**ENERGY CONSERVATION AND AUDIT** **Course Code : 316327**

**Programme Name/s** : **Electrical Engineering/ Electrical Power System**
**Programme Code** : **EE/ EP**
**Semester** : **Sixth**
**Course Title** : **ENERGY CONSERVATION AND AUDIT**
**Course Code** : **316327**

## I. RATIONALE

Due to rapid industrialization, urbanization, and population growth, the world is experiencing an increasing demand for electrical energy. The fossil fuels prime source for generation of electrical energy are depleting at faster rate. One unit of saving of electricity is equivalent to two units of electricity generated. Hence conserving energy is responsibility of every citizen. This curriculum enables the diploma students with the skill sets of carrying out energy audit and conserve electrical energy in electrical systems.

## II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

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

- **Implement energy-saving measures and conduct comprehensive energy audits.**

## III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret energy conservation policies in India.
- CO2 - Implement energy conservation techniques in electrical machines.
- CO3 - Apply energy conservation techniques in electrical installations.
- CO4 - Use Co-generation and relevant tariff for reducing losses in facilities.
- CO5 - Carryout energy audit for electrical system.

## IV. TEACHING-LEARNING & ASSESSMENT SCHEME

| Course Code | Course Title | Abbr | Course Category/s | Learning Scheme | | | | | Credits | Assessment Scheme | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Actual Contact Hrs./Week | | | SLH | NLH | | Paper Duration | Theory | | | | Based on LL & TL | | | | Based on SL | | Total Marks |
| | | | | | | | | | | | | | | | Practical | | | | | | | |
| | | | | CL | TL | LL | | | | | FA-TH | SA-TH | Total | | FA-PR | | SA-PR | | SLA | | |
| | | | | | | | | | | | Max | Max | Max | Min | Max | Min | Max | Min | Max | Min | |
| 316327 | ENERGY CONSERVATION AND AUDIT | ECA | DSC | 4 | - | 2 | 2 | 8 | 4 | 3 | 30 | 70 | 100 | 40 | 25 | 10 | 25# | 10 | 25 | 10 | 175 |

**Total IKS Hrs for Sem. :** 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

## V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

| Sr.No | Theory Learning Outcomes (TLO's)aligned to CO's. | Learning content mapped with Theory Learning Outcomes (TLO's) and CO's. | Suggested Learning Pedagogies. |
|---|---|---|---|
| 1 | TLO 1.1 Present the current scenario of conventional and non-conventional energy sources in India.<br>TLO 1.2 Differentiate between energy management, energy efficiency, energy conservation and energy audit.<br>TLO 1.3 Explain the salient features of Energy conservation act 2001.<br>TLO 1.4 Describe the role of BEE, MEDA and MNRE.<br>TLO 1.5 Interpret the Star Labeling of the given electrical equipment.<br>TLO 1.6 Explain the Concept of energy conservation and its benefits.<br>TLO 1.7 Describe the key features of ECBC and green buildings. | **Unit - I Fundamentals of Energy Conservation and Management**<br>1.1 Energy Scenario: Primary and secondary energy sources, energy demand and supply at National level.<br>1.2 Energy management, energy efficiency, energy conservation and energy audit: Objectives, concepts and difference.<br>1.3 Energy Conservation Act 2001 with latest amendments: Key provisions and relevant clauses.<br>1.4 Role of: Bureau of Energy Efficiency (BEE), Maharashtra Energy Development Agency (MEDA) and Ministry of New and Renewable Energy (MNRE).<br>1.5 Star labeling: Need, significance and benefits.<br>1.6 Concept of energy conservation and benefits.<br>1.7 Energy Conservation Building Codes (ECBC) with latest revision, concept of green buildings. | Lecture Using Chalk-Board<br>Flipped Classroom<br>Video Demonstrations<br>Case Study<br>Presentations |

