Program Name : **Electrical Engineering Program Group**

Program Code : **EE/EP/EU**

Semester : **Third**

Course Title : **Electric Power Generation**

Course Code : **22327**

1. RATIONALE

Electrical power plays significant role in the development of industries and agriculture. With growing demand of electric power and diminishing of fossil fuels it has become important to generate power more efficiently. This course therefore deals in detail about generation of electric power using Thermal (Coal), Hydro, Nuclear fuels, Diesel and gas. These types of power plants need highly skilled technicians who are capable of operating various control equipment to supply uninterrupted power. This course attempts to develop the basic cognitive skills required to take appropriate decisions to maintain the various generating and auxiliary equipment of power plants and also aid for further studies in transmission, distribution, utilization and protection of power system for smooth and steady operation.

2. COMPETENCY

This aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain the efficient operation of various electric power generating plants.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Maintain the optimised working of the thermal power plant.
b. Maintain the optimised working of large and micro hydro power plants.
c. Maintain the optimised working of solar and biomass-based power plants.
d. Maintain the optimised working of wind power plants.
e. Select the adequate mix of power generation based on economic operation.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

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

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

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

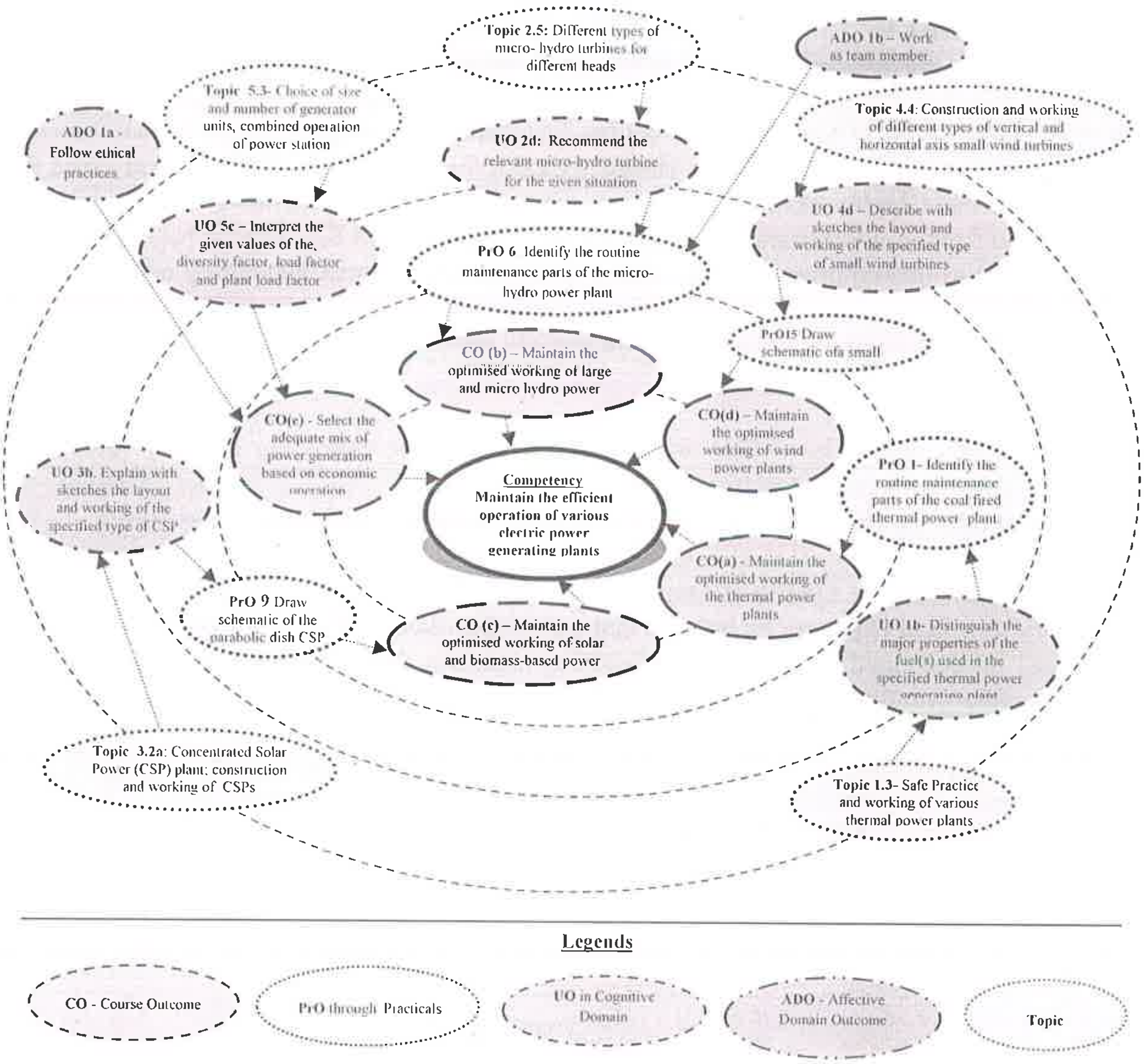

Figure 1 Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the routine maintenance parts of the coal fired thermal power plant after watching a video programme	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
2	Identify the routine maintenance parts of the gas fired thermal power plant after watching a video programme	I	02
3	Draw schematic of a small diesel generator power plant.	I	02*
4	Identify the parts of the nuclear fired thermal power plant after watching a video programme.	I	02
5	Identify the routine maintenance parts of the large hydro power plant after watching a video programme	II	02
6	Identify the routine maintenance parts of the micro hydro power plant after watching a video programme.	II	02
7	Draw the schematic of a micro hydro power plant.	II	02*
8	Draw the schematic of the parabolic trough Concentrated Solar Power (CSP) plant.	III	02*
9	Draw the schematic of the parabolic dish CSP plant.	III	02*
10	Draw the schematic of the solar PV plant.	III	02*
