GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Electrical Engineering
Subject Code: BE05009081
Subject Name: Energy Management and Audit

w.e.f.Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 2

Prerequisite:	Nil
Rationale:	India is one of the world's largest energy consumers and has committed to ambitious targets under the National Action Plan on Climate Change (NAPCC) and COP-26. The Energy Conservation (Amendment) Act, 2022 introduces Carbon Credit Trading, Non-Fossil Consumption Obligations, and mandatory energy audits by BEE-accredited auditors for designated consumers. Gujarat, as a major industrial state with power-intensive sectors such as petrochemicals, textiles, ceramics, and SEZs, requires skilled energy professionals with strong expertise in electrical energy audit and management. This course integrates theory and practice to develop competencies in electrical energy auditing, power quality analysis, demand-side management, renewable integration, and compliance with IEEE, IEC, IS/BIS standards and regulatory frameworks. Thermal and mechanical aspects are covered contextually, while the primary emphasis remains on electrical systems, equipment efficiency, and electrical infrastructure management.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Describe India's energy scenario, legislative framework (EC Act 2001 and Amendment 2022), BEE programmes, and the qualifications and roles of BEE-certified Energy Managers and Energy Auditors.
02	Apply electrical energy audit procedures and instruments to measure and benchmark energy performance of industrial and commercial electrical installations.
03	Analyse power quality parameters — harmonics, power factor, voltage unbalance and flicker — and recommend corrective measures in conformance with IEEE 519, IEC 61000 and relevant IS standards.
04	Evaluate energy efficiency improvement opportunities in electrical equipment and systems including motors, variable frequency drives, pumps, lighting and distribution networks.
05	Prepare an electrical energy audit report with an energy management plan, PAT scheme compliance, renewable energy integration strategy, and financial viability analysis.

TeachingandExaminationScheme:

Teaching-Learning Scheme (inHours per Semester)					TotalCredits = Total Hrs./30	AssessmentPatternandMarks					Total Marks
						Theory		Tutorial/Practical			
L	T	P	PBL	Total hrs.		ESE (E)	PA (M)	PA(I)	PBL (I)	ESE(V)	
45	0	30	15	90	3	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No.of Hours	%of Weightage
1.	**Energy Scenario, Policy and Legislative Framework** Energy scenario in India and Gujarat: electrical energy consumption patterns; sector-wise analysis (industrial, commercial, residential). Energy Conservation Act (EC Act) 2001 — key provisions, designated consumers, penalties. Energy Conservation (Amendment) Act 2022: Carbon Credit Trading Scheme, Non-Fossil Consumption Obligations (RCO/RPO), sustainability building codes. Bureau of Energy Efficiency (BEE): structure and programmes — Perform Achieve and Trade (PAT) scheme, Energy Saving Certificates (ESCerts), Standards and Labelling, UJALA. National Mission for Enhanced Energy Efficiency (NMEEE). State-level energy policies: GUVNL, GEDA, Gujarat Solar and Wind policies, GERC tariff orders. Electricity Act 2003 — relevance to metering and distribution. India's COP-26 commitments and SDG 7.	08	18
2.	**Electrical Energy Audit: Methodology, Instruments and Procedures** Definition and need of energy audit; types — preliminary (walk-through), detailed (diagnostic), investment-grade audit. Energy audit team, scope and boundaries. Data collection, historical energy bills analysis, load profiling, electricity tariff structures (ToD, ToU, HT/LT tariffs). Energy performance indicators (EnPIs), benchmarking and Specific Energy Consumption (SEC). BEE-certified Energy Manager (EM) and Energy Auditor (EA): qualifications, eligibility, accreditation process, statutory duties and responsibilities under EC Act 2001. Measurement instruments: energy analyzers (IEC 61557-12	09	20

