electronics for renewable energy systems, demonstrating a superior understanding of principles, applications and future trends.
LO4 Investigate the impacts of renewable resources to the grid and the various issues associated with integrating such resources to the grid		
P4 Investigate key impacts of renewable resources on the grid and issues associated with integrating such resources	**M4** Evaluate the impacts of renewable resources on the grid and the issues with integration, demonstrating an understanding of the complexities involved.	**D4** Synthesise the challenges and potential solutions, drawing on relevant case studies and cutting-edge research.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Ackermann T. (2012) *Wind Power in Power Systems*. Wiley.

Bhimbhra P.S. (2012) *Power Electronics*. Khanna Publishers.

Cole B. (Editor) (2023) *Power Electronics: Devices, Circuits and Applications* (Hardback). Clanrye International.

Duffie J.A. and Beckman W. A. (2013) *Solar Engineering of Thermal Processes*. Wiley.

Dugan R.C., McGranaghan M.F., Santoso S., and Beaty H.W. (2012) *Electrical Power Systems Quality*, Third Edition (Electronics) Hardcover – Illustrated. McGraw Hill.

Fekik A., Ghanes M. and Denoun H. (Editors) (2023) *Power Electronics Converters and their Control for Renewable Energy Applications* (Paperback). Elsevier Science & Technology.

Kassakian J.G., Perreault D.J., Verghese G.C. and Schlecht M.F. (2023) *Principles of Power Electronics* (Hardback). Cambridge University Press.

Kumar S., Singh B., and Singh A.K. (Editors) (2023) *Recent Advances in Power Electronics and Drives: Select Proceedings of EPREC 2021 − Lecture Notes in Electrical Engineering 852* (Paperback). Springer.

Kumar N., Guerrero J.M., Kastha D., and Saha T.K. (Editors) (2022) *Power Electronics for Next-Generation Drives and Energy Systems. Volume 1: Converters and control for drives*. IET Digital Library.

Masters G.M. (2013) *Renewable and Efficient Electric Power Systems* (IEEE Press) Hardcover – Illustrated. Wiley-IEEE Press.

Na (2014) *A Course in Electrical and Electronic Measurements and Instrumentation* (Nineteenth Revised Edition 2011 Reprint 2014) Paperback. NA.

Peake S. (Editor) (2017) *Renewable Energy: Power for a Sustainable Future* Paperback – Illustrated. OUP Oxford.

Rashid M.H.(Editor) (2023) *Power Electronics Handbook* (Hardback). Elsevier.

Vittal V., Mccalley J.D., Anderson P.M., and Fouad A.A. (2019) *Power System Control and Stability (IEEE Press Series on Power and Energy Systems)* Hardcover. Wiley-IEEE Press.

Willis H.L. (Editor) (2018) *Distributed Power Generation: Planning and Evaluation*. eBook. Routledge.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Energies

Energy and Buildings

Energy Policy

IEEE Power and Energy Magazine

IEEE Transactions on Power Electronics

International Journal of Electrical Power and Energy Systems

International Journal of Sustainable Transportation

Journal of Cleaner Production

Renewable and Sustainable Energy Reviews

Renewable Energy

Transportation Research Part D: Transport and Environment

Links

This unit links to the following related units:

Unit 5018: Sustainability

Unit 5020: Utilisation of Electrical Power.