Details of

Program of Study

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Syllabus of Courses

For

Full Time M. Tech. (Renewable Energy)

Offered by

School of Energy Management

Shri Mata Vaishno Devi University, Katra

Course Structure

Semester I **First Year**

Code	Subject	L-T-P	Credit
EML 6011	Non Conventional energy sources	3-0-0	3
EML 6012	Fuel technology	3-0-0	3
EML 6013	Energy economics and planning	3-0-0	3
EML 6014	Technology forecasting and assessment	3-0-0	3
EML 6015	Thermal science and engineering	3-0-0	3
EMP 6011	Energy Laboratory-I	0-0-4	2
	Total credit points	**15-0-4**	**17**

Semester II **First Year**

Code	Subject	L-T-P	Credit
EML 6016	Energy auditing	3-0-0	3
EML 6017	Power plant engineering	3-0-0	3
EML 6018	Quantitative method for energy management and planning	3-0-0	3
EML 6019	Industrial energy management	3-0-0	3
EML 6020	Biomass & Bio-energy systems	3-0-0	3
EMP 6012	Energy Laboratory-II	**0-0-4**	**2**
	Total credit points	**15-0-4**	**17**

***Compulsory summer training of 2 months and same to be reflected in the semester – III Grade sheet (credits=6)**

As a part of the Industrial / Field training the student should spend time at a wind or solar farm for him/her to understand the technical intricacies of working with these businesses.

Semester III **Second Year**

Code	Subject	L-T-P	Credit
EML7011	Solar energy utilization	3-0-0	3
EML7012	Solar photovoltaic power plants: Planning, Design and Balance of systems	3-0-0	3
EML 7013	Environmental Impact of renewable energy sources	3-0-0	3
EME701X	Program Elective-I	3-0-0	3
EME702X	Program Elective-II	3-0-0	3
EMD7011	Major project phase-I	0-0-12	6
EMT7011	***Summer training**	0-0-12	6
	Total credit points	**15-0-24**	**27**

Semester IV **Second Year**

Code	Subject	L-T-P	Credit
EMD7012	Major project phase-II	0-0-40	20
	Total credit points	**0-0-40**	**20**

Program Electives I

Code	Course Title	L-T-P	Credits
EME7011	Energy efficiency in buildings	3-0-0	3
EME7012	Wind Energy systems	3-0-0	3
EME7013	Small Hydro systems	3-0-0	3
EME7014	Solar passive architecture	3-0-0	3
EME7015	Decentralized generation systems	3-0-0	3
EME7016	Pollution control in power plants and automobiles	3-0-0	3
EME7017	Cogeneration & energy efficiency	3-0-0	3

Program Electives II

Code	Course Title	L-T-P	Credits
EME7021	Demand side management of energy	3-0-0	3
EME7022	Instrumentation and control in energy systems	3-0-0	3
EME7023	Energy storage	3-0-0	3
EME7024	Fuel cell and hydrogen energy	3-0-0	3
EME7025	Solar refrigeration and air-conditioning	3-0-0	3

Non-Credit Courses

Code	Course Title	L-T-P	Credits
EML 6021	Basic Electrical Engineering	1-0-0	0
EML 6022	Communication Skills and project presentation	1-0-0	0

Details of Courses

Non Conventional energy sources
EML6011 **3-0-0=3**

Renewable energy sources, Potential, solar radiation, Atmospheric phenomena, calculation of solar radiation on horizontal and inclined surfaces , Measurement of solar radiation, Low temperature applications, Solar distillation ,Heat pump, Solar refrigerator ,Passive space conditioning, Solar thermal power generation ,Photovoltaic, wind energy ,Physical and thermo chemical methods of bioconversion, Biological methods, Renewable energy economics. Hydropower Energy, Present status of Hydro Power, Magneto-hydro-dynamic (MHD) Energy conversion, Ocean energy resources, ocean wave energy conversion and tidal energy conversion, Geothermal Energy, types of geothermal energy sites, geothermal power plants; Nuclear Energy

Fuel Technology
EML6012 **3-0-0=3**

Principles of combustion , Solid , Liquid and Gaseous fuels, Coal as source of energy and chemicals, Coal preparation, Carbonization, Gasification and Liquefaction of coal and lignite , Petroleum and its derived products, Inter conversion of fuels, Natural gases and derivatives, Sources and Potential, combustion equipment for solid , Liquid and gaseous fuels, Nuclear fuel and technology.