	and IS 15884), clamp meters, data loggers, IR thermographic cameras, lux meters, power quality analyzers. Measurement of: kWh, kVAh, kVArh, power factor, load factor, demand factor. Sub-metering surveys and feeder loss estimation. Energy audit report structure as per BEE format. Numerical problems on energy consumption analysis and benchmarking.		
3.	**Power Quality Assessment and Improvement** Power quality — definition, importance and financial cost of poor power quality. Voltage sags/swells: causes and classification (IEEE 1159). Harmonics: generation by non-linear loads (VFDs, UPS, rectifiers), Total Harmonic Distortion (THD), harmonic spectrum; limits as per IEEE 519-2022, IEC 61000-3-2, IEC 61000-3-12. Harmonic filters — passive, active, hybrid. Voltage unbalance: causes and effects on motors (IEC 60034-26). Flicker: PST, PLT; IEC 61000-4-15. Power factor improvement: effect on losses and tariff penalty; capacitor bank sizing and placement (IS 13925 / IEEE 18); Automatic Power Factor Controllers (APFC). Power quality measurement instruments: Class A analyzers per IEC 61000-4-30. Case study: power quality audit in a Gujarat industrial facility.	08	18
4.	**Energy Efficiency of Electrical Equipment and Systems** Electric motors: efficiency classes IE1–IE4 (IS 12615 / IEC 60034-30-1); right-sizing; efficiency testing (IEEE 112); motor rewinding losses. Variable Frequency Drives (VFD): energy savings, selection criteria and harmonic impact. Pumps and fan systems: affinity laws, system curve, Best Efficiency Point (BEP); specific energy consumption; audit methodology (IS 9137). Distribution transformers: energy-efficient amorphous-core types (IS 1180); K-factor transformers for non-linear loads; loading optimization. (Note: transformer loss theory is not re-taught here; only audit-relevant assessment is covered.) Lighting systems: luminous efficacy (lm/W), BEE star rating for LED luminaires; lux-level audit; ECBC lighting power density requirements (IS 3646). HVAC systems: EER, COP and ISEER ratings; BEE star labels; chiller and split-AC energy audit (secondary reference for electrical audit context only).	09	20
5.	**Demand-Side Management, Supply-Side Efficiency and Grid Technologies** Demand-Side Management (DSM): objectives and strategies — load levelling, valley-filling, load shifting, peak-load management; Time-of-Day (ToD) tariff and smart metering (IS 16444); prepaid metering. Smart grid: Advanced Metering Infrastructure (AMI), demand response, Volt/VAR optimization. Power distribution feeder audit:	07	16

	feeder-level loss calculation, capacitor placement optimization, reconductoring economics. Renewable energy integration — overview: rooftop solar PV energy yield estimation (CUF, performance ratio); net metering (Gujarat policy, IS 16221); Battery Energy Storage Systems (BESS) for peak-shaving (IEC 62933); financial analysis: LCOE, simple payback, NPV, IRR. Non-Fossil Consumption Obligation (RCO) for designated consumers (EC Amendment Act 2022).		
6.	**Renewable Energy Integration and Energy Storage for Audit and Management** Rooftop and ground-mount Solar PV systems: components, MNRE/SECI guidelines; grid-connection as per CEA regulations and CEIG norms; IS 16221, IEC 61730, IEC 61215 (PV module testing); net metering, gross metering — Gujarat net metering policy. Wind energy: capacity factor, wind resource assessment; integration issues; IS 61400 series. Battery Energy Storage Systems (BESS): technology comparison (Li-ion, flow batteries, lead-acid); Non-Fossil Consumption Obligation (RCO) compliance for designated consumers under EC Amendment Act 2022. Green hydrogen (introductory) and its role in industrial energy management.	04	08
	Total	**45**	**100**

Note:
1. 10%-20% weightage should be given to the Examples and Short/Multiple choice questions.
2. The institutes which do not have proper Energy Laboratory are advised to visit nearby Energy laboratory

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	0	20	20	10	10

Where, R: Remember; U: Understanding; A:Application, N:Analyzeand E:Evaluate C:Create(as per 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.

