University of Pune

Revised Syllabus

For

M.Tech (Energy)

School Of Energy Studies
Pune -7
The course consists of four semesters, each semester having five courses. The semester wise courses are given below.

<table>
<thead>
<tr>
<th>Semester –I</th>
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<tbody>
<tr>
<td>EN-111 Energy Scenario and Energy Policy</td>
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<tr>
<td>EN-112 Energy Conversion Systems-I</td>
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<tr>
<td>EN-113 Energy Conversion Systems-II</td>
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<tr>
<td>EN-114 Renewable Energy System -I</td>
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<td>EN-125 Practical-I</td>
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<thead>
<tr>
<th>Semester –II</th>
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<tbody>
<tr>
<td>EN-211 Energy Audit and Management- I</td>
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<td>EN-212 Energy Conservation</td>
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<td>EN-213 Renewable Energy System -II</td>
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<td>EN-214 Environmental Impact of Energy Systems</td>
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<td>EN-225 Practical-II</td>
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<th>Semester –III</th>
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<tbody>
<tr>
<td>EN-311 Energy Audit and Management -II</td>
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<tr>
<td>EN-312 Energy Audit Procedures and Techniques</td>
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<tr>
<td>EN-313 Elective / Special Course (Any one)</td>
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<tr>
<td>a) Advanced Solar Thermal and PV</td>
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<tr>
<td>b) Wind Energy</td>
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<tr>
<td>c) Advanced Energy Management</td>
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<th>Semester –IV</th>
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<td>EN-421 Project Work</td>
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<th>Semester –IV</th>
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<tr>
<td>EN-421 Project Work</td>
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### Semester-I

**Distribution of Credits, Units, Lectures and Marks**

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<thead>
<tr>
<th>Course Code</th>
<th>Course Title and Units</th>
<th>Credits</th>
<th>Lectures</th>
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<td>Unit No.4: Basics of Thermodynamics</td>
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<td>(15 Experiments, 1 Unit= 3 Experiments)</td>
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</table>
Syllabus for Semester-I

EN-111: Energy Scenario and Energy Policy (C-5, L-50)

Unit-01: Global Energy Scenario (C-1.5, L-15)

Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics.

Discovery of various energy sources: Energy Sources and Overall Energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and Projected future demands.

Energy Resources: Coal, Oil, Natural Gas, Nuclear Power and Hydroelectricity, Solar and Other Renewable etc. Depletion of energy sources and impact exponential rise in energy consumption on economies of countries and on international relations.


International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal.


Unit-02: Indian Energy Scenario (C-1.0, L-10)

Energy resources & Consumption: Commercial and noncommercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption


Status of Nuclear and Renewable Energy: Present Status and future promise


Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)

**Unit-03: Energy Policy (C-1.0, L-10)**

Global Energy Issues, National & State Level Energy Issues,

National & State Energy Policy, Industrial Energy Policy,


Energy Productivity (National & Sector wise productivity).

**Unit-04: Basics of Thermodynamics (C-1.5, L--15)**

Basic Units, Dimensions and Conversions For Energy, Concepts of Energy, Heat and Work, Ideal gas law, Ist and II law of thermodynamics (Closed and Open Systems)

Thermodynamics power cycles, Reversible heat Engine cycle, I.C. engine cycles, Carnot Cycle, Rankine Cycle, Otto Cycle, Vapor Refrigeration & power Cycle etc.

**Reference Books:**

2. Energy policy for : B.V.Desai (Weiley Eastern),
5. TEDDY Year Book Published by Tata Energy Research Institute (TERI),
7. ‘International Energy Outlook’ -EIA annual Publication
EN-112: Energy Conversion Systems-I  (C-5, L-50)
(Thermal and Mechanical Energy Utility Systems)

Unit-01: Classification of Energy Sources (C-0.5, L-05)

Classification of Energy Sources,

Principle fuels for energy conversion: Fossil fuels, Nuclear fuels.

Conventional & Renewable Energy

Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics.

Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, Nuclear energy etc.

Energy Conversion through fission and fusion, Nuclear power generation etc.

Unit-02: Thermal and Mechanical Energy (C-1.0, L-10)

Thermal energy using fossil fuels.
Conversion of Thermal Energy to Mechanical energy & Power.
Turbines: Steam turbines, Hydraulic turbines.

