**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**

**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**
Semester-V

**Course Title: Energy Conservation and Audit**
(Course Code: 4352405 )

| Diploma programmer in which this course is offered | Semester in which offered |
|---|---|
| Power Electronics | 5th Semester |

## 1. RATIONALE

Due to The Technological development in all sectors, consumption of electrical energy is increasing day by day. One way to cope up with the increase in electrical energy demand is to increase the production of energy which demands more investment and the other way is to conserve the energy because energy conserved/saved is energy generated. Thus it is necessary to save and conserve energy to the maximum possible extent. 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 and energy audit in the fields of engineering.

## 2. COMPETENCY

The purpose 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 practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

**CO 1)** Interpret energy conservation policies in India.
**CO 2)** Implement energy conservation techniques in electrical machines.
**CO 3)** Apply energy conservation techniques in electrical power and lightning system
**CO 4)** Interpret ECBC, Energy tariff and load management system for reducing losses.
**CO 5)** Carryout energy audit for electrical system.

## 4. TEACHING AND EXAMINATION SCHEME

| Teaching Scheme (In Hours) | | | Total Credits (L+T+P/2) | Examination Scheme | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | Total Marks |
| L | T | P | C | CA | ESE | CA | ESE | |
| 3 | - | 2 | 4 | 30* | 70 | 25 | 25 | 150 |

*(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment 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, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

## 5. SUGGESTED PRACTICAL EXERCISES

*Following practical outcomes (PrOs) that are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. required |
|---|---|---|---|
| 1. | Identify star labeled electrical apparatus and compare the data for various star ratings. | I | 2* |
| 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 | 2 |
| 3. | Determine the reduction in power consumption in star mode operation of Induction motor compared to delta mode. | II | 2* |
| 4. | Use APFC unit for improvement of p. f. of electrical load. | II | 2 |
| 5. | Compare power consumption of different types of Transmission Loss with choke, electronic ballast and LED lamps by direct measurements. | III | 2 |
| 6. | Determine the reduction in power consumption by replacement of lamps in a class room / laboratory. | III | 2* |
| 7. | Determine the reduction in power consumption by replacement of Fans and regulators in a class room / laboratory. | III | 2* |
| 8. | Collect electricity bill of an industrial consumer and suggest suitable tariff for energy conservation and its impact on energy bill. | IV | 2 |
| 9. | Collect electricity bill of a commercial consumer and suggest suitable tariff for conservation and reduction of its energy bill. | IV | 2* |
| 10. | Collect electricity bill of a residential consumer and suggest suitable means for conservation and reduction of the energy bill. | IV | 2* |
| 11. | Estimate energy saving by improving power factor and load factor for given cases. | IV | 2 |
| 12. | Prepare a sample energy audit questionnaire for the given industrial facility. | V | 2* |
| 13. | Prepare an energy audit report ( phase-I) | V | 2* |
| 14. | Prepare an energy audit report ( phase-II) | V | 2* |
| 15. | Prepare an energy audit report ( phase-III) | V | 2 |
| | **Minimum 14 Practical Exercises** | | **28* Hrs.** |

***Note***

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

| S. No. | Sample Performance Indicators for the PrOs | Weightage in % |
|---|---|---|
| 1 | Prepare of experimental setup | 20 |
| 2 | Operate the equipment setup or circuit | 20 |
| 3 | Follow safe practices measures | 10 |
| 4 | Record observations correctly | 20 |
| 5 | Interpret the result and conclude | 20 |
| 6 | Submission of report in time | 10 |
| **Total** | | **100** |

## 6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipments with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

| S. No. | Equipment Name with Broad Specifications | PrO.No. |
|---|---|---|
| 1 | Induction motor (3phase /1 phase) | 2,3 |
| 2 | Ammeter: AC/ DC 0-5-10Amp | 2,3 |
| 3 | Voltmeter: 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) Star- delta convertor | 4 |
| 10 | Star delta converter | 3 |
| 11 | Lux meter | 13,14,15 |
| 12 | Clip on meter ( amp, volts) digital/analog | 13,14,15 |
| 13 | CFL,LED of different ratings | 5 |
| 14 | Electric choke, Electronic ballast | 5 |
| 15 | Electronic regulators | 7 |

## 7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow error free measurement rules during measurement.
c) Practice environmentally friendly methods and processes.(Environment related)
d) Practice energy conservation.