| Sr.No | Theory Learning Outcomes (TLO's)aligned to CO's. | Learning content mapped with Theory Learning Outcomes (TLO's) and CO's. | Suggested Learning Pedagogies. |
|---|---|---|---|
| 2 | TLO 2.1 Justify the need and significance of energy conservation in induction motor and transformer.<br>TLO 2.2 Enlist the energy conservation techniques for a given three phase induction motor.<br>TLO 2.3 Describe the energy conservation techniques for a given Transformer.<br>TLO 2.4 Describe the key features and working of a given energy conservation equipment.<br>TLO 2.5 Compare energy efficient motor with standard motor.<br>TLO 2.6 Compare energy efficient transformer with standard transformer.<br>TLO 2.7 State the energy conservation strategies in compressors pumps, fans and blowers. | **Unit - II Energy Conservation in Electrical Machines**<br>2.1 Need and significance of energy conservation in induction motor and transformer.<br>2.2 Energy conservation techniques in induction motor by: Improving power quality, motor survey, matching motor with loading, minimizing the idle and redundant running of motor, operating in star mode, rewinding of motor, replacement by energy efficient motor, periodic maintenance, by using sensor based motors.<br>2.3 Energy conservation techniques in transformer: Load sharing, parallel operation, isolating techniques, replacement by energy efficient transformers, periodic maintenance.<br>2.4 Energy conservation equipment- key features and working of: Soft starters, Automatic star delta convertor, Variable Frequency Drives (VFD).<br>2.5 Energy efficient motor: Key features, merits, demerits, comparison with standard motor.<br>2.6 Energy efficient transformers: Amorphous transformers, epoxy resin-cast transformer and dry-type of transformer.<br>2.7 Methods and techniques of energy conservation in compressors pumps, fans and blowers. | Lecture Using Chalk-Board<br>Flipped Classroom<br>Video Demonstrations<br>Case Study<br>Site/Industry Visit |

| Sr.No | Theory Learning Outcomes (TLO's)aligned to CO's. | Learning content mapped with Theory Learning Outcomes (TLO's) and CO's. | Suggested Learning Pedagogies. |
|---|---|---|---|
| 3 | TLO 3.1 Interpret losses in the given power system.<br>TLO 3.2 Explain the method to reduce the specified technical loss in the given electrical installation.<br>TLO 3.3 Explain the method to reduce the specified commercial loss in the given electrical installation.<br>TLO 3.4 Select the relevant energy conservation equipment for the given system with justification.<br>TLO 3.5 Explain energy conservation measures for the specified lighting installation.<br>TLO 3.6 State the energy conservation strategies in fan and regulator.<br>TLO 3.7 Describe energy conservation techniques in EVs and batteries. | **Unit - III Energy conservation in Electrical Installation system**<br>3.1 Aggregate technical and commercial losses (ATC).<br>3.2 Technical losses: Causes and remedies-Controlling copper losses, optimizing distribution voltage, balancing phase currents, compensating reactive power flow.<br>3.3 Commercial losses: Causes and remedies.<br>3.4 Energy conservation equipment: Maximum Demand Controller, kVAR Controller, Capacitor bank, Automatic Power Factor controller (APFC), Intelligent Power Factor Controller (IPFC) and Active Harmonic Filters (AHF).<br>3.5 Energy Conservation in Lighting systems: Replacing Lamp sources, using energy efficient luminaries, using light controlled gears, Installation of separate transformer / servo stabilizer for lighting, use of sensors- motion, occupancy, proximity, color, photo sensitive sensors, Periodic survey and adequate maintenance programs.<br>3.6 Energy conservation techniques in fans, electronic regulators using solid state devices.<br>3.7 Energy conservation techniques in electric vehicles and batteries. | Lecture Using Chalk-Board<br>Flipped Classroom<br>Case Study<br>Video Demonstrations<br>Site/Industry Visit |

