M.Tech. -Energy Technology Syllabus

SCHOOL OF ENERGY & ENVIRONMENT MANAGEMENT

(An Autonomous University Teaching Department)

RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA

(State Technological University of Madhya Pradesh)

Airport Road, Bhopal,462033 www.rgpv.ac.in

CURRICULUM OUTLLINE

M.Tech. [Energy Technology]

Core Subject

SEMESTER-I

- MEEM-101 Applied Mathematics
- MEEM-102 Power Generation Transmission & Distribution
- MEEM-103 Solar Power Generation
- MEEM-104 Hydro Power & Nuclear Power Generation
- MEEM-105 Environmental Issues, Policy, Standards & Regulations

SEMESTER-II

- MEEM-201 Clean Coal And Green Power Technology
- MEEM-202 Wind Power Generation
- MEEM-203 Fuel Technology And Air Pollution
- MEEM-204 Energy Conservation, Management And Audit
- MEEM-205 Clean Development Mechanism

SEMESTER-III

- MEEM-301 Elective I
- MEEM-302 Elective II
- MEEM-303 Seminar
- MEEM-304 Dissertation Part –I (literature Review/Problem Formulation /Synopsis)

SEMESTER-IV

- MEEM-401 Dissertation Part-II

ATTENDANCE

Candidates appearing as regular students for any semester examination shall be required to attend at least 75% of lecturers delivered and of the practical's held, separately in each paper, provided that a short fall in attendance up to 5% can be condoned by the Vice Chancellor of Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal respectively for satisfactory reasons.

Note: If a candidate has passed a semester examination in full he/she shall not be permitted to reappear in the examination for improvement of division/marks of any other purpose.

CRITERIA FOR PROMOTION TO HIGHER SEMESTER

According to Ordinance No.8 (A) for degree in Master of Engineering/Technology/Master of Architecture (M.E/M.Tech/M.Arch.) for the Candidates admitted in 1st year on/after July, 2010, under **Credit Based Grading System** applicable from July, 2010, the criteria for promotion to higher semester is as follows:

- For the award of degree minimum Cumulative Grade Point Average (CGPA) required is 5.0.
- To pass a particular subject of the course the minimum required grade is D. However, the candidate should also separately score minimum required of grade D in both mid and end semester examinations of theory and practical parts of the subject individually.
- The distribution of weightage/marks for each component are as following:

Theory Block

i) Quizzes, assignments and regularity	10%
ii) Mid-semester tests	20%
iii) End-semester Examination	70%
Total	**100%**

Practical Block

i) Lab work and performance, quizzes, assignments and regularity	40%
ii) End-semester examination	60%
Total	**100%**

- Project work shall be treated as practical subject.

The grades to be used and their numerical equivalents are as under:

Credit Based Grading System

Grade	**% Marks range (based on absolute marks system)**	**Grade Point**	**Description of performance**
A+	91-100	10	Outstanding
A	81-90	9	Excellent
B+	71-80	8	Very Good
B	61-70	7	Good
C+	51-60	6	Average
C	41-50	5	Satisfactory
D	40 only	4	Marginal
F	Below 40	0	Fail
I		0	Incomplete
W		0	Withdrawal

GUIDE LINES FOR DISSERTATION WORK

- For M. Tech. II year (III & IV Semester) students a project work shall be compulsory.
- The project shall be carried out under the supervision of departmental faculty members or in collaboration with industry / national / international academic institutions.
- The project work shall be of 06 months duration of semesters IV.
- The project synopsis and research methodology in III semester of the same project shall be evaluated by the two external examiners of the national / international repute.
- The seminar based on research paper that is one of the base papers of the same project shall also be evaluated by the external examiner of national/ international standing.
- The candidate shall be required to submit the one project report printed in triplicate after publication of one research and one review article in the peer reviewed journals at the end of the fourth semester/ before obtaining the M.Tech. degree.
- There shall be thesis evaluation by external examiner of national / international status.
- After receiving the evaluation report from the concerning examiner, suggestion/s suggested by the concerning examiner (if any) should be incorporated in the thesis.
- Then the candidate shall be eligible for examination and defense / viva-voce of research project at the end of the IV semester.