Energy Economics and Planning
EML6013 **3-0-0=3**

System economics, Reference energy systems, Econometrics, Statistical approach, Langrangian multiplier, Input–output economics, Macroeconomic growth models, Dynamic models of the economy and simple theory of business fluctuations, Multiple linear and non linear regression analysis, Environmental repercussions and economic structure ,Social costs , Decision and uncertainty. Economics in Renewable Energy Systems.

Technology forecasting and assessment
EML6014 **3-0-0=3**

Module 1:
Forecasting as an input to technology planning, future research , Elements of forecasting, Process, Types of forecasting methods, Quantitative methods of forecasting, Time series models, Growth curves, Precursor, Envelope curves, Experience curves, Technical assessment.

Module 2:
Quantitative methods, Morphological analysis, Relevance trees, Delphi, technological gap analysis, Analogy method, Organizing for technology forecasting.

Module 3:
Technology assessment, Components, Problem definition, Social description, Measure impact assessment, Strategies for assessment, Economic impact analysis, Assessment of risk and uncertainty, Safety and environmental considerations.

Thermal Science and Engineering
EML6015 **3-0-0=3**

First and second law of thermodynamics, Thermal fluid systems, Standard cycles, Mixtures of gases, Heat transfer, Fluid mechanics, Practical examples, Use of steam tables. Theory of heat conduction, Mathematical and numerical analysis of two dimensional heat conduction with and without internal heat generation, Mathematical and numerical analysis of transient and periodic state heat conduction, Theory of convective heat transfer, Boundary layer theory, Heat transfer in duct flow, laminar and turbulent, Heat exchangers, Radiation heat transfer, between black and grey bodies, Laws of radiation heat transfer, Numerical solution of radiation network analysis

Energy Laboratory-I
EMP6011 **0-0-4=2**

The experiments to be carried out by the M.Tech. students will be identified from the following broad areas. However, based on the latest Research, Development and Testing requirements of the Energy Industry, new areas will be identified and experiments will be designed and introduced for the students as and when required so that the Students develop expertise as per the current needs of Industry and R&D institutions

Solar Radiation Data Monitoring and Analysis:
Sunshine hour duration, Direct Solar Radiation, Global Solar Radiation, Diffuse Solar Radiation, Net radiation [W/m2], Outgoing radiation [W/m2] , Infra red radiation, Diffuse radiation from global and direct radiation at a given zenith angle

Solar Photovoltaic:
Current-voltage characteristics of Solar Cell, Efficiency Variation of solar cell, Performance variation of solar photo cell at different light intensities,; Determination of power produced by a solar photo voltaic system, Performance Evaluation of a Solar Photo voltaic lighting system and its components: inverter, charge controller and battery, Performance evaluation of a solar photovoltaic water pump.

Fuel Properties and analysis:
Proximate and ultimate analysis, Calorific value of solid fuels. Density, Viscosity, Flash-point, Fire-point Pour-point, Distillation of liquid fuels, Fuel properties determination: Cloud and pour (melt) point, Viscosity, Calorific value, Sulfur percentage, Flash point, relative density of fuel, Iodine value of bio-fuel, Ash percentage of fuel

Solar thermal measurements and analysis:
Experimental study of thermal performance of Solar water heater, Evacuated tube solar collector, Solar still, Thermal performance of solar drying system , Thermal testing of a box type Solar Cooker, Concentrator type and community solar cookers, Designing and testing of Innovative solar thermal systems

Energy Simulation.