Unit-03: Thermal and Mechanical Energy Utility systems (C-2.0, L-20)

Boilers -Types, combustion in boilers, performance evaluation, analysis of losses, feed water treatment, blow down.

FBC Boilers: Introduction, mechanism of fluidized bed combustion, advantages, types of FBC boilers, operational features, retrofitting FBC system to conventional boilers.

HVAC, Refrigeration and Air Conditioning: Vapor compressor refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air conditioning system performance, Vapor absorption refrigeration systems: Working principle, type and comparison with vapor compressor system.

Unit –04: Basics of Mechanical Engineering (Energy Related) (C-0.5, L-05)

Sterling Engines, Steam Engine, Internal Combustion systems and external combustion system, Overview of different types of turbines.
Mechanical Engineering and Overview: Basic Engineering concepts and design considerations, Governing regulations and codes and standards,

Strength of Materials, mechanical properties of materials, mechanics of materials

Torque and Power: Basic theory, Shafts, Flywheels etc.

Power Transmission: Concepts of Belts Drives, Gearing, Coupling etc.

Bearing and Lubricants as Energy Saving Measures

Electromechanical energy: Electric to mechanical energy conversion, Electric Motors.

**Unit No.5: Co-generation, Tri-generation & Waste Energy Recovery (C-1.0, L-10)**

Co-generation & Tri-generation: Definition, need, application, advantages, classification, saving Potential.


**Reference Books:**

1. Direct Energy Conversion : W.R.Corriss
4. Energy conversion principles : Begamudre , Rakoshdas
5. Fuel Economy Handbook, NIFES,
6. Industrial Furnaces (Vol I & II) and M.H. Mawhinney, (John Wiley Publications)
10. The storage and handling of Petroleum liquid
    (John R. Hughes, Charles Griffin & Co. Ltd.)
11. Fuels and fuel Technology Wilfred Francis, (Pergamon press)
12. Domestic and commercial oil Burners Charles H. Burkhadt (Mcgraw Hill Publication)
13. The efficient use of steam – Oliver Lyle, (HMSO London)
15. The Efficient use of steam generation – General editor – P.M.Goodall
EN 113: Energy Conversion Systems-II (C-05, L-50)
(Electrical and Mechanical Energy Utility Systems)

Unit-01: Basics of Electrical Engineering (Energy Related) (C-0.5, L-05)

Fundamentals of Electricity: Concepts of different electrical parameters like voltage, current, frequency, D.C and A.C circuits, Electrical power and energy.

Electrical loads – Resistive, Inductive and Capacitive.

Phasor Notation, Power in A.C. Circuits, Single and Three Phase A.C. Power, Star and Delta connections, Voltage levels.

Transformers, Generators, Alternators etc.

Conversion of Thermal, Chemical, Electromagnetic and Mechanical energy into electricity.

Unit-02: Electrical Energy Sources (C-0.5, L-05)

Importance of Electrical energy in modern industrial society, Production of electricity using coal, oil, natural gas, nuclear fuels and hydel -its relative advantages and disadvantages (i.e. conversion of Thermal, Nuclear, hydel energy into electric energy)

Electricity generation using Renewable Energy Sources: Basic Principles and Applications. (Conversion of Electromagnetic energy and natural energy sources like solar radiation, Wind, Ocean waves, Solid waste etc. to electricity)

Conversion of chemical energy into electrical energy (fuel cell)

Thermal power plant, nuclear power plants and hydroelectric power plant, Transmission and distribution of electricity, Villages electrification program and problems in India.

Unit-03: Electrical and Mechanical Energy Utility Systems (C-03, L-30)

Transmission and Distribution losses, Pilferage, Transformer losses. Electricity tariff, Load management and maximum demand control, power factor improvement and its benefits, Selection and location of capacitors etc.

Conversion of Electrical Energy to Mechanical Energy (Electric Motors).

Compressed Air System: Types of air compressors, compressors efficiency, efficient compressors operation, Compressed air system components, capacity assessment, and leakage test, factors affecting the performance.

Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies.

Pumps and Pumping Systems: Types, performance evaluation, efficient system operation, flow control strategies, variable speed drives.

Cooling Towers: Types and performance evaluation, efficient system operations, flow control strategies, assessment of saving opportunities.

Illumination / Lighting Systems: Light source, choice of lighting, luminance requirements, electronic ballast, occupancy sensors, energy efficient lighting control.