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Programme Outcomes (POs), Program Specific Outcomes (PSOs) and Course Outcomes (COs) of the Programme offered by the Institution

Programme Code	Programme Name	Institution
MT	M. Tech.- Energy Technology	School of Energy & Environment Management, UTD, RGPV

Programme Outcomes (POs)

PO 01	An ability to independently carry out research /investigation and development work to solve practical problems
PO 02	An ability to write and present a substantial technical report/document.
PO 03	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

Programme Specific Outcomes (PSOs)

PSO 01	To develop workplace skills of global competence that can meet industry requirements, by imparting theoretical knowledge blended with practical training in energy resources and technologies with sustainable development including Solar, Wind, Clean Coal technologies, Biomass, Bio fuels, CCS, Waste to Energy.
PSO 02	To impart a efficient understanding of clean and green energy technologies applicable for improving the quality of life of the rural as well as the urban area and able to contribute towards self-reliant India.
PSO 03	To develop the orientation towards research & development, entrepreneurship by identifying, planning and carrying out a research project independently.

Methods of measuring attainment of PSOs

- Programme Specific Outcomes are ascertained by Periodic Review of the Teaching and Research Activities at the Institute and Presentation of the progress at leading National and International Journals as Research Publications.

- Further Independent Expert Reviews and Teaching Seminars are also conducted for Evaluating the Teachers and Students for keeping the Morale and Scientific Temper and for the whole some development of Education and Research Activities of the Department.

Course Outcomes (COs)

Semester -I

S. No.	Name of the Course	Course Code	Course Outcomes
01.	**Applied Mathematics**	MEEM- 101	**Students should be able to:** • To Make Students familiar with the Applications of Laplace Transformation in Science and Engineering. • To Develop the knowledge of Z-Transform and Fourier Transform. • To Apply the Numerical methods at advance level. • To Develop the knowledge of Probability Distributions and Sampling. • To Introduce the concept of Mathematical Modelling.
02.	**Power Generation Transmission & Distribution**	MEEM- 102	**Students should be able to:** • Know the fact that as we go down the scale of magnitude from Cells to Organelle to Molecules, the understanding of various Biological Processes becomes Deeper and Inclusive. • Understand Membrane Transport and Cell Signaling Mechanisms. • Develop comprehensive understanding of Endo-Membrane System. • Understand Molecular Mechanisms of Prokaryotes and Eukaryotes. • Know the life with Molecular functionalities Instinct of targets for control and Manipulation of Cellular Processes for Research and Development.

03.	**Solar Power Generation**	MEEM- 103	**Students should be able to:** • Perform a solar resource assessment of a potential site. And estimation of shadow formation, tilt angle and orientation of PV panels. • Explain the operation of a PV cell. • Identify the different PV cell technologies used today and compare different PV cell technologies and PV module manufacturing methods. • Explain the operation and performance characteristics of various types of Batteries and select the batteries to meet specific criteria • Explain the operation and performance characteristics of various types of charge controllers and select the charge controllers to meet specific criteria
04.	**Hydro Power & Nuclear Power Generation**	MEEM- 104	**Students should be able to:** • Recognize hydrological facts and differentiate micro, mini and small hydro systems. • Recognize the selection and design criteria of pumps and turbines. • Apply existing technology for speed and voltage regulation and design wind – hydro hybrid standalone system. • Identify investment and marketing issues of hydropower and examine environmental aspects of hydropower plants • Recognize Nuclear facts and differentiate between all types of nuclear power plants as well as their applications. • To understand different types of reactions involved in nuclear plants for power plants

05.	**Environmental Issues, Policy, Standards & Regulations**	MEEM- 105	**Student should be able to:** • Develop understanding of international & national scenario of Climate Change, causes and impacts. • Understand development and its effects on environment and need of sustainable development. • Understand the importance of environmental management, ISO 14000. • Aware about international, national government and other agencies working for the environment protection, addressing the environmental issues and contributing in the development of policies. • Analyze various water quality parameters of drinking water and waste water, able to develop understanding of various sources, impacts of water pollutants. • Be conversant with various environmental acts and laws prevailing in the state and country.

6.	**Lab-I (Energy)**	MEEM-106	**Students should be able to:** • Understand the working principle of solar photovoltaic cell, Wind & biofuels. • Do testing and performance analysis of photovoltaic cell under standard test condition. • Performance analysis of solar water heater at different input parameters. • Performance of solar wind hybrid system in order to do system designing of hybrid system.
07.	**Lab-II (Environment)**	MEEM-107	**Students should be able to:** • Perform common environmental experiments relating to water and wastewater quality, and know which tests are appropriate for given environmental problems. • Statistically analyze and interpret laboratorial results. • Apply the laboratorial results to problem identification, quantification, and basic environmental design and technical solutions. • Understand and use the water and wastewater sampling procedures and sample preservations. • Obtain the necessary background for subsequent courses in environmental engineering.