Energy auditing

EML6016 **3-0-0=3**

Energy audit concepts, Measurements, Mass and energy balances, Evaluation of energy, Conservation opportunities, Presentation of report, Case study, Laboratory work.

Environmental concepts, Elements measurements, Impact assessment, Energy and material analysis, Presentation and case studies. Energy conservation aspects in buildings, HVAC systems and power plants.

Power plant engineering

EML6017 **3-0-0=3**

Economics of power generation

Choice of power plant; Load & Load duration curves; Load factor; Diversity factor; Load deviation curve; Load management; Number and size of generating unit; Cost of electrical energy; Tariff-Power factor improvement.

Different types of power generation

Types of thermal power plants; Steam power plant based on fossil fuels; Thermal power plant equipment: Boiler, Economizer, Super heater, Condenser, Combustion chamber and gas loops, Turbines etc, Auxiliaries.

Hydropower plant

Mass curve and storage capacity; Classification; Components; Turbines- Characteristics and their selection; Governor; Plant layout and design; Auxiliaries; Underground, automatic, remote controlled, and pumped storage plants.

Nuclear power plant

Nuclear reactors and fuels; Radioactivity; Mass defect and binding energy; Chain reaction; Materials used in nuclear plants; Important types of reactors.

Quantitative methods for Energy Management & Planning

EML6018 **3-0-0=3**

A review of probabilities concepts: Axioms of probability. Conditional probability, Baye's theorem, Permutation, combinations, Binomial coefficients. Introduction to operation research: The nature and significance of operation research, Features of operation research approach, Applications and scope of operation research.

Linear programming: Application and model formulation, The graphical model. The simplex method, Duality in linear programming.

Integer programming problem: Cutting method, Search method, Gomory's fractional cut algorithm.

Decision theory and decision trees : Decision making under uncertainty, Decision making under risk. Transportation problems, Sequencing.

Industrial energy management
EML6019 **3-0-0=3**

Energy analysis and mass balance , Economic analysis, Instrumentation and control, combustion analysis, Industrial insulation, Heat exchangers , Energy efficiency in buildings, Condensating steam, Cogeneration, Compressors, Power factor, Transmission and distribution, Principles of management.

Biomass &Bio-Energy Systems
EML6020 **3-0-0=3**

Thermo-chemical conversions: Direct Combustion, Technology of Biomass gasification, Pyrolysis and Liquefaction, Bio- Chemical Conversion: anaerobic digestion, alcohol production from biomass, Chemical conversion process: hydrolysis and hydrogenation,

Biomass Gasifiers: History, Principle, Design of Biomass Gasifiers, updraft gasifier, down draft gasifier, zero carbon biomass gasification plants, Gasification of plastic-rich waste, applications for cooking, electricity generation, Gasifier Engines, Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol and biogas, Biomass integrated gasification/combined cycles systems.

Bio-Energy Systems with Efficient Applications: Traditional Stoves, Energy Efficient Cooking and Space heating Stoves, Metal Stoves Improved Gasifier Stoves, Pollution due to smoke emissions, Bio-gas Systems : Technology of Bio-gas production, Biogas Plants , Digester types, Digester design, Chemical kinetics and mathematical modeling of bio-methanation process, Dung, Vegetable Waste, Night Soil and Municipal Waste based Bio-gas plants, Bio gas as fuel for transportation, Lighting, Running Dual Fuel Engines**,** Electricity generation**,** Bio gas Bottling Plant Technology, Application of Bio gas slurry in agriculture , Design of Biogas for cold climates.

