

ENERGY CENTRE, MANIT, Bhopal
M.Tech. in Green Technology (GT)

First Semester

Course Number	Subject	Scheme of Studies Periods per week			Credits
		L	T	P	
GT511	Advanced Mathematics	3	-	-	3
GT512	Sustainable Energy Systems	3	-	-	3
GT513	Energy from Waste	3	-	-	3
	Elective –1	3	-	-	3
	Elective - 2	3	-	-	3
	Open elective-1	3	-	-	3
GT514	Sustainable Energy Laboratory	-	-	2	2
GT515	Seminar-I	-	2	-	2
Total credit 22					

Second Semester

Course Number	Subject	Scheme of Studies Periods per week			Total Credits
		L	T	P	
GT521	Environment Policy & Planning	3	-	-	3
GT522	Green Buildings	3	-	-	3
GT523	Climate Change & Carbon Sequestration	3	-	-	3
	Elective - 3	3	-	-	3
	Elective - 4	3	-	-	3
	Open elective-2	3	-	-	3
GT524	Environment & Bio-Energy Laboratory	-	-	2	2
GT525	Seminar-II	-	2	-	2
Total credit 22					

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Third Semester

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

ENERGY CENTRE, MANIT, Bhopal

M.Tech. (GT) DEPARTMENTAL ELECTIVES

ELECTIVE-1-2 & ELECTIVE-3-4		
S.No.	CODE	SUBJECT
1	GT 531	Solid Waste Management
2	GT 532	Geothermal Energy
3	GT 533	Pollution Control Technology
4	GT 534	Hydrogen Energy and Fuel cell
5	GT 535	Super-Critical Technology & Cogeneration
6	GT 536	Green Computing Techniques
7	GT 537	Solar Refrigeration and Air Conditioning
8	GT 538	Large Wind TurbineTechnology
9	GT 539	Concentrated Solar Power Generation
10	GT 540	Energy Economics & Trading

ENERGY CENTRE, MANIT, Bhopal

M.Tech. (GT) OPEN ELECTIVES

OPEN-1 & OPEN-2		
S.No.	CODE	SUBJECT
1	GT 551	Grid Connection of Renewable Power
2	GT 552	Alternative Automotive Fuels
3	GT 553	Energy Modelling and Simulation
4	GT 554	Energy Efficient Materials

M.Tech. GREEN TECHNOLOGY
DETAILED SYLLABUS

GT 511 ADVANCE MATHEMATICS

Mathematical modelling: introduction, development of models, model evaluation, modelling 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.

GT 512 SUSTAINABLE ENERGY SYSTEMS

Solar energy, 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, Overview of micro mini and small hydro, Site selection and civil works, Penstocks and turbines, Speed and voltage regulation, 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. Nonconventional energy sources G. D RAI
2. Nonconventional energy resources B. H khan

GT 553 ENERGY FROM WASTE

Waste as a Renewable Energy Source, Waste-to-Energy Conversion: Thermochemical Conversion, Biochemical Conversion, Physico-chemical Conversion, Factors affecting Energy Recovery from waste, Agricultural Residues, Animal Waste, Industrial Wastes, Forestry Residues, Municipal Solid Waste (MSW), Converting Waste Heat to Electricity, Bio energy as by product of waste processing, Environmental significance, Introduction to anaerobic digestion, Process fundamentals and design considerations, Process analysis and reactor configurations, Methane production, Energy assessment, Bio-methanation from sludge digestion, Types of reactors

Reference books:

1. Handbook of Solid Waste Management and Waste Minimization Technologies by Nicholas P. Cheremisinoff.
2. Solid Waste Engineering by P. Aarne Vesilind, William A. Worrell and Debra R. Reinhart.

GT 514 SUSTAINABLE ENERGY LABORATORY

1. Solar resource assessment using simulation software
2. Wind resource assessment using simulation software
3. Simulation of Green Building
4. Study of various phase change materials for energy storage, charging and discharging characteristics of batteries, ultra-capacitors and super capacitors
5. Characterization of Biomass briquettes and pellets
6. Ambient Air quality monitoring and dust concentration
7. Performance evaluation of Evacuated Solar collector.
8. Biodiesel production from various non edible seeds and its characteristics.
9. Performance evaluation of Solar Power plant.