References/Suggested Learning Resources:
Books:

1. W.R. Murphy & G. McKay, Energy Management (1st ed.), Butterworth-Heinemann / Elsevier, 2007.
2. B.K. De, Energy Management, Audit and Conservation (2nd ed.), Vrinda Publications, 2010.
3. Bureau of Energy Efficiency (BEE), Guide Books for Energy Auditors (Vols. 1–4) — available free at beeindia.gov.in (standard reference for BEE EA/EM examinations).
4. S.C. Tripathy, Electric Energy Utilization and Conservation, Tata McGraw-Hill, New Delhi (latest edition).
5. G.G. Khaparde & V. John, Harmonics and Power Systems, Springer, 2007.
6. W.C. Turner & S. Doty, Energy Management Handbook (7th ed.), Fairmont Press, 2009.
7. Roger C. Dugan et al., Electrical Power Systems Quality (3rd ed.), McGraw-Hill, 2012.
8. L.C. Witte, P.S. Schmidt & D.R. Brown, Industrial Energy Management and Utilisation (1st ed.), Hemisphere Publication, 1988.
9. Patrick, Patrick & Fardo, Energy Conservation Guidebook (1st ed.), Prentice Hall, 1993.
10. J. Douglas Balph, Power Factor Correction Handbook, ON Semiconductor, 2014.
11. E.I. Levi, Polyphase Motors: A Direct Approach to their Design, Wiley, 1985 (motor efficiency reference).
12. IEA, Energy Efficiency 2023 Report, International Energy Agency, Paris, 2023.

Suggested Course Practical List:

1. Measurement and analysis of electrical load profile (kW, kVA, kVAr, PF, THD) of a laboratory feeder using a portable power quality analyser (Class A, IEC 61000-4-30).
2. Assessment of Total Harmonic Distortion (THD) in current and voltage waveforms of non-linear loads (UPS, VFDs, rectifiers) and comparison with IEEE 519-2022 limits.
3. Calibration and use of clamp-type energy meter and data logger for 24-hour energy audit of a workshop or laboratory building.
4. Power factor improvement exercise: calculation of required capacitor bank rating; measurement of power factor before and after correction using APFC panel.
5. Performance evaluation of a three-phase induction motor at different loading levels: measurement of input power, efficiency, power factor; comparison with IE class data as per IS 12615 / IEC 60034-30-1.
6. Energy audit of a motor-pump system: measurement of hydraulic and electrical parameters; calculation of overall pump system efficiency and specific energy consumption.
7. Illuminance measurement using digital lux meter (IS 3646) and assessment of lighting energy efficiency in a classroom/lab; comparison with ECBC lighting power density requirements.
8. Infrared thermographic survey (or simulation using IR camera and lab setup) of switchgear and cable joints to identify hotspots and estimate energy losses.
9. Assessment of transformer all-day efficiency under varying loads; measurement of no-load and load losses as per IS 2026 / IEC 60076.
10. Simulation of harmonic spectrum and power quality improvement using MATLAB/Simulink or Power World Simulator: design of passive filter for 5th harmonic elimination.
11. Metering and analysis of rooftop solar PV system (or simulation using PVsyst / Homer): estimation of energy yield, CUF, performance ratio, and calculation of simple payback period.

12. Preparation of a mini energy audit report for the institute's electrical installation: sub-feeder loading analysis, power factor readings, identification of energy conservation opportunities (ECOs) with estimated savings.
13. Study of APFC panel: operation, relay settings, switching transients, measurement of capacitor bank performance.
14. Demonstration and practice: use of flicker meter software / analyzer module (IEC 61000-4-15); measurement of PST and PLT in lab environment.

Design based Problems (DP)/PBL/Open Ended Problem:

1. Design of a capacitor bank (fixed + automatic stages) for power factor correction of an industrial plant with mixed loads; include protection scheme and cost-benefit analysis.
2. Design and sizing of a rooftop solar PV + BESS system for a 500 kVA industrial facility in Ahmedabad for peak-shaving and net metering; compute LCOE, payback period, and NPV.
3. Prepare an Investment-Grade Energy Audit Report (ASHRAE Level II equivalent) for a selected industry (cement, textile, ceramic or pharma sector in Gujarat) with identification of at least five electrical ECOs and PAT compliance roadmap.
4. Propose a Volt/VAR Optimisation (VVO) scheme for a radial 11 kV distribution feeder; simulate using any power systems tool (PSCAD / ETAP / PowerWorld) and estimate annual energy loss reduction.
5. Evaluate harmonic mitigation strategies for a 100 kW VFD-driven pump station: compare passive filter, active filter and 18-pulse rectifier options on cost, performance and IEEE 519-2022 compliance.

