Program Name : **Electrical Engineering Program Group**

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

Semester : **Fifth**

Course Title : **Energy Conservation and Audit**

Course Code : **22525**

1. RATIONALE

The pressure of Technological development in all sectors on the Renewable energy sources has led to the growingthe cost of energy around the world. Efficient and judicious use of the available energy sources would lead to the easing of such pressures and drastic decrease in the operating costs of the organizations and industries. Thus it is necessary to save and conserve energy to the maximum possible extent. Also essential theoretical knowledge and practical skills about the concept of energy conservation is to be provided through different approaches, project management and economics accepts. The process of energy audit will help to identify the various possible avenues in which savings of energy can be effectively adopted. This course makes the diploma holder well acquainted in the techniques of energy conservation in the fields of engineering. It also introduces him to the energy audit procedures.

2. COMPETENCY

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

- **Undertake energy conservation and energy audit.**

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. Interpret energy conservation policies in India.
b. Implement energy conservation techniques in electrical machines.
c. Apply energy conservation techniques in electrical installations.
d. Use Co-generation and relevant tariff for reducing losses in facilities.
e. Carryout energy audit for electrical system.

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
3	-	2	5	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*

1. 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.

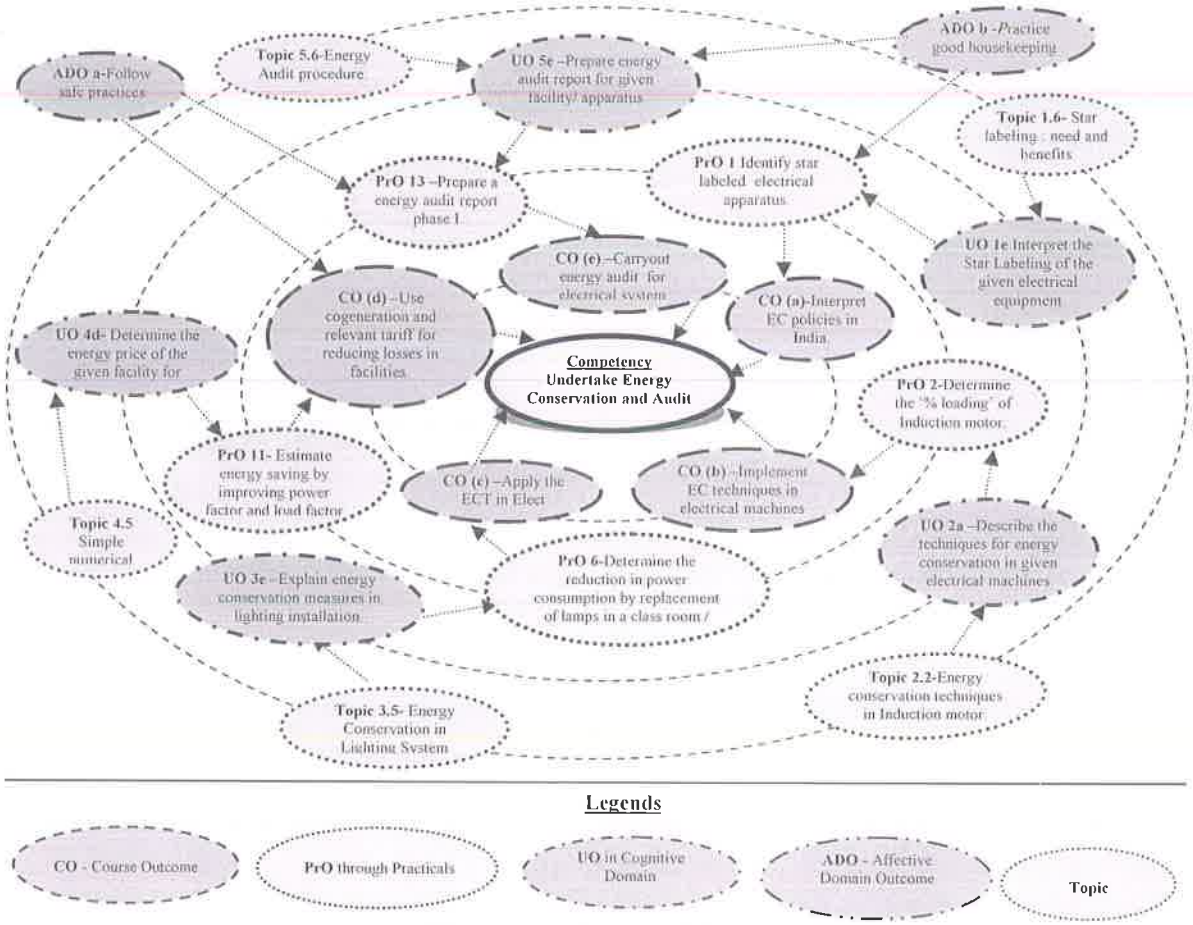

Figure 1 - Course Map

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 star labeled electrical apparatus andcompare the data for various star ratings.	I	02*
2	Determine the '% loading' along with the related efficiency for different loads of given Induction motor (30 to 110 percent in steps of 10%).	II	02*
3	Determine the reduction in power consumption in star mode operation of Induction motor compared to delta mode.	II	02*
4	Use APFC unit for improvement of p. f. of electrical load.	II	02
5	Compare power consumption of different types of TL with choke, electronic ballast and LED lamps by direct measurements.	III	02
6	Determine the reduction in power consumption by replacement of lamps in a class room / laboratory.	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Determine the reduction in power consumption by replacement of Fans and regulators in a class room / laboratory.	III	02*