GT 521 ENVIRONMENT POLICY AND PLANNING

Environmental primary and secondary pollutants, Thermal and radioactive pollution, air and water pollution, Pollution abatement methods, Global and Local Environmental Issues

Climate Change, Environmental laws - Water -prevention & control of pollution act 1974, Effluent standards and ambient air quality standards, Wild life protection act, Forest Conservation Acts.

Environment Basic Issues: Environmental degradation Global initiatives, Climate Change issues, Kyoto Protocol, Emissions Inventories, Clean development mechanism case studies.

Energy-Economy-Environment Linkages, Policy Assessment and Policy Relevance, Planning Issues for Developing Countries: Energy and Environment Policies & Planning from Urban and Rural perspectives. Analysis Methodologies: Scenarios and Models.

Indian environmental degradation, the environmental protection act 1986 - Environmental Acts and Treaties- Global scenario.

Reference Books:

Environmental Impact analysis Handbook by J. Rau and D.C. Wooten

Energy and the Environment by Robert A. Ristinen and Jack J.Kraushaav

GT 522 GREEN BUILDINGS

Need of energy in buildings. Role of building design and building services to evaluate the energy performance in buildings. Study of Climate and its influence in building design for energy requirement, Principles of energy conscious design of buildings, Building Envelope, Orientation, Building Configuration, Passive Cooling, Basic Principles of Day-lighting, Embodied Energy of Building Materials, design guidelines, Commercial Buildings, Industrial buildings, Residential buildings, integration of emerging technologies. Study of Thermal environment and visual environment. Energy rating of buildings and case studies.

Reference Books:

1. Energy Efficient building in India by Mili Majumdar
2. Handbook on Energy Conscious Buildings by J.K. Nayak & J.A. Prajapati

GT 523 CLIMATE CHANGE AND CARBON SEQUESTRATION

Greenhouse emissions .Climate Change: Causes and effects .Diagnostics and baseline determination, Climate change Mitigation and adaptation strategy. Risk assessments & mitigation. Carbon accounting, Carbon Market .Carbon capture and storage .Potential Carbon sequestration (forest sinks), Oceanic, Terrestrial, Biological, geological. Clean Coal Technology, IGCC, Coal blending and gasification. Precombustion and Post Combustion Capture .Energy efficiency opportunities, Kyoto Protocol and Clean development Mechanism ,CDM project activities in Industries; Emission benchmarks; Governments policies for mitigation and adaptation. Technology Perspective: Strategies for technology innovation and transformation. National Action Plan on Climate Change .Carbon credits. Case studies.

Reference Books:

1. Carbon Capture and storage: R&D Technology for Sustainable Energy future By Malti Goel.
2. IPCC (Intergovernmental for Climate Change). Climate Change: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

GT 524 ENVIRONMENT & BIO-ENERGY LABORATORY

1. Study of various water quality parameters of available water resources.
2. Combustion efficiency evaluation of Improved Biomass cooks stoves.
3. Experiment on Artificial photosynthesis.
4. Experiments on various natural dyes/pigments and their characterization.
5. Experiment on Biomass dryer.
6. Determination of Calorific value of Biomass sample using Automatic calorimeter.
7. Determination of Moisture content of Biomass sample using Hot air oven.
8. Determination of Ash content of Biomass sample using muffle furnace.
9. Experiment on Microbial and plant fuel cell.

DEPARTMENTAL ELECTIVES

GT 531 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.

GT 532 GEOTHERMAL 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;

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 India and world scenario.

Reference books:

1. Renewable Energy Resources: basic principle & application by Tiwari and Ghosal.
2. Renewable Energy Sources by Boyle
3. Nonconventional energy sources G.D RAI
4. Nonconventional energy resources BH Khan

GT 533 POLLUTION CONTROL TECHNOLOGY

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.

GT 534 HYDROGEN ENERGY AND 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.

GT 535 SUPER-CRITICAL TECHNOLOGY & COGENERATION

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 biocatalysts. Supercritical steam generator. Supercritical technology in thermal power plants.