**Unit-04: Energy Audit Instruments (C-0.5, L-05)**

Basic measurements – Electrical measurements, Light, Pressure, Temperature and heat flux, Velocity and Flow rate, Vibrations, etc.

Instruments Used in Energy systems: Load and power factor measuring equipments, Wattmeter, flue gas analysis, Temperature and thermal loss measurements, air quality analysis etc.

Mathematical and statistical modeling and analysis.

**Unit-05: Energy Measurement & Verification (C-0.5, L-05)**


**Reference Books:**

2. Direct Energy Conversion : M.A. Kettani
3. Energy Conversion systems : Begamudre, Rakoshdas
4. Direct Energy Conversion : W.R.Corliss
5. Alternative Liquid fuels : B.V. Desai
6. TEDDY year book published by TERI, .
7. The Watt Committee on Energy (Reports)
8. Energy Management Workbook -
16. ASHRAEE Energy Use (4 Volumes),

EN 114: Renewable Energy Systems-I (C-05, L-50)

Unit-01: Solar Energy (C-2.0, L-20)


Various Methods of using solar energy –Photothermal, Photovoltaic, Photosynthesis, Present & Future Scope of Solar energy.

Hybrid wind energy systems - wind + diesel power, wind + conventional grid, wind + Photovoltaic system etc.

Unit-02: Bio-mass (C-0.1, L-10)

Biomass: Generation and utilization, Properties of biomass, Agriculture Crop & Forestry residues used as fuels.

Biochemical and Thermo-chemical Conversion, Combustion, Gasification, Biomass gasifiers and types etc.

Applications of Gasifiers to thermal power and Engines, Biomass as a decentralized power generation source for villages

Concept of Bio-energy: Photosynthesis process, Bio-fuels, Biomass resources Bio based chemicals and materials

Thermo-chemical Conversion: Pyrolysis, Combustion, Gasification, Liquification.

Bio-Chemical Conversion: Aerobic and Anaerobic conversion, Fermentation etc.
Bio-fuels: Importance, Production and applications.

Bio-based Chemicals and Materials: Commercial and Industrial Products, Biomass, Feed stocks, Chemicals, Plastics, Fibres etc.

Government Policy and Status of Bio fuel technologies in

Unit-03: Biomethanation (C-0.5, L-05)

Importance of biogas technology, Different Types of Biogas Plants.
Aerobic and anaerobic bioconversion processes, various substrates used to produce Bio gas (cow dung, human and other agricultural waste, municipal waste etc.)
Individual and community biogas operated engines and their use.
Removal of CO₂ and H₂O, Application of Biogas in domestic, industry and vehicles.
Bio-hydrogen production.
Isolation of methane from Biogas and packing and its utilization.

Unit-04: Wind Energy(C-1.5, L-15)

Wind Energy: Basics & Power Analysis,
Wind resource assessment,
Power Conversion Technologies and applications,
Wind Power estimation techniques,
Principles of Aerodynamics of wind turbine blade,
Various aspects of wind turbine design,
Wind Turbine Generators: Induction, Synchronous machine, constant V & F and variable V & F generations, Reactive power compensation.
Site Selection,
Concept of wind form & project cycle,
Cost economics & viability of wind farm,

Reference Books :

   ( John Wiley and Sons, New york, 1987)
2. Biomass for energy in the developing countries – D.O.Hall, G.W.barnard and P.A.Moss  
   (Pergamon Press Ltd. 1982)
3. Thermo chemical processing of Biomass, Bridgurater A V.
   (Academic press1981)
7. Wind Turbine Technology: Fundamental concepts of wind turbine technology 
   (John Wiley & Sons Ltd.)

EN125:  Practical-I (C-5.0, L-50) (15 Experiments, 1 Unit: 3 Experiments)

Atleast 12 practicals should be done during a semester.

  1) Determination of efficiency of boiler and analysis of flue gases.
  2) Study of heat exchangers.
  3) Study of variable speed drives
  4) COP of cooling towers.
  5) Efficiency of electrical motors.
  6) Study of diesel generator set.
  7) Measurement of load and power factor for the electrical utilities.
  8) Determination of efficiency of pumping system.
  9) Performance evaluation of blower
 10) Performance evaluation of air compressors
 11) Determining efficiency of lighting system/loads
 12) Measurement of Intensity of solar radiation
 13) Energy Content in Wind. (Prototype Wind Mill of 500W)
 14) Bio-gas Production from Kitchen waste.
 15) Performance of Gasifire.