Energy Laboratory-II
EMP6012 **0-0-4=2**

The experiments to be carried out by the M.Tech students will be identified from the following broad areas. However, based on the latest Research, Development and Testing requirements of the Energy Industry, new areas will be identified and experiments will be designed and introduced for the students as and when required so that the Students develop expertise as per the current needs of Industry and R&D institutions

Bio-mass energy:
Biomass properties, Enzyme Production, Cellulose Hydrolysis, Glucose Fermentation, Pentose Fermentation, Ethanol Recovery, Lignin Utilization, Cellulose hydrolysis, Bio-diesel Production

Energy performance of buildings: solar passive buildings:
Testing & performance evaluation of Solar air heating systems: Solar Trombe wall, Thermosyphon heating panels, Attached green houses; Lighting measurements & analysis, Measurement and analysis of heat gain and air-conditioning load in a building, day lighting in a building: sky luminance, daylight from illumination from window and skylight

Energy audit:
Thermal energy audit: Measurement of variables such as, temperature, pressure, air flow, etc of selected energy equipments and analysis; Electric energy audit: Measurement of basic parameters in electric power systems i.e. current, voltage, resistance, power factor, power and energy

Wind energy measurements:
Wind speed, Wind direction, Data measurement and analysis, Performance evaluation of Wind energy system, Wind potential assessment

Bio- energy systems
Experimental study on thermal performance and efficiency of Biomass Energy systems: Gasifier, sampling and analysis of air and flue gas from biomass energy systems: Gasifier, combustor and cook stoves, Biogas production by anaerobic digestion and analysis, Bio-gas Plant comparison, Experimental study of cow dung, Vegetable waste, Municipal waste for biogas production

Energy Simulation

Solar energy utilization
EML7011 **3-0-0=3**

Solar radiation and modeling, soalr collectors and types: flat plate, concentrating solar collectors, advanced collectors and solar concentrators, selective coatings, solar water heating, solar cooking, solar drying, solar distillation and solar refrigeration, Active and passive heating and cooling of buildings, solar thermal power generation, solar cells, home lighting systems, solar lanterns, solar PV pumps, solar energy storage options, industrial process heat systems, solar thermal power generation, and sterling engine.

Solar Photovoltaic Power Plant: Planning and Design
EML7012 **3-0-0=3**

Estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, balance of systems, off grid systems, grid interface, preparing DPR, Supporting structures, mounting and installation, junction boxes, battery storage, power condition unit, selection of cables and balance of systems, planning with software, maintenance and schedule, SCADA system, sensor, data logger, monitoring, data management, analysis and performance, Financial analysis, life cycle costing, Environmental Analysis and social costs, worksheet, customer care. *Financing models of Renewable energy - Solar Farms*

Environmental Impact of renewable energy sources
EML7013 **3-0-0=3**

Environmental impacts of fossil fuel based power generation, Renewable electricity and key elements, Hydropower and its constraints, Wind energy: technology and economics, Resources, systems and regional strategies, Solar thermal power, Photovoltaic technology, Biomass power, tidal power, OTEC, Global climate change, CO2 reduction potential of renewable energy, Social considerations, standalone systems and grid integration.

Energy efficiency in buildings
EME7011 **3-0-0=3**

Thermal, Visual and acoustical comforts, Solar architecture, Heat transfer, Natural heating and cooling of buildings, Qualitative and Quantitative methods, Glazing, insulations , Ventilation, Day lighting, Air conditioning, Load estimation, Climates and energy requirement, Ventilation and fan power, Day lighting, Dehumidification, Software and case studies.

Wind Energy Systems
EME7012 **3-0-0=3**

Wind energy conversion
Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics.

WECS design
Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss Correction.

Design of wind turbine
Wind turbine design considerations; Methodology; Theoretical simulation of wind turbine characteristics; Test methods.

Wind energy application
Wind pumps: Performance analysis, design concept and testing; Principle of WEG; Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy. Utilization; Wind energy in India; Case studies.

Reliability techniques for Wind Turbines

Introduction to reliability engineering, failure data analysis, failure distribution, Improvement in reliability, reliability testing, system reliability by Montecarlo simulation techniques.

Financing models of Renewable energy - Wind Farms

Financial analysis, life cycle costing, Environmental Analysis and social costs, customer care.