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| Sr.No | Theory Learning Outcomes (TLO's)aligned to CO's. | Learning content mapped with Theory Learning Outcomes (TLO's) and CO's. | Suggested Learning Pedagogies. |
|---|---|---|---|
| 4 | TLO 4.1 Enumerate the factors governing the selection of co-generation system.<br>TLO 4.2 Describe suitable type of co-generation system for the given facility.<br>TLO 4.3 Describe the function of combined heat and power (CHP) system in the given facility.<br>TLO 4.4 Explain a given type of tariff structure.<br>TLO 4.5 Describe the suitable tariff system for reducing the electricity bill of a given facility.<br>TLO 4.6 Compare two different tariff structure illustrating electrical energy conserved in a given facility. | **Unit - IV Energy Conservation via Cogeneration and Tariff**<br>4.1 Co-generation: Concept, factors governing the selection of co-generation system and its advantages.<br>4.2 Types of co-generation: Based on sequence of energy use: Topping cycle, Bottoming cycle, Based on technology: Steam turbine, Gas turbine and Reciprocating engine co-generation.<br>4.3 Captive Power Plant: Combined Heat and Power (CHP) system.<br>4.4 Tariff: Concept from the point of view of energy conservation, Types of tariff structure: LT, HT, Special, Time-off-day, Peak-off-day, Power factor tariff, Maximum Demand tariff, Load factor tariff and Availability Based Tariff (ABT), kVAh tariff, Concept of flexible tariff.<br>4.5 Application of tariff system to reduce energy bill (Numerical).<br>4.6 Recent tariff structure of different utilities. | Lecture Using Chalk-Board<br>Flipped Classroom<br>Video Demonstrations<br>Case Study<br>Site/Industry Visit |

| Sr.No | Theory Learning Outcomes (TLO's)aligned to CO's. | Learning content mapped with Theory Learning Outcomes (TLO's) and CO's. | Suggested Learning Pedagogies. |
|---|---|---|---|
| 5 | TLO 5.1 Define energy audit and list the benefits.<br>TLO 5.2 Justify significance of specific energy consumption.<br>TLO 5.3 Explain the types of energy audit.<br>TLO 5.4 Suggest relevant instrument (s) for the specified energy audit with justification.<br>TLO 5.5 Develop questionnaire for the energy audit of the given facility.<br>TLO 5.6 Develop the energy flow diagram of the given facility/ apparatus.<br>TLO 5.7 Calculate the Simple Pay Back period, IRR for the facility created.<br>TLO 5.8 Describe energy audit procedure followed.<br>TLO 5.9 Prepare the energy audit report for the given facility/ apparatus.<br>TLO 5.10 Describe the roles and responsibilities of energy manager and auditor. | **Unit - V Energy Audit**<br>5.1 Energy audit: Definition and its benefits.<br>5.2 Significance of Specific energy consumption pattern.<br>5.3 Types of energy audit: Walk through and detailed audit.<br>5.4 Energy audit instruments and their use: Electrical measuring instruments, power analyzer, lux meter, smart energy meter, fuel efficiency monitor, combustion gas analyzer, thermometer, flow meter and tachometer.<br>5.5 Questionnaire for energy audit projects.<br>5.6 Energy flow diagram (Sankey diagram).<br>5.7 Simple payback period, Internal Rate of Return (IRR) (Numerical).<br>5.8 Energy Audit procedure.<br>5.9 Typical Energy Audit report format commonly used in industries.<br>5.10 Roles and responsibilities of energy manager and auditor. | Lecture Using Chalk-Board<br>Flipped Classroom<br>Video Demonstrations<br>Case Study<br>Site/Industry Visit |

## VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

| Practical / Tutorial / Laboratory Learning Outcome (LLO) | Sr No | Laboratory Experiment / Practical Titles / Tutorial Titles | Number of hrs. | Relevant COs |
|---|---|---|---|---|
| LLO 1.1 Identify star labelled appliances and compare them for various star ratings.<br>LLO 1.2 Compare the data sheet of various star rating appliances. | 1 | *Identification of star labelled electrical appliances/equipment and compare data sheets of various star labelled ratings. | 2 | CO1 |
| LLO 2.1 Compare energy consumed by a green building with that of a conventional building.<br>LLO 2.2 Use energy conservation instruments to measure the various electrical parameters. | 2 | Comparison of energy consumption in a green building with a conventional building using energy conservation instruments. | 2 | CO1 |