11	Draw the schematic small biogas plant to generate electric power	III	02*
12	Draw schematic of the biogas plant.	III	02
13	Identify the routine maintenance parts of the large wind power plant after watching a video programme.	IV	02*
14	Draw schematic of a horizontal axis small wind turbine.	IV	02
15	Draw schematic of a vertical axis small wind turbine	IV	02*
16	Identify the routine maintenance parts of the horizontal axis small wind turbine after watching a video programme.	IV	02*
17	Identify the routine maintenance parts of the vertical axis small wind turbine after watching a video programme.	IV	02
	Total		**34**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below.

S. No.	Performance Indicators	Weightage in %
1	Observations and Recording of different aspects of the viewed video programme	10
2	Use of relevant tools when assembling power plants and accessories	20
3	Use of relevant tools when dismantling power plants and accessories	20
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year

g. 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS SUGGESTED BUT NOT COMPULSORILY NEEDED

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Video programme on coal fired thermal power plant – part I	1
2	Video programme on coal fired thermal power plant – part II	1
3	Video programme on gas fired thermal power plant – part I	-
4	2 to 5 kW Diesel generator set with relevant auxiliaries	3
5	Video programme on nuclear powered thermal power plant – part I	4
6	Video programme on nuclear powered thermal power plant – part II	4
7	Video programme on large hydro power plant – part I	5
8	Video programme on large hydro power plant – part II	5
9	Video programme on micro hydro power plant – part I	6
10	Video programme on micro hydro power plant – part II	7
11	1 to 3 kW microhydro power plant with relevant auxiliaries	7
12	1 to 3 kW parabolic trough Concentrated Solar Power (CSP) plant with relevant auxiliaries	8
13	1 to 3 kW parabolic dish Concentrated Solar Power (CSP) plant with relevant auxiliaries	9
14	1 to 3 kW solar PV plant with solar tracking arrangement	10
15	1 to 3 kW biogas plant with relevant auxiliaries	11,12
16	Video programme on large wind power plant – part I	13
17	Video programme on large wind power plant – part II	13
18	Video programme on small wind power plant – part I	14
19	Video programme on small wind power plant – part II	14
20	1 to 5 kW horizontal axis small wind turbine with towers	14
21	0.5 to1 kW vertical axis wind turbine with towers	15
22	Video programme on horizontal axis small wind turbine.	16

S. No.	Equipment Name with Broad Specifications	PrO. No.
23	Video programme on vertical axis small wind turbine.	17
24	Computer simulations of all the above power plants	All