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, Trigeration, Techno economic and Environ-mental aspects

Reference Books:

1. Introduction to Supercritical Fluids by Richard Smith, Hiroshi Inomata & Cor Peters
2. Supercritical Fluids and Organometallic Compounds by Can Erk
3. Energy Cogeneration Hand Book for Central Plant Design by George Polimeros.
4. Power Plant Technology by M.M.EI- Wakil.

GT 536 GREEN COMPUTING TECHNIQUES

Goals ,scope ,computers, servers, and associated subsystems(monitors, printers, storage devices, and networking and communications systems),design and manufacturing, product life time and improvement, methods of energy efficiency improvement , green chemistry vs green computing, recyclability or biodegradability of products .

GT 537 SOLAR REFRIGERATION AND AIR CONDITIONING

Potential and scope of solar cooling, Types of solar cooling systems, Solar collectors and storage systems for solar refrigeration and air-conditioning, Solar operation of vapour absorption and vapour compression refrigeration cycles and their thermodynamic assessment, Rankine cycle, sterling cycle based solar cooling systems, Jet ejector solar cooling systems, Fuel assisted solar cooling systems, Solar desiccant cooling systems, Open cycle absorption / desorption solar cooling alternatives, Advanced solar cooling systems, Thermal modeling and computer simulation for continuous and intermittent solar refrigeration and air-conditioning systems, Refrigerant storage for solar absorption cooling systems, Solar thermoelectric refrigeration and air-conditioning, Solar thermo acoustic cooling and hybrid air-conditioning, Solar economics of cooling systems.

Reference Books:

1. Solar Refrigeration and Air-Conditioning - Springer by HP Garg.

GT 538 LARGE WIND TURBINE TECHNOLOGY

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 farm & project cycle, Cost economics & viability of wind farm

Reference Books:

1. Wind energy Conversion Systems – Freris L.L. (Prentice Hall 1990)
2. Wind Turbine Technology: Fundamental concepts of wind turbine technology Spera D.A. (ASME Press, NY, 1994)
3. Wind Energy Systems – G.L. Johnson (Prentice Hall, 1985)
4. Wind Energy Explained – J.F. Manwell, J.G. McGowan and A.L. Rogers (John Wiley & Sons Ltd.)

GT 539 CONCENTRATED SOLAR POWER GENERATION

Overview: Solar Energy Conversion and Utility Solar Power: Solar Energy Conversion Overview, Efficiency of Conversion, Utility Scale Power, Environmental Impact of Utility Scale Solar Power, Units and Terminology. Concentration Fundamentals: Available Solar Radiation and How it is Measured, Types and Elements of Concentrating Collectors, Concentration Ratio, Concentration with a Parabolic Reflector, CPC Collectors. Tracking Systems: Why tracking? Apparent daily path of the sun, Types of tracking systems, engineering devices for solar tracking. Concentrating Photovoltaics: What are concentrating photovoltaics? Light concentration effect on PV performance and efficiency, advanced materials for CPV, CPV market overview, ongoing activities and projects in CPV. Concentrating Solar Power Technologies: Introducing Concentrating Solar Power, Parabolic trough CSP technology, Central tower CSP technology, parabolic dish CSP technology. Concentrating Solar Power Strategies: CSP site selection and feasibility analysis, Socio-economic aspects of CSP technology, Environmental assessment of CSP technology, Optimization of CSP systems. Power Conversion: Thermal power conversion, Rankine conversion cycle, Stirling conversion cycle, other conversion cycles. Energy Storage: Principles of energy storage, Heat transfer fluids, molten salt storage, Hydrogen as energy storage.

Reference books:

Concentrating Solar Power Technology: Principles, Developments and Applications: by K Lovegrove, W Stein

GT 540 ENERGY ECONOMICS AND TRADING

Introduction to Energy Economics: Energy Basics, Energy Accounting Framework, Accounting of Traditional Energies, Special Treatments of Some Entries in the Energy Balance, analysis of Energy Balance Information, Alternative Presentation of Energy Accounting Information, Evolution of Demand Analysis, Economic Foundations of Energy Demand, Factor Analysis, Analysis Using Physical Indicators, Energy Demand Analysis Using the Econometric Approach, Disaggregation of Demand, Sectoral Energy Accounting, Analysis at the Sectoral Level.