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| Practical / Tutorial / Laboratory Learning Outcome (LLO) | Sr No | Laboratory Experiment / Practical Titles / Tutorial Titles | Number of hrs. | Relevant COs |
|---|---|---|---|---|
| LLO 3.1 Perform an experiment on three phase induction motor both in star and delta mode.<br>LLO 3.2 Measure the effect of voltage reduction in power consumption. | 3 | *Determination of reduction in power consumption in star mode operation of 3 phase Induction motor compared to delta mode. | 2 | CO2 |
| LLO 4.1 Perform load test on three phase induction motor for different loading conditions.<br>LLO 4.2 Plot the graph of efficiency verses percentage loading of induction motor. | 4 | *Performance of load test on three phase induction motor for different loading conditions and plot the curve. | 2 | CO2 |
| LLO 5.1 Compare energy conserved in two identical transformers where one is a single-phase transformer, and the other one comprises of two single phase transformers in parallel operation (For the same load).<br>LLO 5.2 Observe the effect of load sharing on energy consumption. | 5 | Comparison of energy conserved in two identical transformers where one is a single-phase transformer and the other one comprises of two single phase transformers in parallel operation. (For the same load). | 2 | CO2 |
| LLO 6.1 Improve power factor of given load using APFC.<br>LLO 6.2 Using APFC for improving power factor. | 6 | Power factor improvement using APFC. | 2 | CO2<br>CO3 |
| LLO 7.1 Improve power factor of given load using static capacitor.<br>LLO 7.2 Calculate the value of capacitor to change from initial power factor to desired power factor. | 7 | *Power factor improvement using static capacitor. | 2 | CO2<br>CO3 |
| LLO 8.1 Improve power factor of given load using IPFC.<br>LLO 8.2 Using IPFC for improving power factor. | 8 | Power factor improvement using IPFC. | 2 | CO2<br>CO3 |
| LLO 9.1 Compare power consumption of different types of Tube Light with choke, electronic ballast and LED lamps by direct measurement. | 9 | *Comparison of power consumption of different types of Tube Light with choke, electronic ballast and LED lamps by direct measurement. | 2 | CO3 |
| LLO 10.1 Determine the reduction in power consumption by replacement of different lamps in a classroom / laboratory by energy efficient lamps. | 10 | *Comparison of reduction in power by replacement of lamps in a classroom / laboratory by energy efficient lamps. | 2 | CO3 |
| LLO 11.1 Suggest suitable tariff for energy conservation and reduction of energy bill for an industrial customer.<br>LLO 11.2 Interpreting electricity bill of an industrial consumer. | 11 | Tariff for industrial consumer for reducing the electricity bill. | 2 | CO4 |

| Practical / Tutorial / Laboratory Learning Outcome (LLO) | Sr No | Laboratory Experiment / Practical Titles / Tutorial Titles | Number of hrs. | Relevant COs |
|---|---|---|---|---|
| LLO 12.1 Suggest suitable tariff for energy conservation and reduction of energy bill for a commercial customer.<br>LLO 12.2 Interpreting electricity bill of a commercial customer. | 12 | Tariff for commercial consumer for reducing the electricity bill. | 2 | CO4 |
| LLO 13.1 Suggest suitable tariff for energy conservation and reduction of energy bill for a residential customer.<br>LLO 13.2 Interpreting electricity bill of a residential customer. | 13 | *Tariff for residential consumer for reducing the electricity bill. | 2 | CO4 |
| LLO 14.1 Estimate energy saving by improving power factor and load factor for given case. | 14 | Estimation of Energy saved by improving power factor and load factor for given case. | 2 | CO3<br>CO4 |
| LLO 15.1 Prepare a sample energy audit questionnaire for a given facility. | 15 | Preparation of Energy audit questionnaire for the given facility. | 2 | CO5 |
| LLO 16.1 Prepare energy audit report of your electrical department. | 16 | *Preparation of Energy audit report of electrical department. | 2 | CO5 |
| LLO 17.1 Perform load test on three phase SCIM using DOL, star delta and soft starter.<br>LLO 17.2 Compare the energy consumption in all three cases. | 17 | Comparison of energy consumption using DOL, star delta and soft starter in a three-phase induction motor. | 2 | CO2 |
| LLO 18.1 Carryout energy audit using energy audit software such as SafetyCulture (formally iAuditor) or EnergyCAP.<br>LLO 18.2 Use energy audit software SafetyCulture (formally iAuditor) or EnergyCAP. | 18 | Energy audit using energy audit software such as SafetyCulture (formally iAuditor), EnergyCAP or any other equivalent software. | 2 | CO5 |

**Note : Out of above suggestive LLOs -**

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

## VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

**Micro project**

- Collect electricity bill of your institute and suggest suitable measures for energy conservation and reduction of energy bill.
- Prepare Energy conservation chart using different luminaries.
- Prepare an energy audit report of your department/Institute/Workshop using energy audit instruments.
- Visit MEDA website and enlist various energy conservation schemes. Prepare a presentation highlighting the salient features of any one scheme. (objectives, entitlement, methodology and financial assistance etc.)
- Carry out a case study of at least two nearby industries and prepare a report on energy conservation measures adopted by them.