Note: Problems may be solved using hand calculations, MATLAB, ETAP, Homer, PVsyst or similar licensed/open-source simulation tools.

Major Equipment:

1. Portable three-phase power quality analyser — Class A (IEC 61000-4-30), minimum Category III, with harmonic, flicker and unbalance measurement capability (e.g., Fluke 435, Hioki PQ3198, or equivalent)
2. Three-phase clamp-type power and energy logger with data download capability
3. True RMS digital clamp meter, digital multimeter, phase sequence indicator
4. Digital lux meter (with cosine correction) calibrated as per IS 3646
5. Infrared thermal camera (minimum 160×120 resolution, range up to 350°C) for electrical thermography
6. Three-phase variable load bank (resistive + inductive + non-linear) for motor and transformer testing
7. Automatic Power Factor Correction (APFC) Panel (demonstration unit)
8. Three-phase induction motor test rig (1–5 kW range) with torque measurement
9. Rooftop solar PV demonstration / simulation setup with grid-tie inverter and monitoring system
10. Power systems simulation software: ETAP or PSCAD (licensed) and / or PowerWorld (educational licence)
11. MATLAB / Simulink with Simscape Electrical (Sim Power Systems) toolbox
12. PVsyst or Homer Pro for renewable energy simulation
13. BEE-provided energy audit software (BEE Tools for designated consumers)

List of Open-Source Software/learning website:

Open-source software:

1. MATLAB / Simulink (MathWorks) — https://www.mathworks.com
2. Homer Pro (Renewable energy system design) — https://www.homerenergy.com
3. PVsyst (Solar PV design and simulation) — https://www.pvsyst.com
4. OpenDSS (Distribution System Simulation) — https://sourceforge.net/projects/electricdss/
5. ETAP (Power systems analysis) — https://www.etap.com (educational licence)
6. GNU Octave — https://www.gnu.org/software/octave/

Web / Digital Resources

Government and Regulatory Portals

1. Bureau of Energy Efficiency — https://beeindia.gov.in (Energy Audit resources, PAT data, BEE tools)
2. Ministry of Power, India — https://powermin.gov.in (EC Act, RDSS, national policies)
3. MNRE — https://mnre.gov.in (solar / wind grid integration guidelines)
4. GEDA Gujarat — https://geda.gujarat.gov.in (state-level renewable energy policy)
5. GERC — https://www.gercin.org (tariff orders, net metering regulations)
6. Central Electricity Authority — https://cea.nic.in (grid standards, load generation balance report)

NPTEL / SWAYAM Courses

1. NPTEL: Energy Efficiency, Acoustics and Daylighting in Buildings — https://nptel.ac.in
2. NPTEL: Power Electronics — (for understanding inverter-based power quality aspects)
3. NPTEL: Power System Analysis — (for distribution loss estimation context)
4. BEE e-learning portal: https://beeindia.gov.in/content/energy-auditors

Standards Bodies

1. IEEE Xplore Digital Library — https://ieeexplore.ieee.org
2. IEC Standards — https://www.iec.ch
3. Bureau of Indian Standards — https://www.bis.gov.in

Applicable Standards, Acts and Regulations (For reference)

A. IEEE Standards

1. IEEE 519-2022: Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
2. IEEE 1159-2019: Recommended Practice for Monitoring Electric Power Quality
3. IEEE 1453-2022: Standard for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems
4. IEEE 1547-2018: Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
5. IEEE 1547.9-2022: Guide to Using IEEE Std 1547 for Interconnection of Energy Storage DERs
6. IEEE 2800-2022: Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems
7. IEEE 112-2017: Standard Test Procedure for Polyphase Induction Motors and Generators
8. IEEE 18-2012: Standard for Shunt Power Capacitors
9. IEEE 1250-2018: Guide for Identifying and Improving Voltage Quality in Power Systems
10. IEEE P3457 (under development): Guide for Energy-saving Transformation of Electric Facilities in Existing Buildings

