

ENERGY CENTRE, MANIT, Bhopal
M.Tech. in Renewable Energy (RE)

First Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
RE511	Advanced Mathematics	3	-	-	3
RE512	Renewable Energy Systems	3	-	-	3
RE513	Energy Conservation & Audit	3	-	-	3
	Elective - 1	3	-	-	3
	Elective - 2	3	-	-	3
	Open elective-1	3	-	-	3
RE514	Energy Instrumentation Laboratory	-	-	2	2
RE515	Seminar -I	-	2	-	2
Total Credits 22					

Second Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
RE521	Wind Energy Systems	3	-	-	3
RE522	Solar Energy	3	-	-	3
RE523	Biomass Conversion Technologies	3	-	-	3
	Elective - 3	3	-	-	3
	Elective - 4	3	-	-	3
	Open elective-2	3	-	-	3
RE524	Performance Analysis Laboratory	-	-	2	2
RE525	Seminar -II	-	2	-	2
Total Credits					22

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Third Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
RE 611	Major Project Dissertation Phase -I	-	3	20	23
Total Credits					
23					

Fourth Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
RE 621	Major Project Dissertation Phase -II	-	3	20	23
Total Credits					
23					

ENERGY CENTRE, MANIT, Bhopal

M.Tech. (RE) DEPARTMENTAL ELECTIVES

ELECTIVE-1-2 & ELECTIVE-3-4		
S.No.	CODE	SUBJECT
1	RE 531	Power Controllers for Energy Systems
2	RE 532	Power Plant Engineering
3	RE 533	Environment and Ecology
4	RE 534	Energy Instrumentation
5	RE 535	Energy Policy And Planning
6	RE 536	Micro Hydro Technology
7	RE 537	Fuel and Combustion
8	RE 538	Operation and Control of Energy Systems
9	RE 539	Energy Efficiency in Electrical Utilities
10	RE 540	Energy Efficiency in Thermal Utilities

ENERGY CENTRE, MANIT, Bhopal

M.Tech. (RE) OPEN ELECTIVES

OPEN-1 & OPEN-2		
S.No.	CODE	SUBJECT
1	RE 551	Energy Storage Technology
2	RE 552	Nuclear Energy Systems
3	RE553	Ocean Energy
4	RE 554	Integrated Energy Systems

M.TECH. RENEWABLE ENERGY
DETAILED SYLLABUS

RE 511 ADVANCE MATHEMATICS

Mathematical modeling: introduction, development of models, model evaluation, modeling approaches: Analytical, deterministic, Stochastic and numerical. High speed computing and error analysis. Interpolation. Numerical differentiation and integration.

Statistical techniques: Sampling design and theory .sampling distributions, common probability functions, confidence intervals, tolerance limits. hypothesis testing,

Curve fitting: correlation and regression analysis, regression analysis of non-linear models.

Fundamentals of simulation.

Reference books:

1. Numerical Methods for Scientific & Engg. Computation Jain, Iyenge and Jain
2. Numerical Methods for Mathematics, Science and Engineering John H Mathews
3. Applied Numerical Analysis CF Gerld and PO Wheatley
4. Fundamentals of Applied Statistics S.C. Gupta and V. K. Kapoor,
5. Numerical methods for Engineers Chapra, S.C. and Canale, R.P. Tata McGraw Hill, New Delhi.
6. Advanced Engineering Mathematics. Kreyszig, E. John Wiley & Sons, India
7. Introductory Probability and Statistical Applications. Meyer, P.L. (1970). Oxford &

IBH Publishing Co. Ltd, New Delhi.

RE 512 RENEWABLE ENERGY SYSTEMS

Solar energy: radiation measuring instrument, Basics of Flat plate collectors, Concentrators Solar Principle of photovoltaic conversion of solar energy. Wind energy: characteristics and measurement, Wind energy conversion principles,

Types and classification of WECS. Biomass Energy: Classification of biomass. Physicochemical characteristics of biomass as fuel. Biomass conversion routes. Small Hydropower: Overview of micro, mini and small hydro system, ~~types of hydro turbine~~; Ocean Energy, Principle of ocean thermal energy conversion system, Principles of Wave and Tidal energy conversion. Geothermal energy: Origin of geothermal resources, type of geothermal energy deposits. Hydrogen as a source of energy. Types of fuel cell, fuel cell system.