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## Semester-II

### Distribution of Credits, Units, Lectures and Marks

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Lectures</th>
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<td>(15 Experiments, 1 Unit= 3 Experiments)</td>
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Syllabus for Semester-II

EN-211: Energy Audit and Management- I (C-5, L-50)

Unit -01: General Aspects (C-1.5, L-15)

General Philosophy and need of Energy Audit and Management. 
Energy Audit: Need, Types, Methodology and Approach. 
Energy Management Approach, Understanding Energy Costs, Benchmarking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution.

Unit -02: Procedures and Techniques (C-1.5, L-15)

Data gathering : Level of responsibilities, energy sources, control of energy and uses of energy get Facts, figures and impression about energy /fuel and system operations, Past and Present operating data, Special tests, Questionnaire for data gathering.

Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation.

Evaluation of saving opportunities: Determining the savings in Rs, Noneconomic factors, Conservation opportunities, estimating cost of implementation.

Energy Audit Reporting: The plant energy study report- Importance, contents, effective organization, report writing and presentation.

Unit -03: Energy Policy Planning and Implementation (C-1.0, L-10)


Unit -04: Energy Balance & MIS (C-0.5, L-05)

Energy Balance sheet and Management Information System (MIS) 
Energy Modeling and Optimization.
Unit -05: Energy Audit Instruments (C-0.5, L-05)

Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy

Reference Books:
1. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
9. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)
11. ASHRAEE Energy Use (4 Volumes)

EN-212: Energy Conservation (C-5, L-50)

Unit-01: General Aspects (C-0.5, L-05)

Introduction to ENCON, Approach and modern techniques, benefits, trends.
Energy Conservation Technology (Thermal Energy).
Techno-Economic evaluation of conservation technologies, Efficiency Improvements
Thermal Utilities: Boilers, Steam System, Thermic Fluid Heating Systems, Furnaces, Heating and Melting Applications,Refractories etc..
Fuel Shift: Oil, Gas, Coal, Bio-mass, and Renewable.

Unit-02: Waste Heat Recovery (C-1.0, L-10)

Sources of waste heat and its potential applications, Waste heat survey and measurements, Data collection, Limitations and affecting factors
Heat recovery equipment and systems, Heat Exchangers, Incinerators
Regenerators and Recuperates.
Waste Heat boilers.
System Integration.
Unit-03: Energy Efficiency in Buildings & ECBC-2007 (C-1.0, L-10)

Introduction, Definition and concepts, Energy and Water as a resource, Criticality of resources and needs of modern living, Envelop heat loss and heat gain and its evaluation, Thermal Comport improvement methods, Optimum performance, Other building comports, IAQ requirements, Electrical Energy Conservation, Opportunities and Techniques for energy conservation in Buildings.
Adoption to sustainable resources, process and Technologies.
Eco-housing concepts and National and International norms.

Unit-04: Energy Storage (C-1.0, L-10)

Need and importance of Energy storage in Conventional and Nonconventional Energy Systems. Technical Aspects (Measurements, Quantify)
Various forms of Energy Storage: Thermal, Chemical, Mechanical, Electrical and Nuclear

Unit-05: Case Studies: Thermal Energy Conservation (C-1.5, L-15)

Case studies of Commercial/ Industrial/ Residential thermal energy conservation systems and their economical analysis.

Books:
1. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
9. Energy Conservation guide book Patrick/Patrick/Fardo (Prentice Hall)
11. ASHRAEE Energy Use (4 Volumes),
Unit-01: Geothermal, Tide and Wave Energy (C-1.0, L-10)


Unit-02: Hydrogen Energy (C-1.0, L-10)

Hydrogen as a renewable energy source, Sources of Hydrogen, Fuel for Vehicles.

**Hydrogen Production:** Direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production.

**Storage of Hydrogen:** Gaseous, Cryogenic and Metal hydride

Unit-03: Fuel Cell (C-1.0, L-10)

Fuel cell – Principle of working, construction and applications.

Unit-04: Hydel Energy (C-1.0, L-10)

Hydro power: Potential, Hydropower Generation and Distribution, Mini and Microhydel Power (MHP) Generation: Classification of hydel plants, Concept of micro hydel, merits, MHP plants: Components, design and layout, Turbines, efficiency, Status in India. Integrated Energy systems and their cost benefit analysis.