8	Collect electricity bill of an industrial consumer and suggest suitable tariff for energy conservation and its impact on energy bill.	IV	02
9	Collect electricity bill of a commercial consumer and suggest suitable tariff for conservation and reduction of its energy bill.	IV	02*
10	Collect electricity bill of a residential consumer and suggest suitable means for conservation and reduction of the energy bill.	IV	02*
11	Estimate energy saving by improving power factor and load factor for given cases.	IV	02
12	Prepare a sample energy audit questionnaire for thegiven industrial facility.	V	02*
13	Prepare an energy audit report (phase-I)	V	02*
14	Prepare an energy audit report (phase-II)	V	02*
15	Prepare an energy audit report (phase-III)	V	02*
	Total		**30**

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 %
a.	Preparation of experimental set up	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	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. Work as a leader/a team member.
e. 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
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	Pr O. No.
1	Induction motor (3phase /1 phase)	2,3
2	Ammeters MI Type: AC/ DC 0-5-10Amp	2,3
3	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V	2,3
4	Wattmeter: Three phase double element 5/10Amp, 250/500V	2,3
5	Wattmeter: Single phase, single element 2.5/5Amp, 200/400V,	5,6,7
6	Low power factor wattmeter : Single phase, 5/10Amp, 250/500V	4
7	Three phase Power factor meters: AC, 415V, 50 Hz , 5-10 Amp	1
8	Load bank: Resistive, 3-phase, 5kW, 415V	4
9	Automatic power factor controller (APFC)	4
10	Star- delta convertor	3
11	Lux meter	13,14
12	Clip on meter (amp, volts) digital/analog	5,13,14
13	FTL,CFL,LED of different ratings	5
14	Electric choke, Electronic ballast	5
15	Electric regulators ,Electronic regulators	7

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught 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 Energy Conservation Basics	1a. Interpret the given energy conservation clause(s) 1b. Explain the specified BEE role(s) 1c. Explain the specified MEDA role(s) 1d. Interpret the Star Labeling of the given electrical equipment	1.1 Energy Scenario: Primary and Secondary Energy, Energy demand and supply, National scenario. 1.2 Energy conservation and Energy audit; concepts and difference 1.3 Energy Conservation Act 2001; relevant clauses of energy conservation 1.4 BEE and its Roles 1.5 MEDA and its Roles 1.6 Star Labeling: Need and its benefits.
Unit– II Energy Conservation in	2a. Describe the techniques forenergy conservation in the given electrical machine.	2.1 Need for energy conservation in induction motor and transformer. 2.2 Energy conservation techniques in induction motor by:

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Electrical Machines	2b. Explain with sketches the working principle of the given energy conservation equipment. 2c. Select relevant energy conservation equipment for given electrical machine with justification. 2d. Describe the technique(s) to improve the performance efficiency of the given type of electrical machine(s). 2e. Describe with sketches the construction and applications of the specified energy efficient transformer.	a) Improving Power quality. b) Motor survey c) Matching motor with loading. d) Minimizing the idle and redundant running of motor. e) Operating in star mode. f) Rewinding of motor. g) Replacement by energy efficient motor i) Periodic maintenance 2.3 Energy conservation techniques in Transformer. a) Loading sharing b) Parallel operation c) Isolating techniques d) Replacement by energy efficient transformers e) Periodic maintenance 2.4 Energy Conservation Equipment : Soft starters, Automatic star delta convertor, Variable Frequency Drives, Automatic p. f. controller (APFC) , Intelligent p. f. controller (IPFC), Active Harmonic filters (AHF). 2.5 Energy efficient motor; significant features, advantages, applications and limitations. 2.6 Energy efficient transformers, amorphous transformers; epoxy Resin cast transformer / Dry type of transformer.
Unit-III Energy conservation in Electrical Installation systems	3a. Interpret losses in the given Power system 3b. Explain the method to reduce the specifiedtechnical loss in the given electrical installation. 3c. Explain the method to reduce the specified commercial loss in the given electrical installation. 3d. Select the relevant energy conservation equipment for the given system with justification. 3e. Explain energy conservation measures for the specified lighting installation.	3.1 Aggregated Technical and commercial losses (ATC); Power system at state, regional, national and global level. 3.2 Technical losses; causes and measures to reduce by. a) Controlling I^2R losses. b) optimizing distribution voltage c) balancing phase currents d) compensating reactive power flow 3.3 Commercial losses: pilferage, causes and remedies 3.4 Energy conservation equipments: Maximum Demand Controller , kVAR Controller, Automatic Power Factor controller(APFC) 3.5 Energy Conservation in Lighting System a) Replacing Lamp sources. b) Using energy efficient luminaries. c) Using light controlled gears. d) Installation of separate transformer/ servo stabilizer for lighting.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		e) Periodic survey and adequate maintenance programs. 3.6 Energy Conservation techniques in fans, Electronic regulators.
Unit –IV Energy conservation through Cogeneration and Tariff	4a. Describe the method (s) to minimize losses in the given electrical system. 4b. Explain the method for optimum use of energy source in the given facility. 4c. Identify the cogeneration system for the given facility. 4d. Determine the energy price of the given facility for energy saving.	4.1 Co-generation and Tariff; concept, significance for energy conservation **4.2 Co-generation** a) Types of cogeneration on basis of sequence of energy use (Topping cycle, Bottoming cycle) b) Types of cogeneration basis of technology (Steam turbine cogeneration, Gas turbine cogeneration, Reciprocating engine cogeneration). c) Factors governing the selection of cogeneration system. d) Advantages of cogeneration. **4.3 Tariff** a) Types of tariff structure: LT and HT, Special tariffs; Time-off-day tariff, Peak-off-day tariff, Power factor tariff, Maximum Demand tariff, Load factor tariff and Availability Based Tariff (ABT). 4.4 Application of tariff system to reduce energy bill.
Unit-V Energy Audit of electrical systems	5a. Suggest relevant instrument (s) for the specified energy audit with justification. 5b. Develop questionnaire for the energy audit of the given facility. 5c. Develop the energy flow diagram of the given facility/ apparatus. 5d. Calculate the 'Simple Pay Back period' for the given situation. 5e. Prepare the energy audit report for the given facility/ apparatus	5.1 Energy audit (definition as per Energy Conservation act), Specific energy consumption. 5.2 Energy audit instruments and their use. 5.3 Questionnaire for energy audit projects. 5.4 Energy flow diagram (Sankey diagram) 5.5 Simple payback period, Energy Audit procedure (walk through audit and detailed audit). 5.6 Energy Audit report format.