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Thermal Power Plants: Coal, Gas/ Diesel and Nuclear-based	1a. Describe the layout of the electric power generating process with labeled block diagram of the specified thermal power plant. 1b. Distinguish the major properties of the fuel(s) that is used in the specified thermal power generating plant(s). 1c. Explain with sketches working of the given type of nuclear power plant. 1d. Explain with sketches the function of the specified thermal power plant auxiliary. 1e. Describe the specified safe practice to the followed with respect to specified thermal power plant. 1f. State the location of the specified thermal power plant in Maharashtra	1.1 Layout and working of a typical thermal power plant with steam turbines and electric generators. 1.2 Properties of conventional fuels used in the energy conversion equipment used in thermal power plants: Coal, Gas/ diesel, Nuclear fuels –fusion and fission action 1.3 Safe Practices and working of various thermal power plants: coal-based, gas-based, diesel-based, nuclear-based. 1.4 Functions of the following types of thermal power plants and their major auxiliaries: a. Coal fired boilers: fire tube and water tube. b. Gas/diesel based combustion engines c. Types of nuclear reactors: Disposal of nuclear waste and nuclear shielding. 1.5 Thermal power plants in Maharashtra.
Unit – II Large and Micro-hydro Power Plants	2a. Identify the type of the hydro turbine required for the given site data with justification. 2b. Explain with sketches the construction and working of the specified type of hydro power plant for the given head. 2c. Explain the layout with sketches the working of the given type of micro-hydro power plant. 2d. Recommend the relevant	2.1 Energy conversion process of hydro power plant. 2.2 Classification of hydro power plant: High, medium and low head. 2.3 Construction and working of hydro turbines used in different types of hydro power plant: a. High head – Pelton turbine b. Medium head – Francis turbine c. Low head – Kaplan turbine. 2.4 Safe Practices for hydro power plants. 2.5 Different types of micro- hydro turbines for different heads: Pelton, Francis and Kaplan turbines

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	micro-hydro turbine for the given situation with justification. 2e. Describe the specified safe practices to the followed with respect to hydro power plants.	2.6 Locations of these different types of large and micro-hydro power plants in Maharashtra 2.7 Potential locations of micro-hydro power plants in Maharashtra.
Unit– III Solar and Biomass based Power Plants	3a. Mark the location of the given global solar power radiation values in the map of India. 3b. Explain with sketches the layout and working of the specified type of CSP. 3c. Describe with sketches the layout and working of the specified type of solar power plant. 3d. Explain with sketches the layout of the specified type of biomass-based power plant. 3e. Describe the features and the energy extraction process of the given type of biomass fuel.	3.1 **Solar Map of India:** Global solar power radiation. 3.2 **Solar Power Technology** a. Concentrated Solar Power (CSP) plants, construction and working of: Power Tower, Parabolic Trough, Parabolic Dish, Fresnel Reflectors b. Solar Photovoltaic (PV) power plant: layout, construction, working. 3.3 **Biomass-based Power Plants** a. Layout of a Bio-chemical based (e.g. biogas) power plant: b. Layout of a Thermo-chemical based (e.g. Municipal waste) power plant c. Layout of a Agro-chemical based (e.g. bio-diesel) power plant 3.4 Features of the solid, liquid and gas biomasses as fuel for biomass power plant.
Unit– IV Wind Power Plants	4a. Mark the locations of the given wind power density values in the given map of India. 4b. Describe with sketches the layout and working of the specified type of large wind power plant. 4c. Differentiate the salient features of the specified type of electric generators used in large wind power plants.	4.1 Wind Map of India: Wind power density in watts per square meter 4.2 Layout of Horizontal axis large wind power plant: a. Geared wind power plant. b. Direct drive wind power plant. 4.3 Salient Features of electric generators used in large wind power plants: a. Constant Speed Electric Generators: Squirrel Cage Induction Generators (SCIG), Wound Rotor Induction Generator (WRIG) b. Variable Speed Electric Generators: Doubly-fed induction generator (DFIG), wound rotor synchronous generator (WRSG), permanent magnet synchronous generator (PMSG)
	4d. Describe with sketches the layout and working of the specified type of	4.4 Construction layout of different types of horizontal and vertical axis small wind turbines