Reference books:

1. Renewable Energy by Godfrey Boyle
2. Renewable Energy Resources by John Twidell and Tony Weir.
3. Nonconventional energy sources G.d RAI
4. Nonconventional energy resources MH khan

RE513 ENERGY CONSERVATION & AUDIT

Energy Audit, types of energy audit; Energy Audit approach: optimizing the input energy requirement; Energy audit instruments. Energy Management: Concept of energy management, energy demand and supply, economic analysis; Duties and responsibilities of energy managers, Energy conservation Act. Energy Conservation: Basic concept, energy conservation in Household, Transportation, Agricultural, service and Industrial sectors, Lighting, Heating Ventilation & Air Conditioning. Energy Action Planning, Monitoring and Targeting. Tariffs and Power factor improvement in power system, Demand Side management concept, Energy Efficient Practices and Technologies.

Reference Books:

1. Hand book of Energy Audits by Albert Thuman, P.E.,C.E.M.
2. Energy Management and Conservation Handbook by Kreith & Goswami.

RE514 ENERGY INSTRUMENTATION LABORATORY

Experiments

1. Demonstration of various energy auditing instruments.
2. Measurement of efficiency of Hybrid Fuel cell.
3. Measurement of illumination using lux meter and its comparison with IS.
4. Calculate cooling load using temp. and humidity measurement

5. Measurement of energy consumption using energy meter.
6. Measurement of Noise level of environment.
7. Demonstration of weather quality parameters like temperature, humidity, intensity, wind speed, etc
8. Emmissivity measurement.
9. Measurement of heat transfer in natural and forced-convection.
10. Flash & Fire Point and Cloud & Pour Point of all type of fuels.

RE 521 WIND ENERGY SYSTEMS

Introduction: Historical developments, latest developments, state of art of wind energy technology, Characteristics of wind: Nature of atmospheric winds; wind resource characteristics and assessment, anemometry, wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography Aerodynamics of blade and rotor, Wind turbine design, Control Mechanisms: Wind turbine dynamics, Wind farm: design, Planning.

Books:

1. Wind Energy Comes of Age by Paul Gipe, John Wiley & Sons Inc.
2. Wind power project & development by Joshua Earnest

RE 522 SOLAR ENERGY

Solar Radiation: Extra-terrestrial and terrestrial, radiation measuring instrument, radiation measurement and predictions. Solar thermal conversion: Basics, Flat plate collectors-liquid and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills Solar ponds, solar cooling and refrigeration, Solar thermal power generation and sterling engine. Solar photovoltaic: Principle of photovoltaic conversion of solar energy. Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options.

Reference books:

1. Solar Engineering and Thermal Processes, J. A. Duffie and W.A. Beckman, 2nd Edition John Wiley and sons.
2. Solar Energy, G. N. Tiwari, Narosa Publishing House

RE 523 BIOMASS CONVERSION TECHNOLOGIES

Biomass resource assessment, properties of biomass, different energy conversion methods combustion, gasification, pyrolysis, liquification, biomass pre-treatment and processing, Biomethanation technology, case studies, bio diesel, improved wood stove, bio-hydrogen generation, electricity generation from biomass gasifier, engine systems, petrol, diesel and duel fuel engine.

Reference books:

1. Recent Advances in Thermochemical Conversion of Biomass, 1st Edition by pandey & Bhaskar & Stöcker & Sukumaran

RE524 PERFORMANCE ANALYSIS LABORATORY

1. Performance evaluation of different designs of wind mill.
2. Wind speed measurement at various sites and heights using portable anemometer and Plotting Wind Rose diagram using WR plot. .
- 3 Measurement of Global, beam and diffuse radiation using pyranometer and pyroheliometer
4. Measurement of sunshine hours using sunshine recorder.(solarimeter)
5. Performance evaluation of various designs of solar still.
6. Performance evaluation of solar greenhouse dryer.
7. Performance evaluation of ~~36-W~~ solar PV module.
8. I-V characteristics of various solar photovoltaic modules.
9. Operation and Efficiency of a Gasifier-Engine
10. Experiment to evaluate the Life time of the solar cell.