- Carry out internet survey (BEE) to collect information and prepare a report related to any two energy conservation projects.
- Poster preparation and competition on energy conservation (Visit MEDA website).

**Assignment**

- Visit a facility adopting cogeneration system and prepare a presentation.
- Estimate the payback period, depreciation cost, for the given energy saving equipment in the transmission and distribution system.
- Prepare a report on maintenance procedure followed for improving efficiency of a given lighting scheme.
- Collect information about energy efficient luminaries and prepare a report on it.
- Write report on performance of motor after rewinding.
- Compile the energy saved in at least five star labeled various appliances and prepare a report.
- Prepare a report on various star labeled equipment.
- Compare the energy conserved by an energy efficient motor with a standard motor and prepare a report.
- Prepare a report on BIS standards related to Energy Conservation

**Seminar topics**

- Energy conservation act 2001.
- Energy conservation equipment
- Cogeneration and its advantages in energy conservation.
- “Bachat Lamp Yojana” Scheme.
- Energy Audit instruments and their working.
- Energy conservation schemes of Maharashtra.

**Visit**

- Visit to your nearby market/shop for Identifying star labeled electrical apparatus and compare the data for various star ratings. Prepare a chart and submit the report.
- Visit nearby industry which has a captive power plant and observe the working of Captive power plant its inputs and outputs. Prepare a report and submit with the main focus on energy saved due to captive power plant.

**Self-learning topics**

- Captive Power Plant
- Demand side management.
- Green buildings.
- Energy conservation initiatives in Agricultural sector.

**Note :**

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

## VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

| Sr.No | Equipment Name with Broad Specifications | Relevant LLO Number |
|---|---|---|
| 1 | Lux meter | 15,16 |
| 2 | Soft starter/ DOL starter/ star delta starter. | 17 |
| 3 | Energy audit software such as SafetyCulture (formally iAuditor), EnergyCAP or any other equivalent open-source software. | 18 |
| 4 | Star delta convertor. | 3 |
| 5 | Induction motor: Single phase/three phase. | 3,4 |
| 6 | Clamp on ammeter. | 3,4,5,7,9 |
| 7 | Ammeter: MI type, AC/ DC 0-5-10Amp. | 3,4,5,7,9 |
| 8 | Voltmeter: MI type, AC/DC, 0-150/300V, 0-250/500V. | 3,4,5,7,9 |
| 9 | Wattmeter: Single phase/three phase, single element/double element, 2.5/5Amp -5/10 Amp, 200/400V -250/500V. | 3,4,5,7,9,10,17 |
| 10 | Multi-function meter. | 3,4,5,7,9,10,17 |
| 11 | Single/ three phase power factor meters: AC, 415V, 50 Hz, 5-10 Amp. | 4,7 |
| 12 | Transformer: Single phase. | 5 |
| 13 | Automatic power factor controller. | 6 |
| 14 | Low power factor wattmeter: Single phase, 5/10Amp, 250/500V. | 6,8 |
| 15 | Load bank. | 7 |
| 16 | Single phase capacitor bank. | 7 |
| 17 | Electronic choke, electronics ballast. | 7,9 |
| 18 | Intelligent power factor controller. | 8 |
| 19 | LED lamp/ tube. | 9 |
| 20 | Tube light (Fluorescent Tube/ CFL) | 9 |

## IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

| Sr.No | Unit | Unit Title | Aligned COs | Learning Hours | R-Level | U-Level | A-Level | Total Marks |
|---|---|---|---|---|---|---|---|---|
| 1 | I | Fundamentals of Energy Conservation and Management | CO1 | 8 | 2 | 2 | 4 | 8 |
| 2 | II | Energy Conservation in Electrical Machines | CO2 | 14 | 4 | 4 | 6 | 14 |
| 3 | III | Energy conservation in Electrical Installation system | CO3 | 14 | 2 | 6 | 8 | 16 |
| 4 | IV | Energy Conservation via Cogeneration and Tariff | CO4 | 14 | 4 | 4 | 8 | 16 |
| 5 | V | Energy Audit | CO5 | 10 | 2 | 6 | 8 | 16 |
| **Grand Total** | | | | **60** | **14** | **22** | **34** | **70** |

## X. ASSESSMENT METHODOLOGIES/TOOLS

**Formative assessment (Assessment for Learning)**

- Two unit tests, each worth 30 marks, will be conducted, and the average of the two tests will be considered.