Unit-05: Nuclear Energy (C-1.0, L-10)


**Reference Books :**
4. Solar Cell : Marteen A. Green
8. Batteries Volume (I) and (II) - Collins

Unit-01: Impact of Energy Systems on Environment (C-0.5, L-05)

Environmental degradation due to energy production and utilization, Primary and Secondary pollution such as SOx, NOx, SPM in air, thermal and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation. Sociological and Economical problems due to Thermal and other energy projects. Physiological, ecological and environmental and health problems due to energy plants.

Methods of Environmental Impact Assessment.

Unit-02: Pollution due to Thermal, Hydel and Nuclear Power Plants (C-1.5, L-15)

Potential sources of Pollution in thermal power plant, Air, water, land pollution due to estimation for thermal power plant.

Environmental pollution limits guidelines for thermal power plant pollution control. Various pollution control equipments such as dust collector, bag filter, electrostatic separator, working principle and selection criteria, designing the pollution control system, methods and limitation.

Water pollution in thermal power plant, physical and chemical methods of pollution control, Land pollution effect of land pollution, measurement of land pollution.

Limitations and advantages of pollution control systems.

Hydrothermal plant environmental assessment, hydrothermal plant and rehabilitation measures for hydrothermal plant.

Nuclear power plants and environmental pollution, pollution control measures.

Unit-03: Pollution due to Vehicles and Utilities (C-0.5, L-05)

Pollution due to vehicles and utilities, Methods to Control emission from Vehicle, Boilers, Furnaces etc, International Standards for Quality of air and norms for exhaust gases.

Effect of Hydro electric power stations on ecology and environment.

Unit-04: Industrial and Urban Waste & Waste Energy Recovery (C-1.0, L-10)

Industrial waste, Waste and effluent treatment, 
Waste as a source of energy: Industrial, domestic and solid waste as a source of energy. 
Pollution control: Causes, process and exhaust gases and its control, mechanism and devices for pollution control.

Unit-05: Environmental and Pollution Control Laws (C-1.0, L-10)

United Nations Framework Convention on Climate Change (UNFCC), Protocol, Conference of Parties (COP)
Clean Development Mechanism (CDM), Prototype Carbon Funds (PCF)
Carbon Credits and it’s trading, Benefits to developing countries, Building a CDM project.

Unit-06: Global Environmental Concern (C-0.5, L-05)
Global Environmental Issues, ozone layer depletion, Global Warming, Green House Gases Emission

Books:

EN-215: Practical-II (C-5.0, L-50) (15 Experiments, 1 Unit: 3 Experiments)

Atleast 12 practicals should be done during a semester.

1) Study of solar collector.
2) Study of solar hot water systems (FPC and ETC)
3) Study of solar hot air collector/solar dryer.
4) Performance evaluation of box type and concentrating type solar cooker.
5) Study of heat pipe
6) Characteristics of SPV system.
7) Determination of efficiency of DC/AC inverter.
8) Study of Chulla and Gas Stove.
9) Study of Lead Acid Battery as a energy storage.
11) Determination of “Star Rating” of Refrigerator.
12) Flue gas analysis of petrol, diesel and LPG Engines.
13) Wind power and annual energy estimation from wind data.
14) Pay back analysis, financial work sheet of a renewable energy project.
15) a) Find COP of 1.5 TR window / Split AC.
    b) Find COP with Heat Balance method.
    c) Effect of Condenser coding on COP of AC.
    d) Effect of desuperheater (Hot water generation)
### Semester-III

#### Distribution of Credits, Units, Lectures and Marks

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<th>Credits</th>
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Syllabus for Semester-III

EN-311: Energy Audit and Management- II (C-5, L-50)

Unit No.01: Economic Analysis and Financial Management (C-1.5, L-15)
Objectives, Investment needs, appraisal and criteria, sources of funds.
Tax considerations: Depreciation, types and methods of depreciation, Income tax Considerations.
Financial analysis: Simple pay back period, Return on investment (ROI), Net Present value (NPV), Internal Rate of Return (IRR), and Annualized cost, Time value of money, Cash flows, Discounting, Inflation Risk and sensitivity analysis, financing options.
Pros and cons of the common methods of analysis.