11. Comparison of Thermal performance of box type solar cooker/parabolic.
- 12 Performance of Four Stroke Single Cylinder Diesel Engine with biodiesel blends

DEPARTMENTAL ELECTIVES

RE 531 POWER CONTROLLERS FOR ENERGY SYSTEMS

Introduction to power electronic devices: SCRs, Triacs, GTOs, Power-MOSFETS, IGBT and other devices. Typical gate and triggering circuits, Opto-couplers. Converters: A.C. to D.C. convertors- single phase & three phase. Commutation circuits, Choppers- types and application Inverters: single phase and three phase bridge inverters. Voltage control, frequency control, PWM inverter. Application of power controller in grid connected and stand alone renewable energy systems

Books:

1. Power Electronics by PS Bhimbra
2. Power Electronics by MD Singh

RE 532 POWER PLANT ENGINEERING

Layout of Steam , Hydel , Diesel , MHD, Nuclear and Gas turbine Power Plants Combined Power cycles – comparison and selection , Load duration Curves .Steam boilers and cycles Fluidised Bed Boilers. Fuel and ash handling, Combustion Equipment for burning coal, Mechanical Stokers. Pulveriser, Electrostatic Precipitator, Draught- Different Types, Surface condenser types, cooling Towers. Types of Reactors, Pressurized water reactor ,Boiling water reactor, Waste disposal and safety Hydel Power plant- Essential elements, Selection of turbines, governing of Turbines. Types of diesel plants, components, Selection of Engine type, applications-Gas turbine power plant- Fuels- Gas turbine material – open and closed cycles- reheating – Regeneration and intercooling – combines’ cycle. Geo thermal ,Pumped storage –Solar central receiver system Cost of electric Energy, Fixed and operating costs-Energy rates- Types tariffs- Economics of load sharing, comparison of various power plants.

TEXT

1. Arora S.C and Domkundwar S, "A Course in Power Plant Engineering", Dhanpat Rai, 2001
2. Nag P.K , "Power Plant Engineering". Third edition Tata McGraw- Hill ,2007

BOOKS:**REFERENCES:**

1. EI-Wakil M.M ,Power "Plant Technology," Tata McGraw-Hill 1984
2. K.K.Ramalingam , " Power Plant Engineering ", Scitech Publications, 2002
3. G.R,Nagpal , "Power Plant Engineering", Khanna Publishers 1998
4. G.D.Rai, "Introduction to Power Plant technology" Khanna Publishers, 1995

RE 533 ENVIRONMENT AND ECOLOGY

Origin of the earth. Earth's temperature and atmosphere. Sun as a source of energy, nature of its radiation. Biological processes, photosynthesis. Food chains Marine ecosystem. Ecosystem theories. Autecology, sources of energy, classification, quality and concentration of an energy source, characteristics temperature.Environmental degradation, primary and secondary pollutants. Thermal and radioactive pollution, air and water pollution. Micro climatic effects of pollution. Pollution abatement methods. Global initiatives Kyoto Protocol, Clean development mechanism case studies.

Reference books:

1. Energy and the Environment by Robert A. Ristinen and Jack J.Kraushaav
2. Energy Ecology and the Environment by Richard Wilson and William J.Jones.

RE 534 ENERGY INSTRUMENTATION

Basic measurement 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 analysers, Exhaust gas analysers, Solar energy measurement requirements and instruments, Meteorological data measurements, Energy auditing instruments, Energy audit kit, humidity measurement, characterization of electrical power systems, Instruments for monitoring electrical parameters, Analysis of power system measurements. Analog signal conditioning, A/D and D/A converters, Digital data processing and display

RE 535 ENERGY POLICY AND PLANNING

Energy and Environment Basic Issues, Environmental degradation Global initiatives Kyoto Protocol, Emissions Inventories, Carbon Trading, Clean development mechanism, case studies.