- For formative assessment of laboratory learning 25 marks: Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment. and the average of all practical will be considered.

**Summative Assessment (Assessment of Learning)**

- End semester summative assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks through offline mode of examination.

## XI. SUGGESTED COS - POS MATRIX FORM

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PO-1 Basic and Discipline Specific Knowledge | PO-2 Problem Analysis | PO-3 Design/ Development of Solutions | PO-4 Engineering Tools | PO-5 Engineering Practices for Society, Sustainability and Environment | PO-6 Project Management | PO-7 Life Long Learning | PSO-1 | PSO-2 | PSO-3 |
| CO1 | 3 | 1 | 1 | - | 2 | - | 3 | | | |
| CO2 | 3 | 2 | 2 | 1 | 2 | 1 | 3 | | | |
| CO3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | | | |
| CO4 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | | | |
| CO5 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | | | |

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

## XII. SUGGESTED LEARNING MATERIALS / BOOKS

| Sr.No | Author | Title | Publisher with ISBN Number |
|---|---|---|---|
| 1 | Bureau of Energy Efficiency (BEE) | Guidebooks no. 1 to 4 for National Certification Examination for Energy Managers and Energy Auditors | Bureau of Energy Efficiency (A Statutory body under Ministry of Power, Government of India) (Fourth Edition 2015) |
| 2 | Dr. Sanjeev Singh, Dr. Umesh Rathore | Energy Management | S K Kataria & Sons, New Delhi. ISBN-13: 9789350141014 |
| 3 | V.K.Mehta and Rohit Mehta | Principles of Power System | S. Chand & Co. New Delhi, 2022, ISBN: 9789355010773 |
| 4 | Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher Gautam | Energy Management Conservation and Audits | CRC Press, 2020, ISBN: 9780429325458 |
| 5 | Stephan A. Roosa, Steve Doty, Wayne C. Turner | Energy Management Handbook | Fairmount Press, New York 2020 ISBN: 9781003151364 |
| 6 | Murphy W.R. | Energy Management | Butterworth-Heinemann Publication, ISBN: 9788131207383. |
| 7 | K.V. Sharma, P. Venkataseshaiah. | Energy Management and Conservation | I K International Publishing House Pvt. Ltd; 2011 ISBN 9789381141298 |

| Sr.No | Author | Title | Publisher with ISBN Number |
|---|---|---|---|
| 8 | Yogendra V. Talware. | Art of reading Electricity bills. | Dnyatavya Prakashan |

## XIII . LEARNING WEBSITES & PORTALS

| Sr.No | Link / Portal | Description |
|---|---|---|
| 1 | https://mnre.gov.in/ | Information about new and renewable energy. |
| 2 | https://powermin.gov.in/ | Indian power scenario. |
| 3 | https://aipnpc.org/Guidebooks.aspx | BEE guidebooks 01 to 04. |
| 4 | https://akshayurja.gov.in/res/renw-all-india-cp | Akshay Urja Ministry of New and Renewable Energy (MNRE) |
| 5 | https://www.mahaurja.com/meda/en/energy_conservation/energy_conservation_program | Energy Conservation Schemes in Maharashtra state (MEDA) |
| 6 | https://www.eia.gov/totalenergy/ | U S Energy information administration. |
| 7 | https://beeindia.gov.in/sites/default/files/ECBC%20User%20Guide%20V-0.2%20(Public).pdf | Energy Conservation Building Code User Guide. |
| 8 | https://iiec.org/ | International Institute for Energy Conservation (IIEC) |
| 9 | https://cea.nic.in/ | Central Electricity Authority |

**Note :**

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students