Unit No.02: Project Management (C-0.5, L-05)
Definition and scope of project, technical design, financing, contracting, implementation and performance monitoring.
Implementation plan for top management, Planning budget, Procurement procedures, construction, Measurements and verification

Unit No.03: Energy Monitoring, Targeting Review and Evaluation (C-1.5, L-15)
Definition – Monitoring and targeting, elements of monitoring and targeting, data and information analysis, techniques energy consumption, production, cumulative sum of difference (CUSUM), Review and evaluation.

Unit No.04: Energy Policy (C-0.5, L-05)

Unit No.05: Energy Management –Case Studies (C-1.0, L-10)
Study of 4 to 6 cases of Successful Energy Management in Industries.

Reference Books:
1. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
EN-312: Energy Audit Procedures and Techniques (C-5, L-50)

Unit No.01: Energy Audit Methodology & Recent Trends (C-1.0, L-10)
Current Practices, Integration of two or more systems, Switching of Energy Sources, Economics of implementation of energy optimisation projects, it’s constraints, barriers and limitations, Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits. Guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations. Case studies of implemented energy cost optimization projects in electrical utilities as well as thermal utilities.

Unit No.02: Electrical Distribution and Utilisation (C-1.0, L-10)

Unit No.03: Thermal Systems (C-1.0, L-10)

Unit No.04: Cogeneration (C-1.0, L-10)
Integrated analysis of steam base co-gen system, Gas turbine combine cycle operation, IC engine base co-generation and tri-generation, extraction turbines and steam cycle of co-generation.
Unit No.05: System Audit of Mechanical Utilities (C-1.0, L-10)
Pumps, types and application, unit’s assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems

Blowers types & application, its performance assessment, series & parallel operation applications & advantages. Energy Saving in Blowers

Compressors, types & applications, specific power consumption, compressed air system, & economic of system changes. Energy Saving in Compressors & Compressed Air Systems

Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers

HVPC & Psychometric, vapour compression cycles & comfort cooling, refrigerants new trends, COP, Capacity assessment, Vapor absorption refrigeration’s – Li Br & Ammonia Cycles, working principle and system analysis, comparison of different cooling systems, heat pump off ions for HVPC systems improvements and its analysis. Energy Saving in HVAC Systems

Water system and water analysis for power generation, water audit and it utilization, Hydro-pneumatic applications for optimization of water pumping cost

Study of 4 to 6 cases of Energy Audit & Management in Industries (Boilers, Steam System, Furnaces, Insulation and Refractories, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery etc.)

Study of 4 to 6 cases of Electrical Energy audit and management (Power factor improvement, Electric motors, Compressed air systems, Pumping systems, Fans and blowers, Cooling Towers, Industrial/Commercial Lighting system, Diesel based power Generation system etc.)

Study of Energy Audit reports for various Industries and Organizations

Reference Books:
1. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
EN-313: Special Course (Any one of the following) (C-5, L-50)

A) ADVANCED SOLAR THERMAL AND PV: (C-5, L-50)

Unit No.01: Solar Radiation (C-0.5, L-05)

Unit No.02: Photo thermal Systems (C-2.0, L-20)

Unit No.03: Photovoltaic systems (C-1.5, L-15)
Solar cells & panels, performance of solar cell, estimation of power obtain from solar power, solar panels PV systems, components of PV systems, performance of PV systems, design of PV systems, applications of PV systems, concentrating PV systems, P{V power plants, power plant with fuel cells

Unit No.04: Design & modeling of solar energy systems (C-0.5, L-05)
F Chart method, φ– F Chart method, Utilizability modeling & simulation of Solar Energy Systems,

Unit No.05: Economic analysis of Solar energy Systems (C-0.5, L-05)

Reference Books:
J.A.Duffie & W.A. Beckman: Solar Engineering of Thermal Process
S.A.Kalogirou: Solar Energy Engineering
B) WIND ENERGY (C-5, L-50)

Unit No.01: Wind Energy Fundamentals (C-0.5, L-05)

Unit No.02: Wind Measurements, Analysis and Energy Estimates (C-1.0, L-10)
Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz’s Limit, Turbulence Analysis

Unit No.03: Aerodynamics Theory (C-0.5, L-05)
Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads

Unit No.04: Wind Turbines Technology & Components of MW series WTGs.
(C-1.0, L-10)

Wind turbines types:
Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator

Wind Turbine Technology & Components of WTG
1) Gear Coupled Generator Type [Const. Speed]
2) Direct Coupled Generator Type [Variable Speed Variable Frequency]: Multipole Synchronous / PMG Generators.