Small hydro systems
EME7013 **3-0-0=3**

Small hydropower systems
Overview of micro, mini and small hydro systems; Hydrology; Elements of pumps and turbine; Selection and design criteria of pumps and turbines; Site selection and civil works; Speed and voltage regulation; Investment issues load management and tariff collection; Distribution and marketing issues: case studies; Potential of small hydro power in North East India.

Solar Passive Architecture
EME7014 **3-0-0=3**

Thermal analysis and design for human comfort
Thermal comfort; Criteria and various parameters; Psychometric chart; Thermal indices, climate and comfort zones; Concept of sol-air temperature and its significance; Calculation of instantaneous heat gain through building envelope; Calculation of solar radiation on buildings; building orientation; Introduction to design of shading devices; Overhangs; Factors that effects energy use in buildings; Ventilation and its significance; Air-conditioning systems; Energy conservation techniques in air conditioning systems

Passive cooling and heating concepts
Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel.

Heat transmission in buildings
Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; solar temperature; Decrement factor; Phase lag. Design of day lighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

Bioclimatic classification
Bioclimatic classification of India; Passive concepts appropriate for the various climatic zones in India; Typical design of selected buildings in various climatic zones; Thumb rules for design of buildings and building codes.

Energy efficient landscape design
Modification of microclimatic through landscape element for energy conservation; Energy conservation through site selection, planning, and design; Sitting and orientation

Decentralized Generation Systems
EME7015 **3-0-0=3**

Introduction
Decentralized generation technologies; Costs and choice of technology, Demand and benefits forecasting and program development, Principles of cost-benefit calculations, Economic and

financial analysis of stand-alone electrification projects, Decentralized versus central station generation, Traditional power systems, Load curves and load curve analysis

Different distributed generators
Basic gas turbine generator concepts; Utility system turbine generators; Mini and micro gas turbine generators; Solar thermal power generation, utility scale photovoltaic (USPV) generation; Wind-powered generation; Biomass based generation; DG Evaluation: Cost from past, present, and future, basic DG cost analysis, cost Evaluation and schedule of demand.

Grid interconnection options
The power grid; DG-Grid interconnection issues; Case Study.

Pollution control in power plants and automobiles
EME7016 **3-0-0=3**

Pollution in power plants, particulate gaseous pollutants, thermal pollution ,solid waste pollution strategies to control pollution from coal based thermal plants, pollution control methods (1) pre combustion controls. (2) combustion controls low NOx burners, fluidized bed boilers (3) post combustion controls, particulate controls, cyclone ,wet scrubbers, ESP and fabric filters , gaseous pollutants control flue gas desulphurization FGD systems ,VSR reduction application of electron beam and non thermal plasmas for Sox and NOx treatments . Cooling towers for thermal pollution and solid waste treatment plants, fly ash disposal and utilization, efficiency improvements, PFBC, FGCC, combined cycle systems. Pollution control is automobiles.

Cogeneration & energy efficiency
EME7017 **3-0-0=3**

The cogeneration concept, cogeneration alternatives, Cogeneration potentials, Gas turbine, Steam turbine, Diesel engine, Bottoming cycle technologies, Industry/utility cogeneration, thermodynamic evaluation, environmental evaluation, cost allocation methods, Sizing & operating cogeneration systems,

Demand Side Management of Energy
EME7021 **3-0-0=3**

The concepts and methods of DSM
Load control, Energy efficiency, Load management; DSM planning, design, marketing; Impact assessment.

Customer load control
Direct, Distributed, and Local control, Interruptible load; Configuration of control system for load control; Assessment of Impact on load shape.

Strategic Conservation and Load Management Technologies
Strategic conservation via improving building envelope, Air-conditioning, Lighting; Electric motor, and other industrial processes and equipment; Load shifting and load leveling through Thermal Energy Storage.
Customer Incentives, Program Marketing Design and Penetration

Type of incentives and programs, Program design; Use of Analytic Hierarchical Process for assessment of Customer Acceptance and Program penetratio

Assessment of Impact on System Load Shape
Energy Audit and assessment of customers' load shape for different customer groups; Impact of DSM programs on load shapes in customer groups, Categorized in economic sub sectors, and by geographical location.