Introduction to Energy Demand Forecasting, Econometric Approach to Energy, Demand Forecasting, End-Use Method of Forecasting, Common Energy Demand Analysis Models.

Introduction to Energy Demand Management, Load Management, Energy Efficiency, Improvements and Energy Conservation, Analyzing Cost Effectiveness of DSM Options, Energy Efficiency Debate.

Basics of the Economic Analysis of Projects, Economic Versus Financial Investment Analysis, Indicators of Cost-Benefit Comparison, Uncertainty and Risk in Projects, Economics of Electricity Supply, Investment Decisions in the Power Sector, The Economics of Renewable Energy Supply, The Economics of Bio-fuels.

Energy Markets and Principles of Energy Pricing, Government Intervention and Role of Government in the Sector, Energy Pricing and Taxation, Tradability of Energy Products and Opportunity Cost, Peak and Off-Peak Pricing, Energy Taxes and Subsidies.

Overview of Global Energy Challenges, Impact of High Energy Prices, Investment Issues in the Energy Sector, Regulation of Energy Industries, Reform of the Energy Industry, Introduction to energy trading, trading markets of Natural Gas, Electricity, oil, coal, Emission markets, Financial options and statistics.

Option pricing, spread option, spatial load forecasting, tolling agreements, Wheeling power – trading mechanism, solar power-Investment Perspective, Wind power- Financial modeling, Nuclear power- trading issues, Electricity storage, Natural gas transportation, Natural gas storage and Liquefied natural gas.

Reference books:

1. Subhes C. Bhattacharyya (auth.)-Energy Economics_ Concepts, Issues, Markets and Governance-Springer-Verlag London (2011).
2. Davis Edwards-Energy Trading and Investing_ Trading, Risk Management and Structuring Deals in the Energy Market-McGraw-Hill (2009)

OPEN ELECTIVES

GT 551 GRID CONNECTION OF RENEWABLE POWER

General layout of transmission and distribution system, Insulators, method of improving string efficiency, Mechanical characteristics of transmission lines, Sag templates. Transmission line parameters Overhead lines & Underground Cables: parameters calculations. EHV AC Transmission: Need of EHV transmission, standard transmission voltage, electrical and mechanical considerations of EHV lines, Features of EHV transmission lines. HVDC Transmission: Flexible AC Transmission Systems: Fundamentals of ac power transmission, transmission problems and needs, Mechanism of active and reactive power flow control, basic FACTS controllers with application and principles of operation. Introduction to distribution automation, Layout of substations and feeders, Optimum siting and sizing of substations Distribution system load flow, configuration of distribution system, optimum capacitor placement.

Reference Books:

1. C.L. Wadhwa, 'Generation, Distribution and Utilization of Electrical Energy', New Age International Pvt. Ltd, 2003.
2. B.R. Gupta, 'Generation of Electrical Energy', Eurasia Publishing House (P) Ltd, New Delhi, 2003.
3. Transmission and distribution of electrical energy by Walter LeRoy Weeks.

GT 552 ALTERNATIVE AUTOMOTIVE FUELS

An introduction to hydrocarbon fuels—their availability and effect on environment, Gasoline and diesel self-ignition characteristics of the fuel, Octane number, Cetane number, Alternative fuels - liquid and gaseous fuels, Physico-chemical characteristics, Alternative liquid fuels, Alcohol fuels - ethanol & methanol, Fuel composition, Fuel induction techniques, Fumigation, Emission of oxygenates, Applications to engines and automotive conversions, Biodiesel formulation techniques, Trans esterification, Application in diesel engines, DME (Dimethyl ether), properties fuel injection consideration general introduction to LPG and LNG, Compressed natural gas components, mixtures and kits, fuel supply system and emission studies and control, Hydrogen combustion characteristics, Flashback control techniques, Safety aspects and system development, NO_x emission control, Biogas, Producer gas and their characteristics system development for engine application.

GT 553 ENERGY MODELLING 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.

GT 554 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. Thermoelectric, 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
