GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: WIND AND SOLAR ENERGY SYSTEMS
(COURSE CODE: 3350905)

Diploma Programmers in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

Gujarat is one of the several states in India where a large number of wind and solar grid connected electric power installations, and competent technicians to maintain these vital renewable energy power plants is a dire need of the industry. It is to fulfill this need, that this curriculum has been designed so that the diploma engineer would be able to maintain the installations thereby minimising the downtime. It is presumed that the students have studied

2. COMPETENCY (Programme outcome according to NBA terminology

The course should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Maintain various types of wind power plants and solar power plants.**

3. COURSE OUTCOMES

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

i. Maintain constant speed wind power plants.
ii. Maintain variable speed wind power plants.
iii. Maintain concentrated solar power (CSP) and solar photovoltaic (PV) wind power plants,
iv. Check the grid compatibility of the power from wind and solar power plants.
v. Resolve the grid integration issues of wind and solar power plants

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5. COURSE DETAILS

Unit	Major Learning Outcomes (Major outcomes in Cognitive Domain)	Topics and Sub-topics
Unit – I Constant Speed Wind Power Plants	1a. Explain the working principle of a squirrel cage induction generator (SCIG) used in Type-A WPP. 1b. Describe the starting methods of stall and pitch controlled Type-A WPPs. 1c. With relevant sketches, explain the reactive power compensation methods that is used in Type-A WPP.	1.1 Type-A WPP: • Working Principle • SCIG Torque-Slip characteristics • Different topologies • Starting methods • Reactive Power in constant speed WPPs. • Maintenance procedure
	1d. Explain the working principle of a wound rotor induction generator (WRIG) used in Type-B WPP. 1e. Compare the major differences in the maintenance of Type-A and Type-B WPPs.	1.2 Type-B WPP: • Working Principle • SCIG Torque-slip characteristics • Maintenance procedure
Unit – II Variable Speed Wind Power Plants	2a. Explain the working principle of a doubly fed induction generator (DFIG) used in Type-C WPP	2.1 Variable Speed Type-C WPP: • Working Principle Back to Back control • Maintenance procedure of Type-C WPPs
	2b. Explain the working principle of a wound rotor synchronous generator (WRSG) used in a Type-D geared WPP. 2c. Explain the working principle of a permanent magnet synchronous generator (PMSG) used in a Type-D geared WPP. 2d. Compare the major differences in the maintenance of Type-D geared WPPs using WRSG and PMSG.	2.2 Variable speed Type-D Geared WPPs • With WRSG - working principle • With PMSG - working principle • With variable speed SCIG - working principle • Maintenance procedure of Type-D Geared WPPs
	2e. Explain the working principle of a wound rotor synchronous generator (WRSG) used in a Type-D direct-drive WPP. 2f. Explain the working principle of a permanent magnet synchronous generator (PMSG) used in a Type-D direct-drive WPP. 2g. Compare the major differences in the maintenance of Type-D direct drive WPPs using WRSG and PMSG.	2.3 Type-D direct-drive WPPs • With WRSG - working principle • With PMSG -working principle • Maintenance procedure of Type-D direct-drive WPPs
Unit – III Solar Power Plant	3a. Explain the concept of solar thermal power plants. 3b. Describe the construction and	3.1. Solar Thermal Power Plants: Working of a typical Concentrated