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

## 8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

| Unit | Unit Outcomes (UOs)<br>(4 to 6 UOs at Application and above level) | Topics and Sub-topics |
|---|---|---|
| **Unit – I Elements of Energy conservation and audit.** | 1.a Classify energy sources. | 1.1 Energy Scenario: Primary and Secondary Energy, Renewable and non renewable, commercial and non-commercial, Indian energy scenario. |
| | 1.b Explain energy conservation & audit with its importance. | 1.2 Energy conservation & audit: Definition, concepts, needs and importance. |
| | 1.c Explain the specified BEE on Basics role(s) | 1.3 BEE and its Roles. |
| | 1.d Interpret the Standard and Labeling (S&L) of the given electrical equipment. | 1.4 Standard and Labeling (S&L): Main provision of Energy conservation act-2001 on S&L , MEPS, star ratings, label period, equipment covert under S&L program. |
| | 1.e Calculate electricity consumption, loading and efficiency of electrical load. | 1.5 Electricity consumption, loading and efficiency of electrical load. |
| **Unit– II Energy conservation in Electrical Machines.** | 2.a Describe the technique(s) to improve the performance efficiency of the given type of electrical machine(s). | 2.1 Energy conservation techniques in Transformer by: Parallel operation, Replacement by energy efficient transformers and Periodic maintenance.<br>2.2 Energy conservation technique in induction motor by: Improving Power supply quality, Reducing under load, Operating in star mode, Sizing to |

| Unit | Unit Outcomes (UOs) (4 to 6 UOs at Application and above level) | Topics and Sub-topics |
|---|---|---|
| | | variable load, PF correction, Rewinding of motor. |
| | 2.b Select relevant energy conservation equipment for given electrical machine with justification. | 2.3 Energy Conservation Equipment: Soft starters, Automatic star delta convertor, Automatic P.F. controller (APFC), intelligent P.F. controller (IPFC). |
| **Unit – III Energy conservation in electrical power and lightning system.** | 3.a Assessment of transmission and distribution system losses in power system. | 3.1 Transmission and distribution system losses: Technical and commercial losses. |
| | 3.b Explain Harmonics in power system. | 3.2 Harmonics: cause and effect, Methods for overcoming harmonics, |
| | 3.c Explain power factor improvement and its benefits. | 2.4 P.F. basics, advantages of improvement, cost benefits of PF improvement, selection and location of capacitor, performance assessment of PF capacitor. |
| | 3.d Explain energy conservation measures for the specified lighting and fan system.<br>3.e Describe Standard and labeling programs in lamps. | 3.3 Energy Conservation in Lighting and fan System by<br>• Use Occupancy sensor<br>• Localized switching<br>• Street light system and control<br>• Replacing Lamp sources.<br>• Using energy efficient luminaries.<br>• Using light controlled gears.<br>• Use electronic fan regulator.<br>3.4 Standard and labeling programs in lamps. |
| **Unit – IV Energy conservation Building Code, Energy Tariff and load management.** | 4.a Explain Energy conservation Building Code (ECBC).<br>4.b Explain ECBC guideline on electrical power and lightning system.<br>4.c Explain energy efficiency measures in building. | 4.1 Energy conservation Building Code: definition, climate zone, aspects.<br>4.2 ECBC guideline on electrical power equipments and lightning system.<br>4.3 Energy efficiency measures in AC, lightning system. |
| | 4.d Explain the component of tariff. | 4.4 Components of tariff structure: Maximum demand charges, Energy charges, P.F. tariff, Fuel cost, electricity duty charges, time of day rant, penalty for demand and surcharge, demand curve. |

| Unit | Unit Outcomes (UOs) (4 to 6 UOs at Application and above level) | Topics and Sub-topics |
|---|---|---|
| | 4.e Explain electrical load management and maximum demand control. | 4.5 Need for electrical load management, step by step approach for maximum demand control. |
| **Unit– V Energy Audit of Electrical systems.** | 5.a Explain types of energy audit<br>5.b Suggest relevant instruments for the specified energy audit. | 5.1 Types: preliminary, targeted, detailed.<br>5.2 Electrical measuring instruments: energy meter, Lux meter and tachometer. |
| | 5.c Develop questionnaire for the energy audit of the given facility. | 5.3 Questionnaire for energy audit. |
| | 5.d Develop the energy flow diagram of the given facility/ apparatus. | 5.4 Energy flow diagram (Sankey diagram). |
| | 5.e Calculate the 'Simple Pay Back period' for the given situation. | 5.5 Simple payback period, Energy Audit procedure (walk through audit and detailed audit). |
| | 5.f Prepare the energy audit report for the given facility/ apparatus. | 5.6 Energy Audit report format. |

