

ENERGY DEPARTMENT

M.TECH. RENEWABLE ENERGY

**Course of Study & Scheme of Examination
2016-17**



**Maulana Azad National Institute of Technology,
Bhopal**

SCHEME**M.Tech. in Renewable Energy*****First Semester***

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
RE511	Advance Mathematics	3	-	-	3
RE512	Renewable Energy Sources	3	-	-	3
RE513	Energy Audit & Conservation	3	-	-	3
	Elective - 1	3	-	-	3
	Elective - 2	3	-	-	3
	Open elective-1	3	-	-	3
RE514	Measurements laboratory	-	-	2	2
RE515	Seminar –I & Mini Project	-	2	-	2
Total credit 22					

Second Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
RE521	Wind Energy Design and Applications	3	-	-	3
RE522	Solar Energy Utilization	3	-	-	3
RE523	Power Plant Engineering	3	-	-	3
	Elective - 3	3	-	-	3
	Elective - 4	3	-	-	3
	Open elective-2	3	-	-	3
RE524	Performance Analysis Laboratory	-	-	2	2
RE525	Seminar –II & Mini Project	-	2	-	2
Total credit 22					

Electives are common for both the courses.

DEPARTMENTAL ELECTIVES

S.No	CODE	SUBJECT
1.	RE/GT532	Energy Storage Technology
2.	RE/GT 533	Super Critical Technology
3.	RE/GT 534	Geothermal & Ocean Energy
4.	RE/GT 535	Energy policy and planning
5.	RE/GT 536	Power Conversion Techniques
6.	RE/GT 537	Hydrogen Energy and Fuel cell
7.	RE/GT 538	Environment and Ecology
8.	RE/GT 539	Solid Waste Management
9.	RE/GT 540	Cogeneration

OPEN ELECTIVES

S.No	CODE	SUBJECT
1.	RE/GT 551	Energy Modeling and Simulation
2.	RE/GT 552	Integrated Energy Systems
3.	RE/GT 553	Energy Efficient Materials
4.	RE/GT 554	Pollution Control Technology
5.	RE/GT 555	Fuel Efficient IC Engines

SYLLABUS

Semester- I

RE511 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 Gerald 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.

RE512 RENEWABLE ENERGY SOURCES

Solar energy: radiation measuring instrument, Basics of Flat plate collectors, Concentrators
Solar Principle of photovoltaic conversion of solar energy. Application 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.

RE513 ENERGY AUDIT & CONSERVATION

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.

Experiments

RE514 Measurements Laboratory

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.

RE521 WIND ENERGY DESIGN AND APPLICATIONS

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

RE522 SOLAR ENERGY UTILIZATION

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 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 BOOKS:

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

REFERENCES:

1. El-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

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

RE532 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, Earthstorage, 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

RE533 SUPER CRITICAL TECHNOLOGY

Introduction to super critical technology, history, advantages, environmental impact
Interpretation of phase diagrams in supercritical fluids, equipment and safety issues,
fundamentals about solubility of small molecules, and fundamentals and applications of
extraction, chromatography, polymer processing, particle formation processes, reactions and
biocatalysis. supercritical steam generator. Supercritical technology in thermal power plants.

Reference books:

- 1 Introduction to Supercritical Fluids by Richard Smith, Hiroshi Inomata & Cor Peters
2. Supercritical Fluids and Organometallic Compounds by Can Erk

RE534 GEO THERMAL AND OCEAN ENERGY

Introduction of Geothermal Energy, Geothermal resources; definition and classification, Hydrothermal system, Hot dry rock systems, Geopressured reservoirs, Magma energy, Dry rock and hot aquifer analysis Utilization of geothermal resources, Direct utilization; Swimming bathing & balneology, space conditioning, district heating, Geothermal heat pump; basic concept of heat pump, air conditioner, heating and cooling mode in heat pump, Heat pump with geothermal resources; typical GHP loop configuration Ocean Thermal: Introduction, OTEC history and technology progress, working principle, resources & site requirement

Reference books:

1. Renewable Energy Resources: basic principle & application by Tiwari and Ghosal.
2. Renewable Energy Sources by Boyle

RE535 ENERGY POLICY & PLANNING

Energy and Environment Basic Issues: Criteria for Economic Growth; Energy-Economy-Environment Linkages; Emissions Inventories: Assessment and Policy Relevance. Issues for Developing Countries: Energy and Environment Policies from Urban and Rural perspectives. Analysis Methodologies: Scenarios and Models, Global and Local Environmental Issues: Climate Change Negotiations Technological Options: Energy-Efficiency and New Energy Technologies; Renewable Energy: Issues, Prospects and Policies.