Unit	Major Learning Outcomes (Major outcomes in Cognitive Domain)	Topics and Sub-topics
Performance	performance of a typical CSP plant 3c. Describe the maintenance procedure of a typical CSP plant	Solar Power (CSP) plant 3.2. Maintenance procedure of CSP systems
	3d. Explain the concept of solar PV power plants. 3e. Describe the construction and performance of a typical solar PV power plant. 3f. Describe the maintenance procedure of a typical solar PV power plant. 3g. Describe the features required of a battery for solar PV system 3h. Explain the significance of solar PV tracking.	3.3. Solar photovoltaic (PV) Power Plants: Working of a typical Solar PV Power plant. 3.4. Maintenance procedure of typical Solar PV Power plant 3.5. Batteries for solar PV system.
Unit – IV Wind and Solar Power Quality	4a. Describe the phenomenon of local impact of wind power on the grid 4b. Suggest ways to handle these local impacts safely	4.1. Local impact of wind power on the grid.
	4c. Explain the phenomenon of system wide impact of wind power 4d. Suggest ways to handle these system wide impacts safely	4.2. System wide impact of wind power on the grid. 4.3. Power Quality of solar PV systems
	4e. Differentiate the features of the power obtained from the solar PV and CSP power plant.	4.4. Power quality of CSP solar plant. 4.5. Power quality of solar PV power plant
Unit –V Grid Connection of Wind and Solar Power Plants	5a. State the grid interface issues of wind power and methods to resolve them. 5b. State the grid operational issues of wind power and methods to resolve them.	5.1. Grid interface issues of wind power. 5.2. Grid operational issues of wind power.
	5c. State the method(s) of integrating into the grid the power obtained from a CSP plants with sketches. 5d. State the method(s) of integrating into the grid the power obtained from solar PV power plants with sketches. 5e.Describe with sketches and labels the concept of a grid connected wind solar hybrid system. 5f. Describe the maintenance procedure of a typical grid connected wind-solar PV hybrid system.	5.3.Grid connection of CSP plants. 5.4. Grid connection of solar PV power plants 5.5. Wind- solar hybrid systems 5.6.Maintenance of solar PV and wind solar Hybrid system

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Constant Speed Wind Power Plants	12	04	12	04	20
II	Variable Speed Wind Power Plants	12	04	12	04	20
III	Solar Power Plant Performance	08	04	06	02	12
IV	Wind and Solar Power Quality	06	02	06	04	12
V	Grid Connection of Wind and Solar Power Plants	04	02	04	00	06
	Total	**42**	**16**	40	14	**70**

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills ***(outcomes in psychomotor and affective domain)*** so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note*: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Hours Required
1	I	Dismantle a small planetary gearbox used in WPPs	02
2	I	Assemble a small planetary gearbox used in WPPs	02
3	I	Identify the various parts of a squirrel cage induction generator (SCIG) commonly used in Type-A WPPs	02
4		Dismantle a small SCIG.	02
5	I	Assemble a small SCIG.	02
6	I	Operate the squirrel cage induction motor as a SCIG to	02

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Hours Required
		test the performance.	
7	I	After viewing the video of Type-A WPP and identify the parts which require preventive maintenance	02
8	I	Identify the various parts of a wound rotor induction generator (WRIG).	02
9	I	Dismantle a small WRIG.	02
10	I	Assemble a small WRIG.	02
11	I	Operate the wound rotor induction motor as a WRIG to test the performance.	02
12	I	After viewing the video of Type-B WPP and identify the parts which require preventive maintenance	02
13	II	Identify the various parts of a doubly-fed induction generator (DFIG).	02
14	II	Dismantle a small DFIG.	02
15	II	Assemble a small DFIG.	02
16	II	Operate the DFIG to test the performance.	02
17	II	After viewing the video of Type-C WPP and identify the parts which require preventive maintenance	02
18	II	Identify the various parts of a wound rotor synchronous generator (WRSG) also used in Type-D geared WPPs	02
19	II	Dismantle a WRSG.	02
20	II	Assemble a WRSG.	02
21	I1	Operate the WRSG to test the performance.	02
22	I1	After viewing the video of Type-D geared WPP with WRSG and identify the parts which require preventive maintenance	02
23	II	Identify the various parts of a permanent magnet synchronous generator (PMSG) also used in Type-D geared WPPs	02
24	II	Dismantle a PMSG.	02
25	II	Assemble a PMSG.	02
26	II	Operate the PMSG to test the performance.	02
27	II	After viewing the video of Type-D geared WPP with PMSG and identify the parts which require preventive maintenance	02
28	I1	After viewing the video of Type-D direct-drive WPP with WRSG and identify the parts which require preventive maintenance	02
29	II	After viewing the video of Type-D direct-drive WPP with	02

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Hours Required
		PMSG and identify the parts which require preventive maintenance	
30	III	Assemble a CSP system	02
31	III	Dismantle a CSP system	02
32	III	Assemble a solar PV cell, module, array system with and without battery connection	02
33	III	Dismantle a solar PV cell, module, array system with and without battery connection	02
34	III	Test the performance of a solar PV cell, module, array system with and without battery connection	02
35	III	Connect the solar PV modules in series and parallel	02
36	III	Test the solar PV tracking system	02
37	III	Test the effect of Light and temperature intensity on the solar PV system	02
38	V	Assemble a wind-solar PV hybrid system	02
39	V	Dismantle a wind-solar PV hybrid system	02
40	V	Test the performance of a wind-solar PV hybrid system	02
		TOTAL	**80**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following are the list of proposed student activities such as:

i. A 'portfolio' of information on a renewable energy topic/technology will be developed by each student.
ii. Install and bring down a hydraulically operated tubular tilt-up/tilt-down tower of a wind solar hybrid system in the polytechnic campus
iii. Prepare journals based on experiments performed in laboratory