Criteria for Economic Growth; Energy-Economy-Environment Linkages, Policy Assessment and Policy Relevance, Issues for Developing Countries

Energy Management Principles, Organizing location of energy management, top management support, managerial functions, role and responsibilities of energy manager, accountability.

Energy Action Planning, Key elements, Force field analysis, Energy policy purpose, perspective, Contents, Formulation, Ratification. Decision support systems for energy planning and energy policy simulation, Renewable Energy: Issues, Prospects and Policies.

Energy and Environment Policies from Urban and Rural perspectives, Analysis Methodologies, Scenarios and Models, Energy Acts and Treaties Global scenario.

ReferenceBooks

Energy Planning Reports of CMIE, State Governments & Govt. of India

Energy Economic by Parag Diwan

Energy Sources & Policies in India by Rishi Muni Dwivedi

RE-536- MICRO HYDRO TECHNOLOGY

Hydro Power Plant- types, classification, construction, Micro-hydro Power- Introduction, site-Assessment, Plant layout; Diversion weir and channel, de-silting tank, Forebay, penstock, tailrace, speed governor, Turbine; classifications- Impulse turbine (Pelton turbine, Turgo turbine, crossflow turbine), Reaction turbines(Francis turbine, The propeller turbine and Kaplan, reverse pumps or pumps as turbines PATs), Turbine characteristics and selection, Generators, Hydroelectric Plant equipment ,Head and flow measurement, Regulation and incentives from the Government, Economics of using micro-hydro power, Advantages and disadvantages of micro-hydro schemes

Reference Books

1. Harvey A, Hettiarachi P, Iversin AR. Micro Hydro Design Manual. ITDG, UK; 1993 Jan 1.
2. Harvey A, Inversin A. Micro-Hydro Design Manual: A guide to small-scale water power schemes. In Natural Resources Forum 1994 (Vol.18, No. 1, p. 69). London: Butterworths
3. Jiandong T, Jing H, Naibo Z, Huishen D, Xianhuan W. Mini hydropower. John Wiley & Sons; 1997.

RE 537 FUEL AND COMBUSTION

Working of I.C. Engines, Combustion in IC Engines; Engine parameters affecting combustion, Homogeneous Charge Compression Ignition Engine, Ultra Lean Burn Engines, Fuel Injection in SI Engines, Multi valve engines, Variable valve timing. Direct and Indirect injection systems, Combustion chambers, Turbo charging, Formation and control of NOX , HC/CO and Particulate emissions, Alternative fuels; Combustion and Emission Characteristics of SI and CI Engines using alternate fuels.

Reference books:

1. John B Heywood, " Internal Combustion Engine Fundamentals", Tata McGraw-Hill 1988

2. Gupta H.N, “Fundamentals of Internal Combustion Engines” ,Prentice Hall of India, 2006

RE 538 OPERATION AND CONTROL OF ENERGY SYSTEMS

Real Time Monitoring of Power Systems : State Estimation, Topological observability Analysis, Security Analysis of Power Systems, Economic Dispatch & Unit Commitment Control of Power & Frequency : Turbine -Governor Control Loops, Single Area and Multi-Area Systems Control, Effect of high penetration of Wind & Other Renewable/Distributed Generation on P-F Control of Voltage & Reactive Power : Generator Excitation Systems, & Automatic Voltage Regulators, Transformer Tap Changes Controls, Voltage Control in Distribution Networks using New Power Electronic Devices Introduction to Market operations in Electric Power Systems : Restructured Power Systems, Short Term Load Forecasting, Power Trading through Bilateral, Multilateral Contracts and Power Exchanges, Role of Distributed Generators in market Operations.