Gear Coupled Generator Wind Turbine Components and their construction

Direct Rotor Coupled Generator (Multipole) [Variable Speed,Variable Freq.]
Excited Rotor Synch.Generator / PMG Generator, Control Rectifier, Capacitor Banks, Step Up / Boost Converter (DC-DC Step Up), Grid Tied Inverter, Power Management, Grid Monitoring Unit (Voltage and Current), Transformer, Safety Chain Circuits

Doubly Fed Induction Generator and Power Control

Unit No5: Modern Wind Turbine Control & Monitoring System (C-0.5, L-05)
Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases: Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life
Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new Grid Codes.

**Unit No.06: Concept of Wind Farms and project cycle (C-1.0, L-10)**
Project planning, Site selection, Project execution, Operation and maintenance

**Environmental concerns:** Pollution free power; Noise; birds; Aesthetics; Radio waves interference; Rainfall

**Unit No.07: Cost Economics (C-0.5, L-05)**
Wind resource assessment and R & D costs, Fixed and variable costs, Value of wind energy, Life cycle costing and cash flow of wind power projects, Wind project owners / developers, Wind energy market

**Reference Books:**
Anna Mani : Wind Energy Data for India
C-Wet : Wind Energy Resources Survey in India VI
S. Rangarajan : Wind Energy Resources Survey in India V
Sathyajith Mathew : Wind Energy
Prepared by WISE: Wind Power in India (5000MW BY 2015)
B.H.Khan: Non-Conventional Energy Sources

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**C) ADVANCED ENERGY MANAGEMENT (C-5, L-50)**

**Unit No.01: Rules, Regulations & Laws governing Energy Conservation in India (C-1.0, L-10)**

Various Energy Efficiency Rating Systems for Buildings- LEEDS, BEE & GRIHA Rating Systems

**Unit No.03:- Energy Efficiency Projects & Financing of Energy Efficiency Projects (C-0.5, L-05)**
Unit No.04: Energy Performance Contracts & Energy Service companies

Types of Energy Performance Contracts, Energy Service Companies (ESCOs) and their Role, Emphasis on ESCOs

Unit No.05: Clean Development Mechanism Benefits for Energy Conservation Projects, Methodology & Procedure

What is CDM? Methodology & Procedures for CDM, Eligibility Criteria, UNFCCC, Role of UNFCCC & Government of India,

Reference Books:

**EN-324: Industrial Training**

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<td>1.5 Months or 6 weeks</td>
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The Industrial Training should be carried out in a Industry or Research Laboratory engaged in the R & D activities in Energy Field. The NGO’s undertaking pilot projects in the Field of Energy can also impart training to the M.Tech student. The training shall be for a period of six weeks and student should spend approximately 100 hours on training. A brief report of training activities certified by authorities imparting training shall be submitted at least one month before the end of semester.

The assessment of training shall be done as follows.

1) Evaluation by Training Institute of Student- 2.5 Credits (50 Marks)
2) Mid-Term Evaluation of Training (including Energy Awareness programme) – 2.5 Credits (50 Marks)
3) Final Viva Voce Examination – 5 Credits (100 Marks)
## Semester-IV

**Distribution of Credits, Units, Lectures and Marks**

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<td>5 months/ 20 weeks</td>
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Industrial Project or Research Project equivalent to 25 Credits shall be completed by the student during fourth semester. A project report giving details of work done under the project should be submitted one month before the end of the semester. The project work shall be monitored by internal guide and / or a authorized / qualified person from the industry where student is doing the work.

The topic of the project and work-plan shall be approval by the internal committee formed under the chairmanship of Director, School of Energy Studies. Mid-Term and pre-submission viva-voce examination shall be compulsory to every student.

Distribution of Credits fro Project work shall be as follows.

1) Selection of Topic and Work-Plan- 2.5 Credits, 50 Marks
2) Mid-Semester presentation – 5 Credits, 100 Marks
3) Pre- Submission Presentation - 5 Credits, 100 Marks
4) Find Viva- Voce Examination- 12.5 Credits , 250 Marks

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