***Note**: The UOs need to be formulated at an 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

| Unit No. | Unit Title | Teaching Hours | Distribution of Theory Marks | | | |
|---|---|---|---|---|---|---|
| | | | R Level | U Level | A Level | Total Marks |
| **I.** | **Elements of Energy conservation and audit.** | **06** | **7** | **3** | **3** | **13** |
| **II.** | **Energy Conservation in Electrical Machines** | **07** | **4** | **7** | **3** | **14** |
| **III.** | **Energy conservation in electrical power and lightning system.** | **12** | **7** | **7** | **3** | **17** |
| **IV.** | **Energy conservation Building Code, Energy Tariff and load management.** | **07** | **3** | **4** | **4** | **11** |
| **V.** | **Energy Audit of electrical systems** | **10** | **4** | **4** | **7** | **15** |
| **Total** | | **42** | **25** | **25** | **20** | **70** |

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly 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) Carry out internet survey (BEE website) to collect information related Energy conservation projects.
b) Collect the catalogues of star labeled equipments.
c) Classify of Energy Audit instruments.
d) Make a presentation on harmonics and power factor improvement.
e) Make a presentation on sample of energy audit.

## 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) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.11***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Use Flash/Animations to explain working of Energy Conservation techniques and equipment.

## 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 (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 duration of the micro-project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students 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. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

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 conservation policies:** Prepare report on energy conservation policies of Govt. of Gujarat & Govt. of India.
d) **Energy Manager and Energy Auditor:** Identify from available resources their roles and responsibilities.

## 13. SUGGESTED LEARNING RESOURCES:

| S. No. | Title of Book | Author | Publication with place, year and ISBN |
|---|---|---|---|
| 1 | Guide Books no. 1,3,4 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, Govt. of India) |
| 2 | India The Energy Sector | Henderson, P. D. | University Press, Delhi, 2016 ISBN: 978-0195606539 |
| 3 | Energy Conservation And Audit | S. M. Chaudhari, S. A. Asarkar, M. A. Chaudhari | Nirali Prakashan ISBN: 9789388897860 |
| 4 | Energy Management Handbook | Turner, W. C. | Fairmount Press, 2012 ISBN 9781304520708 |
| 5 | Energy Management and Conservation | Sharma, K. V., Venkataseshaiah P | I K International Publishing House Pvt. Ltd; 2011 ISBN 9789381141298 |
| 6 | Energy Management | Singh, Sanjeey; Rathire, Unmesh | S K Kataria&sons,New Delhi ISBN-13: 9789350141014. |

## 14. SOFTWARE/LEARNING WEBSITES

a) www.bee-india.nic.in
b) https://nptel.ac.in
c) www.mnes.nic.in
d) https://swayam.gov.in/
e) https://shodhganga.inflibnet.ac.in/
f) www.worldenergy.org

## 15. PO-COMPETENCY-CO MAPPING

| Semester V | Energy Conversation and Audit | | | | | | |
|---|---|---|---|---|---|---|---|
| | POs and PSOs | | | | | | |
| Competency & Course Outcomes | PO 1 Basic & Discipline specific knowledge | PO 2 Problem Analysis | PO 3 Design/ development of solutions | PO 4 Engineering Tools, Experimentation &Testing | PO 5 Engineering practices for society, sustainability & environment | PO 6 Project Management | PO 7 Life-long learning |
| Competency | Undertake energy conservation and energy audit.. | | | | | | |
| CO 1) Interpret energy conservation policies in India. | 1 | -- | 1 | - | 2 | 2 | 2 |
| CO 2) Implement energy conservation techniques in electrical machines. | 1 | 2 | 2 | 1 | 1 | 1 | 2 |
| CO 3) Apply energy | 1 | 2 | 2 | 1 | 1 | 1 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **conservation techniques in electrical power and lightning system** | | | | | | | |
| **CO 4)** | **Interpret ECBC, Energy tariff and load management system for reducing losses.** | 1 | - | 1 | - | 2 | 2 | 2 |
| **CO 5)** | **Carryout energy audit for electrical system.** | 1 | 1 | 2 | 2 | 2 | 2 | 3 |

Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation ofeach competency, CO, with PO/ PSO

## 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

**GTU Resource Persons**

| S. No. | Name and Designation | Institute | Contact No. | Email |
|---|---|---|---|---|
| **1.** | **Mr. Vinod N. Makwana Lecturer – Power Electronics Department.** | **Dr. S. & S. S. Ghandhy college of engineering & Technology, Surat** | **9427386784** | **vinodmakwana1@rediffmail.com** |
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