9. SPECIAL INSTRUCTIONAL STRATEGIES

i. Visit to wind farms
ii. Visit to solar power plants
iii. Visit to wind solar hybrid systems
iv. Use Video films/animation films on working of various types of wind power plants.
v. Use Video films/animation films on working of various types of solar power plants.
vi. Mini project.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Wind Power Technology	Earnest , Joshua	PHI Learning, New Delhi, 2014
2.	Solar Photovoltaic: A Lab Training Module	Solanki,Chetan Singh, Arora, Brij M., Vasi Juzer, Patil, Mahesh B.	Cambridge University Press, New Delhi, 2009
3.	Solar Photovoltaic: Fundamentals, Technologies and Application	Solanki,Chetan Singh,	PHI Learning, New Delhi, 2009
4.	Wind Power Plants and Project Development	Earnest , Joshua and Wizelius, Tore	PHI Learning, New Delhi, 2011
5.	Solar Energy	S.P. Sukhatme, J.K.Nayak.	Tata McGraw, New Delhi, 2010.
6.	Introduction to Photovoltaics	John R. Balfour, Michael L. Shaw, Sharlave Jarosek	Jones & Bartlett Publishers, Burlington, 2011
7.	Concentrator Photovoltaic	Luque A. L. and Andreev V.M.	Springer, 2007
8.	Solar Cells and Their Applications	Partain L.D., Fraas L.M.	Wiley, 2nd Ed., New Delhi, 2010

B) Major Equipment/Instruments with Broad Specifications

i. Squirrel Cage Induction Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
ii. Wound Rotor Induction Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
iii. Doubly fed Induction Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. -- 2 Nos
iv. Wound Rotor Synchronous Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
v. Permanent Magnet Synchronous Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz. - 2 Nos
vi. Planetary Gearbox: Matching with 50/100/ 250 kW wind turbine second hand or new : 5 Nos.
vii. GFRP Wind Turbine blades: suitable for 10kW Wind turbines : 12 Nos.
viii. 3-bladed Geared Wind Turbine: 5/10/20/30 kW, Upwind with 20/30 m hydraulically operated tilt-up/tilt-down tubular tower or whichever lowest rating that is available in the market - 1 No.
ix. Concentrated Solar Power (CSP) system - 5/10/20/30 kW or whichever lowest rating that is available in the market

x. Polycrystalline solar PV module: 10/20/30/30 or 50 W module or whichever lowest rating that is available in the market - 5 Nos. or whichever lowest rating that is available in the market - 5 Nos.
xi. Monocrystalline solar PV module: 10/20/30/30 or 50 W module or whichever lowest rating that is available in the market - 5 Nos.
xii. Wind (1kW) - Solar PV (1kW) Hybrid System complete in all aspects - 1 set
xiii. Non-motorised solar PV tracking systems - 200/300 or 500 W - 1 set
xiv. Solar Photovoltaic Training Kit from Electrical Engineering Dept. IIT, Mumbai - 10 kits

C) List of Software/Learning Websites

i. Wind Power

- http://www.awea.org/Resources/Content.aspx?ItemNumber=900
- http://www.windpowerwiki.dk/
- http://learn.kidwind.org/teach

ii. Solar Power

- http://www.fao.org/docrep/010/ah810e/AH810E11.htm
- http://www.renewables-made-in-germany.com/en/renewables-made-in-germany-start/solar-energy/solar-thermal-energy/overview.html
- http://www.renewables-made-in-germany.com/en/renewables-made-in-germany-start/solar-energy/solar-thermal-power-plants/overview.html
- http://www.eai.in/ref/ae/sol/technology_options.html

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- Prof. J.K. Rathod, Hod (Electrical Engg.), Tolani F.G. Polytechnic, Adipur

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. (Mrs.) C.S. Rajeshwari**, Professor and Head, Department of Electrical and Electronics Engineering
- **Prof. Joshua Earnest**, Professor, Department of Electrical and Electronics Engineering