B. IEC Standards

1. IEC 61000-3-2:2018: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
2. IEC 61000-3-12:2011: Limits for harmonic currents produced by equipment with input current > 16 A and ≤ 75 A per phase
3. IEC 61000-4-15:2010: Flickermeter — Functional and design specifications
4. IEC 61000-4-30:2015: Power quality measurement methods (Class A / Class S instruments)
5. IEC 60034-30-1:2014: Rotating electrical machines — Efficiency classes of line operated AC motors (IE code)
6. IEC 60034-2-1:2014: Rotating electrical machines — Standard methods for determining losses and efficiency of rotating electrical machinery
7. IEC 60076-1:2011 to 60076-7: Power Transformers series (losses, loading, temperature rise, dielectric)
8. IEC 61215-1:2016 & IEC 61730: Terrestrial PV modules — Design qualification and type approval
9. IEC 61557-12:2018: Performance requirements for measuring instruments for electrical power quality in LV distribution systems
10. IEC 62933-1/2/3: Electrical Energy Storage Systems — general requirements, unit parameters, safety
11. IEC 60364-8-1:2019: Low-voltage electrical installations — Energy efficiency requirements
12. ISO 50001:2018: Energy Management Systems — Requirements with guidance for use
13. IEC 62116:2014: Test procedure for islanding prevention measures for utility-interconnected inverters

C. IS / BIS Standards

1. IS 12615:2018: Specification for Energy Efficient Induction Motors (IE1 to IE4)
2. IS 13925 (Part 1-3): Power capacitors for LT applications
3. IS 1180 (Part 1):2014: Outdoor type oil-immersed distribution transformers — General requirements
4. IS 2026 (Part 1-4): Power Transformers
5. IS 3646: Code of practice for interior illumination
6. IS 10160: Specification for luminaires (LV distribution)
7. IS 15884: Specification for power quality instruments
8. IS 16444: Specification for advanced electricity meters (Single and Three Phase)
9. IS 16221 (Part 1 & 2): Grid interactive solar photovoltaic power conditioning units
10. IS 13779: Requirements for AC static watt-hour meters
11. IS 9137: Acceptance tests for centrifugal, mixed flow and axial pumps

D. Government Acts, Policies and Regulatory Frameworks

1. Energy Conservation Act, 2001 (Government of India) — Chapters on BEE, Designated Consumers, Energy Auditors
2. Energy Conservation (Amendment) Act, 2022 — Carbon Credit Trading, Non-Fossil Consumption Obligations, amended BEE governance
3. Electricity Act, 2003 — Open access, metering, tariff regulation
4. Bureau of Energy Efficiency (Manner and Intervals of Time for Conduct of Energy Audit) Regulations, 2010
5. BEE (Manner and Interval for conduct of Energy Audit in Electricity Distribution Companies) Regulations, 2021 (enforced 2022)
6. National Action Plan on Climate Change (NAPCC) — National Mission for Enhanced Energy Efficiency (NMEEE)
7. PAT (Perform Achieve and Trade) Scheme — Energy Saving Certificates (ESCerts)
8. Energy Conservation Building Code (ECBC) 2017 / Energy Conservation and Sustainable Building Code (ECSBC) 2022
9. MNRE: Grid-Connected Rooftop Solar PV System Installation Guidelines
10. Central Electricity Authority (CEA) Regulations — metering, grid connectivity, technical standards for construction of electrical plants and electric lines
11. Gujarat Solar Power Policy and Gujarat Wind Power Policy (GUVNL / GEDA)
12. GERC (Gujarat Electricity Regulatory Commission) Tariff Orders and Net Metering Regulations
13. Revamped Distribution Sector Scheme (RDSS) — Ministry of Power, 2021
14. National Electricity Policy (NEP) 2021 — energy efficiency provisions

SDGs Relevant to Energy Management and Audit

SDG	Goal Title	Connection to Energy Audit & Management Syllabus
SDG 3	Good Health & Well-Being	Safe handling of electrical equipment; lab safety protocols during energy audits
SDG 4	Quality Education	BEE mock exams, NPTEL/BEE e-learning, simulation-based practicals, self-learning activities
SDG 7	Affordable & Clean Energy	Entire course — energy auditing, RE integration, demand-side management, energy efficiency
SDG 8	Decent Work & Economic Growth	BEE-certified Energy Auditor/Manager careers; PAT scheme compliance in industry
SDG 9	Industry, Innovation & Infrastructure	Motor efficiency (IE4), smart metering (AMI), FACTS devices, grid modernisation
SDG 11	Sustainable Cities & Communities	ECBC building energy codes, smart grid/DSM for urban feeders, lux-level audits in buildings
SDG 12	Responsible Consumption & Production	SEC benchmarking, load profiling, VFD adoption, transformer optimisation, AT&C loss reduction
SDG 13	Climate Action	EC Act 2022 carbon credits, COP-26 commitments, RE integration, NMEEE, green hydrogen
SDG 17	Partnerships for the Goals	Industry–institution linkage via BEE, GEDA, GERC; international standards (IEC/IEEE/ISO)