Reference books :

1. Energy Economic by Parag Diwan
2. Energy Sources & Policies in India by Rishi Muni Dwivedi

RE536 POWER CONVERSION TECHNIQUES

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

RE537 HYDROGEN ENERGY & FUEL CELL

Hydrogen Energy – introduction and application, General introduction to infrastructure requirement for hydrogen production, storage, dispensing & utilization. Electrochemical: Electrolysis, Photo electro chemical. Biological: Photo Biological, Anaerobic Digestion Fermentative Micro- organisms. Physics and chemical properties: General storage methods, compressed storage, Glass micro sphere storage, Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. Overview of hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, Principles of fuel cells, types of fuel cells, fuels for fuel cells, low, medium and high temperature fuel cells, power generation by fuel cells, applications of fuel cells, future potential of fuel cells.

Reference books:

1. Hydrogen and Fuel Cells by Sorensen, B.
2. The Hydrogen Economy Opportunities and Challenges by Michael Ball and Martin Wietschel.

RE538 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 539 SOLID WASTE MANAGEMENT

Introducing Municipal Solid Waste Management; Overview process of collection, transport, processing, recycling or disposal, managing and monitoring of waste materials. Waste Generation and characterization, Aspects ; Waste Collection, Storage and Transport Waste Disposal ; Waste Processing Techniques ; Source Reduction, Product Recovery and Recycling Recovery of Biological Conversion Products: Compost and Biogas, Incineration pyrolysis and Energy Recovery ; Hazardous Waste: Management and Treatment; landfill designs **Reference Books:**

1. Diaz, L.F., G.M. Savage, L.L. Eggerth, and C.G. Golueke, *Composting and Recycling Municipal Solid Waste*, Lewis Publishers, Ann Arbor, Michigan, USA, 1993.
2. George Tchobanoglous; *Integrated Solid Waste management* ,McGraw-Hill Publishers,1993

RE 540 COGENERATION

The concept of cogeneration, main design parameters for cogeneration, cogeneration alternatives, Bottoming and topping cycles, Steam turbine plants, Gas turbine plant, Diesel and gas engine plants, Thermodynamic evaluation, Combined cycle applications, Sterling engine, Industry / utility cogeneration, Trigenation, Techno economic and Environ-mental aspects, Cogeneration in sugar, textile, paper and steel industry.

Reference Books:

1. Energy Cogeneration Hand Book for Central Plant Design by George Polimeros.
2. Power Plant Technology by M.M.El- Wakil.

OPEN ELECTIVES

RE551 ENERGY MODELING AND SIMULATION

Energy Models. Surveys, Steady-State Computer Models, Dynamic Models: advantages and disadvantages, Interdependence of energy-economy-environment; Modeling concept, and application. Network analysis: PERT, CPM, Gantt Chart. Quantitative methods. Basic concept of econometrics and statistical analysis, Two variable regression model, The multiple regression model, Tests of regression coefficients and regression equation, Forecasting Techniques : Moving Average, Method of Least squares, Parabolic trend. Analysis of Variance: ANOVA (one way & two way). usage of MATLAB .Econometric techniques used for energy analysis with case studies. Input-output analysis, Energy multiplier and implication of energy multiplier for analysis of regional and national energy policy.

Reference Books:

1. Energy Planning and Economics by A.V. Desai.
2. Energy Policy Analysis and Modeling by Munasinghe M. and P. Meier.

RE552 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.

RE 553 ENERGY EFFICIENT MATERIALS

Need of Alternative materials, Green Materials, Biomaterials, Natural and synthetic Polymers ., Photovoltaic (PV) thin films for solar cells; Organic Solar Cells; dye sensitized solar cells; Thermo photovoltaic (TPV) devices Fuel cells, The role of the fuel in the operation, performance and degradation of fuel cells; Membrane electrode assemblies for polymer electrolyte membrane fuel cells; Developments in membranes, catalysts and novel cathode and anode materials; Membranes, adsorbent materials and solvent-based materials for syngas and hydrogen production fuel cells , Batteries, Ultra capacitor; Super capacitors. Thermoelectrics, Novel illumination sources for efficient lighting, Energy saving in buildings. Materials and techniques for energy harvesting; Lithium batteries: Current technologies and future trends. Thermoelectric materials for conversion of heat to electricity. Materials issues for future nuclear energy; Radiation damage, recovery mechanisms, and creep-rupture, modeling and theoretical aspects

Reference

1. Materials for Renewable and Sustainable Energy(Springer)

RE 554 POLLUTION CONTROL TECHNOLOGIES

Classification of Pollution and Pollutants, Causes, Effects and Sources of Pollution air pollution: primary and secondary pollutants, automobile pollution, industrial pollution, ambient air quality standards, meteorological aspects of air pollution---temperature lapse rates and water pollution: point and non-point source of pollution, major pollutants of water, water quality requirement for different uses, global water crisis issues. marine and nuclear pollution: misuse of international water for dumping of hazardous waste, coastal pollution due to land/soil pollution: Effects of urbanization on land degradation, Impact of Modern Agriculture on Soil, Effect on Environment and Life sustenance, Abatement measures.

Reference Books:

1. Text book of Environmental Science and Technology by Dr. M. Anji Reddy.
2. Environmental Science- Towards a sustainable future by Richard T. Wright.

RE555 FUEL EFFICIENT IC ENGINES

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