***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 FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Energy Conservation Basics	02	02	02	04	08
II	Energy Conservation in Electrical Machines	12	02	04	08	14
III	Energy conservation in Electrical Installation system	12	00	08	08	16
IV	Energy conservation through Cogeneration and Tariff	11	04	04	08	16
V	Energy Auditof electrical systems	11	04	04	08	16
Total		**48**	**12**	**22**	**36**	**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 any two of the 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) Carry out internet survey (BEE/MEDAwebsite) to collect information related Energy conservation projects.
b) Collect the catalogues of star labeled equipments (min.2)
c) Write report on performance of motor after rewinding.
d) Collect videos to demonstrate working of Energy Conservation Equipments(any 2)
e) Prepare PPT presentation on energy efficient motors.
f) Prepare PPT presentation on energy efficient transformers.
g) Collect information about energy efficient luminaries.
h) Collect videos to demonstrate working of Energy Audit instruments.
i) Visit a facility adopting cogeneration systemand prepare a presentation.

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) Use Flash/Animations to explain working of Energy Conservation techniques and equipment.
g) Pre-guided visits to malls, railway stations and areas adopting conservation strategies in which the students will casually observe during their visits.

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 is 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 she/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 isgiven here. Similar micro-projects could be added by the concerned faculty:

a) **Energy efficient lamps:**Prepare comparative charts with ratings, cost and manufacturer details.
b) **Energy conservation campaign:** Prepare charts/slogans to create energy conservation awareness in polytechnic.
c) **Energy efficient electrical machines**: Prepare technical presentation on details of energy efficient transformers / motors.
d) **Energy conservation policies**: Prepare report on energy conservation policies of Govt. Maharashtra 2017.
e) **Energy Manager and Energy Auditor**: Identify from available resources their roles and responsibilities.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Guide Books no. 1 to 4 for National Certification Examination for Energy Managers and Energy Auditors	Bureau of Energy Efficiency (BEE)	Bureau of Energy Efficiency (A Statutory body under Ministry of Power, Government of India) (Fourth Edition 2015)
2	India - The Energy Sector	Henderson, P. D.	University Press, Delhi, 2016 ISBN: 978-0195606539
3	Energy Management Handbook	Turner, W. C.	Fairmount Press, 2012 ISBN 9781304520708
4	Energy Management and Conservation	Sharma, K. V., Venkataseshaiah; P.	I K International Publishing House Pvt. Ltd; 2011 ISBN 9789381141298
5	Principles of Power System	Mehta ,V. K.	S. Chand &Co.New Delhi, 2016, ISBN 9788121905947

S. No.	Title of Book	Author	Publication
6	Energy Management	Singh, Sanjeey; Rathire, Unmesh	S K Kataria&sons,New Delhi ISBN-13: 9789350141014.
7	Efficient Use and Management of Electricity in Industry	Desai, B. G.; Rana, J. S.; A. Dinesh, V.;Paraman, R.	Devki Energy Consultancy Pvt. Ltd.
8	Energy Engineering And Management	Chakrabarti, Amlan	e-books Kindle Edition
9	Energy Management	Murphy W.R.	Butterworth-Heinemann Publication
10	Art of reading Electricity bills	TalwareYogendra	DnyatavyaPrakashan

14. SOFTWARE/LEARNING WEBSITES

a) Website of bureau of energy and efficiency : www.bee-india.nic.in
b) Website of AkshayUrja News Bulletin : www.mnes.nic.in
c) Notes on energy management on : www.energymanagertraining.com
d) www.greenbusiness.com
e) www.worldenergy.org
f) Maharashtra Energy Development Agency (MEDA):www.mahaurja.com
g) Notes on energy management on: www.energymanagertraining.com
h) www.greenbusiness.com
i) www.worldenergy.org