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	horizontal/vertical axis small wind turbine. 4e. Recommend the relevant small wind turbine for the specified location.	4.5 Working of different types of horizontal and vertical axis small wind turbines: direct-drive and geared; permanent magnet generators and induction generators. 4.6 Location and installation of small wind turbines
Unit– V Economics of Power generation and Interconnected power system	5a. Interpret the given load curve, load duration curve, integration duration curve 5b. Interpret the given values of the demand factor, plant capacity factor, plant use factor. 5c. Interpret the given values of the, diversity factor, load factor and plant load factor 5d. State the causes and impact of the given grid system fault	5.1 Related terms: connected load, firm power, cold reserve, hot reserve, spinning reserve. Base load and peak load plants; Load curve, load duration curve, integrated duration curve 5.2 Cost of generation: Average demand, maximum demand, demand factor, plant capacity factor, plant use factor, diversity factor, load factor and plant load factor. 5.3 Choice of size and number of generator units, combined operation of power station. 5.4 Causes and Impact and reasons of Grid system fault: State grid, national grid, brownout and black out; sample blackouts at national and international level

Note: *To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Thermal Power Plants: Coal, Gas/ Diesel and Nuclear-based.	20	03	04	06	13
II	Large and Micro-Hydro Power Plants.	10	04	04	08	16
III	Solar and Biomass Power Plants.	12	04	04	08	16
IV	Wind Power Plants.	12	02	03	05	10
V	Economics of Power Generation and Interconnected Power System .	10	03	04	08	15
	Total	**64**	**16**	**19**	**35**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note: *This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Illustrate importance of electrical energy requirement.
b. Prepare models in the form of mini-projects.
c. Prepare power point presentation related to power plants
d. Prepare charts of power plants.
e. Collect data of conventional generation for India and Maharashtra.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. At least one visit to any one generating plant.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Prepare a labeled clay model and other materials of coal fired thermal power plant.
b. Prepare a labeled clay model and other materials of gas fired thermal power plant.
c. Prepare a labeled clay model and other materials of diesel fired thermal power plant.
d. Prepare a labeled clay model and other materials of nuclear powered thermal power plant.
e. Prepare a labeled clay model and other materials of large hydro power plant.
f. Prepare a labeled clay model and other materials of micro hydro power plant.
g. Prepare a labeled clay model and other materials of CSP plant.
h. Design a small wind turbine or some of its components.

i. Prepare a clay model and other materials of electric grid system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Power plant Engineering	Nag P K	McGraw Hill, New Delhi, 2017 ISBN: 978-9339204044
2	A course in electrical power.	Gupta, J.B.	S. K Kataria and sons, New Delhi. 2014, ISBN: 9789350143742
3	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2015, ISBN:978-81-203-5166-0
4	Solar Energy	Solanki, Chetan Singh	PHI Learning, New Delhi, 2016, ISBN:978-81-203-5111-0
5	Generation of electrical Energy	Gupta, B.R.	S.Chand & Co. New Delhi, 2010, ISBN: 9788121901024
6	A course in electrical power.	Soni, Gupta, Bhatnagar	Dhanpatrai and sons, New Delhi, 2010, ISBN: 9789350143742
7	Principles of power system	Mehta, V.K. and Rohit mehta	S.Chand & Co. New Delhi, 2005, ISBN: 9788121924962

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.ntpc.co.in
b. www.nhpcindia.com
c. http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/
d. http://mnre.gov.in/file-manager/grid-wind/guideline-wind.pdf
e. http://mnre.gov.in/schemes/grid-connected/solar/
f. http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/
g. http://mnre.gov.in/schemes/grid-connected/biomass-gasification/
h. http://mnre.gov.in/schemes/grid-connected/biogas/
i. http://mnre.gov.in/schemes/new-technologies/biofuels/
j. http://mnre.gov.in/schemes/grid-connected/small-hydro/
k. http://mnre.gov.in/schemes/new-technologies/geothermal/
l. http://mnre.gov.in/schemes/new-technologies/tidal-energy/
m. http://mnre.gov.in/schemes/new-technologies/hydrogen-energy/
n. www.powergridindia.com
o. www.howstuffworks.com
p. www.electrical4u.co
q. www.meda.com