Activities Suggested for Self-Learning:

Sl. No.	PBL Activity	Activity	Hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry Visit: Conduct a walk-through energy audit of a nearby industrial unit (textile, pharma, ceramics, engineering) or electricity distribution substation. Document electrical load inventory, meter readings, and preliminary energy conservation opportunities (ECOs).	Visit=5h, Report=5 h, Total=10 h	Quality of one-line diagram sketched, completeness of load inventory, clarity of ECO identification, adherence to BEE audit format.
2	Survey & Micro Project	Use a portable power quality analyser (or simulated data) to record voltage, current, power factor, and harmonic levels at a selected distribution panel for a short duration (30–60 minutes). Analyse the recorded data, identify any major power quality issues, compare measured harmonic levels with typical IEEE 519 limits, and prepare a brief	Measure ment & Report=5 h, Total=5h	Accuracy of captured parameters, correct application of IEEE 519 limits, quality of mitigation recommendations.

		report with observations and recommendations.		
3	Assignment/ Technical Writing / Research Writing	Numerical Assignments: Minimum 5 assignments covering — tariff analysis, power factor correction sizing, motor energy savings calculation (VFD vs. DOL), transformer all-day efficiency, harmonic filter design, solar PV yield estimation, NPV/IRR of ECO.	5 × 2h = 10h	Correctness of methodology, application of appropriate standards, logical presentation.
4	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Simulation Task: Model and simulate a power distribution feeder with capacitor placement in OpenDSS or ETAP; compare losses before and after VAR compensation. Alternatively, simulate harmonic spectrum and passive filter design in MATLAB/Simulink.	5 × 2h = 10h	Simulation accuracy, proper interpretation of results, correct use of software tools, documentation quality.
5	MOOC Course	Online Certification: Complete at least 10 hours of an online course related to energy audit, power quality, renewable energy or smart grid (NPTEL, Coursera, edX, BEE e-learning platform).	10h	Certificate of completion + quiz/viva on course content.
6	Seminar / Poster Presentation	Technical Seminar / Poster Presentation: Prepare and present a 10-minute seminar or technical poster on a current topic — examples: 'Impact of EV Charging on Grid Power Quality', 'Rooftop Solar + BESS for SMEs in Gujarat', 'Carbon Credit Trading under EC Act 2022', 'IE4/IE5 Motor Adoption Roadmap in India'.	Research =5h, Preparation=5h, Total=10 h	Technical accuracy, use of standards and data, communication clarity, response to questions.
7	BEE Mock Examination	BEE EA / EM Mock Examination: Attempt one full-length mock examination of BEE Energy Auditor (Paper I or Paper II) under examination conditions; review answers with faculty.	5h	Score and quality of review noting error patterns, identification of weak areas for improvement.
8	Patent Search / Literature Review	Patent / Literature Review: Search 5–8 recent patents or IEEE/Scopus papers on a chosen topic (e.g., smart energy metering, demand response algorithms, AI-based energy forecasting, advanced APFC controllers); prepare a one-page annotated bibliography.	10h	Relevance of papers selected, quality of critical analysis, identification of research gaps.

Note:

Notes: (i) All activities must be directly related to electrical energy audit and management. (ii) Suggestive hours may be redistributed by faculty, but total hours are fixed. (iii) Evaluation rubrics shall be prepared and displayed by the concerned faculty. (iv) All records must be maintained at institute level and produced on demand. (v) Digital submission via Microsoft Teams, Moodle or institute LMS is encouraged. (vi) In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject Energy Management and Audit incorporates;

- Mini Project – 10 Marks
- Micro Project and – 5 Marks

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of Energy Management and Audit. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice. (vii) The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

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