Cost/Benefit Analysis and Feasibility of DSM Program
DSM program costing and Load Shape Impact on system; DSM program cost/benefit and Feasibility; Environmental benefits.

Integrated Electric Utility Service under Deregulated Situation
Institutional, Legal, and Political environments and the stages of development of Electric Utility Service; The mechanism of competition and development of the financial environment for economic utilization of resources for electric service.

Instrumentation and control in energy systems
EME7022 **3-0-0=3**

Basic measurements concepts, measurement errors, Transducer classification, static and dynamic characteristics of transducers, instruments for measuring temperature, pressure, velocity and flow, heat flux, liquid level and concentration in energy systems, characterization of combustors, flue gas analyzer, exhaust gas analyzer, solar energy measurement requirements and instruments, meteorological data measurements, energy auditing instruments, energy audit kit, humidity measurements, characterization of electrical power systems, instruments for monitoring electrical parameters, analysis of power system measurements. Analog and signal conditioning, A/D and D/A converters, digital data processing and display, computer data processing and control, feedback control system, stability and transient analysis of control systems, application of PID controllers, general purpose control devices and controller design, air pollution sampling and measurement of particulates, SO_x, NO_x, CO, O_3, hydrocarbons.

Energy storage
EME7023 **3-0-0=3**

Need for energy storage; Different modes of energy storage

Potential energy; Pumped hydro storage; KE and Compressed gas system; Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage; Capacitors, electromagnets and battery storage systems; Chemical Energy storage; Thermao-chemical, photochemical, bio-chemical, electrochemical, fossil fuels and synthetic fuels and hydrogen storage

SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage

Phase Change Materials (PCMs); Selection criteria of PCMs; Stefen problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process

Food preservation; Waste heat recovery; Solar energy storage; Green house heating; Power plant applications; Drying and heating for process industries

Fuel cell and hydrogen energy
EME7024 **3-0-0=3**

Hydrogen energy
Hydrogen: Its merit as fuel; production: from fossil fuels, electrolysis, thermal decomposition, photochemical, photo catalytic, hybrid; storage: metal hydrides, metallic alloy hydrides, carbon nano tubes, sea as source of deuterium.

Fuel cell principle of working, basic thermodynamics and electrochemical principles, classification, electrolytes, fuel types, fuel-cell electrodes and carbon nano tubes; application of power and transportation.

Solar Refrigeration and Air-conditioning
EME7025 **(3-0-0)**

Potential and scope of solar cooling. Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and airconditioning. Solar operation of vapour absorption and compression refrigeration cycles and their assessment. Solar dessicant cooling system. Open cycle absorption/desorption solar cooling alternatives. Advanced solar cooling systems. Refrigerant storage for solar absorption cooling systems. Solar thermoelectric refrigeration and airconditioning. Economics of solar cooling

Basic Electrical Engineering
EML6021 **(1-0-0)**

Power circuits and electrical machinery, AC circuit analysis, Three phase circuits, Power circuits components and energy conservation devices, Variable speed drives, Demand controls.

Communication skills and project presentation
EML6022 **(1-0-0)**

what is communication, components of communication, concepts and problems of communication, basic technical communication skills.

E-mail and formal letter writing, applications, cover letters and CVs, notes making, Notice, Minutes and Agenda, Claims, adjustments and enquiries.

phrasal verbs, common errors, antonyms and synonyms, one word substitution, words often confused, writing grammar and punctuation.

Professional speaking: the interview process, characteristics of job interview, pre-interview job preparation techniques, answering strategies, body language,

Nature and significance of report writing, structure of technical report and writing strategies, methodology of group discussion, project presentation and techniques of individual contributions.