

Branch Name:	Electrical Engineering
ProgramCode:	ET213
CourseName:	Elective: IV- Power Electronics For Renewable Energy Systems
CourseCode:	2ET2130402
Pre-requisiteCourse:	Fundamental Knowledge of Power Electronics and Renewable Energy.

Course Objectives:

1. To understand concepts of the increasing demand of the energy and have accelerated the interest in the renewable energy sources.
2. To identify the need of power electronic converters and its topologies for different renewable sources.
3. To understand issues in the operation, control and integration of usage of renewable energy sources.

Teaching and Examination Scheme:

Credit	Teaching Scheme Hours per week				Evaluation Scheme (Marks)								
					Theory (Marks)				Practical (Marks)				Total (Marks)
	L	T	P	Total	SEE		CCA		SEE		CCA		
					Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
4	4	-	-	4	24	60	16	40	-	-	-	-	100

Course Contents:

Sr. No	Topic	Total Hours	Weightage (%)
1	Energy Scenario: National and International current energy scenario; Share of renewable and non-renewable energy sources.	03	05%
2	Photovoltaic Energy Conversion Systems: Introduction to solar cell, PV cell technology, I-V and P-V curves of PV cell/modules/array, Electrical modelling of PV cell, Sun tracking and Sun tracking System (Mechanical Tracking), Maximum Power Point Tracking (Electrical Tracking), MPPT techniques, I-V and P-V curves under non uniform conditions, PV inverter configurations, Distributed MPPT, Control of PV inverter/converter configurations, Grid connected Systems, Islanded systems, Recent development in converter configurations for PV.	10	25%
3	Wind Energy Conversion Systems: Basics of wind energy, Components of wind turbine, Wind turbine aerodynamics, MPPT control, Modelling of wind energy system, Types of generators: induction (singly fed and doubly fed) and synchronous generators, Converters for wind energy conversion system, Fixed speed and variable speed wind energy conversion system, Control schemes for different wind energy conversion system configurations.	12	30%
4	Operation and control of Distributed Energy Generators: Distributed Power Generation Systems, Single-Stage Photovoltaic Systems, Small/Medium-Sized Wind Turbine Systems, Overview of the Control Structure, Control of Power Converters for Grid-Interactive Distributed Power Generation Systems, Droop Control; Power Control in Micro grid, Control Design Parameters, Harmonic Compensation, Ancillary Feature, Voltage Support at Local Loads Level, Reactive Power Capability, Voltage Support at Electric Power System Area: Anti-islanding, Ride-through requirements.	06	15%

5	Issues, Regulations and Standards for Grid Connection: Grid requirements for PV system and modern wind energy system: Issues like safety, harmonics, stability, synchronization, islanding, restoration and ride-through etc., Recent international standards adopted by various countries.	05	10%
6	Energy Storage system: Introduction, The Structure of Power Storage Devices, Pumped storage, Hydroelectricity, Compressed Air Energy Storage System, Flywheels, Battery Storage, Battery charging circuits, Hydrogen Storage, Superconducting Magnet Energy Storage, Super-capacitors, Role of Energy Storage Devices for distributed generation, Fuel Cell: Principle, types and applications, Converters for fuel cell, Control of Fuel Cell Control System, Electric and Hybrid Vehicles, Power Electronics for EV and Hybrid vehicles, Vehicle to grid and vehicle to home system, Concept of Smart Grid, Communication, metering, issues etc.	07	15%

Text Books:

1. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, "Grid Converters for Photovoltaic and Wind Power Systems", Wiley IEEE Press, Jan 2011.
2. Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, "Power Conversion and Control of Wind Energy Systems", Wiley IEEE Press, July 2011.
3. Haitham Abu-Rub, Mariusz Malinowski, Kamal Al-Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", Wiley IEEE Press, June 2014.

Reference Books:

1. Chetan S. Solanki; "Solar Photo voltaics: Fundamentals, Technologies & applications", Prentice Hall of India, 2009.
2. Mukund R. Patel; "Wind & Solar Power System Design, analysis & Operation", Taylor & Francis, 2006.
3. Qing-Chang Zhong, Tomas Hornik; "Control of Power Inverters in Renewable Energy and Smart Grid Integration", Wiley IEEE Press, Jan 2013.
4. M. Hashem Nahrir, Caisheng Wang; "Modeling and Control of Fuel Cells: Distributed Generation Applications", Wiley IEEE Press, 2009.

List of Open Source Software/learning website:

1. MIT OPEN COURSE WARE by Massachusetts Institute of Technology-website: ocw.mit.edu
2. Courses available through NPTEL.-website: npTEL.ac.in.

Course Learning Outcomes (CLO): On completion of this course, the students will be able to:

CLO	Description	Bloom's Taxonomy Level
CLO1	Understand the need of renewable energy for the benefit of the society.	2 Understanding
CLO2	Understand the use of power converters for processing of renewable power.	2 Understanding
CLO3	Applying appropriate power electronic converter for particular renewable energy source.	3 Applying
CLO4	Design the control scheme for power converter for PV system.	4 Analyze 6 Creating
CLO5	Design the control scheme for power converter for Wind Energy Conversion System.	4 Analyze 6 Creating
CLO6	Evaluate various issues involved in the control and integration of renewable sources with the grid.	5 Evaluate

Mapping of CLOs with POs & PSOs

Course Learning Outcomes	Program Outcomes (POs)												Program Specific Outcomes (PSOs)			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CLO1	L			M			L				M		M			L
CLO2	L			M			L				M		M			L
CLO3		H		L	M	L		M					H		H	L
CLO4	L		L		M			M		L		M		M	H	L
CLO5	L		L		M			M		L		M		M	H	L
CLO6		H	L	M				H			L			L	H	