Reference books:

1. Electric Energy Systems: Analysis and Operation by Antonio Gomez-Exposito, Antonio J. Conejo, Claudio Canizares
2. Power Generation, Operation, and Control, 3rd Edition by Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé

RE 539 ENERGY EFFICIENCY IN ELECTRICAL UTILITIES

Introduction to Electrical system Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Electric motors: Types, Losses in induction motors, Motor efficiency, Factors affecting motor performance, Energy saving opportunities with energy efficient motors. HVAC and Refrigeration System, Fans and blowers, Pumps and Pumping System, Lighting System: Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues, Diesel Generating system: Factors affecting selection, Energy performance assessment of diesel conservation avenues

Reference books:

1. Energy Efficiency, 1st Edition by F Sioshansi

RE 540 ENERGY EFFICIENCY IN THERMAL UTILITIES

Introduction to Fuels, Properties of Fuel oil, Coal and Gas, Storage, handling and preparation of fuels, Principles of Combustion, Combustion of Oil, Coal, and Gas; Boilers: Types, Combustion in boilers, Performances evaluation, Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities. Steam System; Furnaces: Classification, General fuel economy measures in furnaces, Excess air, Heat distribution, Temperature control, Draft control, Waste heat recovery. Insulation and Refractories; Mechanism of fluidized bed combustion boilers; Waste Heat Recovery

Open Electives

RE 551 ENERGY STORAGE TECHNOLOGY

Introduction, Need of Energy storage, Different modes of energy storage, Technology Types– Mechanical energy storage: flywheels, compressed air, and pumped hydro; Electrical and Magnetic Energy storage: Batteries, Capacitors, electromagnets, Chemical energy storage.

Basics of Sensible heat storage, Stratified storage, Rock bed storage, Thermal storage in buildings, Earth storage, Aquifers storage. Basics of Latent heat storage, Phase change materials (PCM), Stefan problem. Brief description of the technologies and the differences between them; State-of-the-art – Past demonstrations, existing hurdles and performance targets for commercialization;

Reference books:

1. Energy Storage Science & Technology by Pendse
2. Energy Storage by Mullick and Garg

RE 552 NUCLEAR ENERGY SYSTEMS

Fission and fusion, Need for plasma, Lawson criterion, Confinement problem, Laser driven fusion, Magnetic confinement, Plasma concept, Single particle motions in complex magnetic field geometries, Equilibrium and stability, Cross field transport, Important heating schemes, Tokamak and magnetic mirror, Reactor concepts, Current status.

RE 553 OCEAN ENERGY

TIDAL ENERGY: Tidal barrage methods; Single basin barrage, Ebb generation mode, Double basin systems, Marine current turbine, Axial turbines, Vertical and horizontal axis cross-flow turbines, Venturi effect, Commercial plans, Potential sites.

WAVE ENERGY: Types of wave energy technology, Oscillating Water Column (OWC), The Pelamis, The Wave Dragon, The Archimedes Wave Swing (AWS), The McCabe Wave Pump, The Power Buoy, The AquaBuOY.

Ocean Thermal Energy Conversion: Types of OTEC technology, Closed-cycle, Open-cycle, Hybrid cycle, Applications, Perspectives.

FORECAST OF ALTERNATIVE ENERGY DEVELOPMENT: Renewable energy technology cost trends, Wave, Ocean current, Renewable energy capacity expansion, Integration of electricity generation into transmission networks.

Reference books:

1. OCEAN ENERGY TECHNOLOGIES for RENEWABLE ENERGY GENERATION by Peter Meisen and Alexandre Loiseau.

RE 554 INTEGRATED ENERGY SYSTEMS

System Aspects of Integration: voltage effects, thermal effects, fault level. Islanding. Stand Alone Systems: Network voltage and system efficiency, Case studies of standalone system. Hybrid Energy Systems and its economic evaluation. Mathematical modeling of Integrated Energy Systems. Technological aspects of power electronic systems connection to the grid. Hybrid and integrated energy systems, Total energy concept and waste heat utilization, Energy modeling to optimize different systems.

Reference books:

1. Renewable Energy Sources for fuels and Electricity by Laurie Barrtom.
2. Wind-Diesel Systems by R. Hunter and G. Elliot, Cambridge University Press.