Course Outcomes (COs)

Semester –II

S. No.	Name of the Course	Course Code	Course Outcomes
01.	**Clean Coal And Green Power Technology**	MEEM- 201	**Students should be able to:** • Ability to identify, track and solve various combustion problems and evaluate theoretically the performance of various components involved in thermal power plants. • Gaining appropriate knowledge on principal of operation, construction and working of power plants equipment and components. • Becoming aware of the appropriate technologies used in the power plants and integration of the thermal energy management system. • To analyze the various approaches for carbon capture. • To understand the carbon sequestration method and management, carbon footprints, carbon credit etc.
02.	**Wind Power Generation**	MEEM- 202	**Students should be able to:** • Understand the concepts of Wind Energy Systems • Understand the principles of Aerodynamics in Wind Turbines • Analyse the performance of Modern Wind Turbines • Design and Analyse Wind Energy Conversion System for both Standalone and Grid Connected. • Examine the environmental impacts of Wind farms.
03.	**Fuel Technology And Air Pollution**	MEEM- 203	**Students should be able to:** • Understand the concepts of energy usage and global energy scenario • Understand types of Fuels and have profoundness in understanding their application • Understand and work out analytical problems related to combustion theory. • Learn about the energy and environment, air pollution climate changes and its impacts on sustainable development..
04.	**Energy Conservation, Management And Audit**	MEEM- 204	**Students should be able to:** • Becoming aware of the energy crisis, and of environmental and sustainability concerns associated with the energy management. • Appreciating the importance of energy conservation and having the knowledge of energy conservation strategies and methods. • Becoming aware of typical electrical energy powered machinery and equipment of organizations, specially the industrial units. • Becoming aware of the Energy Conservation Act, 2001, and of the legal energy requirements applicable to the routinely used thermal and electrical energy systems Aware. • Having the knowledge and awareness of the tools

			and techniques and the management practices for the conservation and management of electrical energy in organizations. • Acquiring the techniques and skills of electrical energy analysis and identification of opportunities and options for electrical energy conservation and management.
05.	**Clean Development Mechanism**	MEEM- 205	**Students should be able to:** • Learn concepts of CDM, international & national scenario of GHG reduction, issues & policy. • Understanding methodology, project cycle, project Design Documents of CDM projects. • Calculation of CER's, Carbon credits of an CDM projects contributing in reduction of carbon foot prints. • Analyse performance of CDM projects in terms of GHG mitigation, technology transfer and the contribution towards sustainable development.
06.	**Lab-III (Energy)**	MEEM- 206	**Students should be able to:** • Measure solar radiations and test the performance of different solar thermal applications • Characterize solar cells and analyze different parameters such as power flow, efficiency of different • components such PV module, battery, inverter and PV system • Characterize the properties of solid biofuels along with performance testing of cook stove • Analyze the performance of wind energy converter and hybrid systems with DC and AC micro-grids.
07.	**Lab-IV (Environment)**	MEEM-207	**Students should be able to:** • Demonstrate the ability to write clear technical laboratorial reports. • Use word processors and other modern software packages in writing and finishing the reports. • Demonstrate the ability to work in groups. • Understand the impact of water and wastewater treatment on people and the environment. • Understand and apply ethical issues associated with decision making and professional conduct in the laboratorial and field environment

Course Outcomes (COs)

Semester-III

S. No.	Name of the Course	Course Code	Course Outcomes
01.	**Elective-I** **Water and Waste Water Treatment**	MEEM-301(1)	**Students should be able to:** • Define and explain the significance of terms and parameters frequently used in water supply engineering and wastewater management. • Evaluate the influence of the different parameter in design and treatment of water treatment plant (water quality parameters) and wastewater treatment plant (wastewater characteristics). • Understand the uses of pumps and their applications in rural, urban and industrial sectors. Uses of pumps for raw water supply and wastewater supply. Its capacity calculations, costing, head loss, total head etc. • Basic methodology for water treatment (viz., sedimentation, coagulation, flocculation, filtration, • disinfection and water softening) and wastewater treatment (screening, grit chambers, sedimentation, • biological treatment and chemical treatment) • Assess methods employed for water reuse, wastewater reclamation and reuse, characterization of wastewater and storm water control
02.	**Elective-I** **Instrumentation and Control in Energy System**	MEEM-301(2)	**Students should be able to:** • Understand the basic measurement principles, transducers and their types with applications. • Understand fundamentals of control theory, system modelling and PID Controllers • Analyze the steady state and transient response of systems and to perform stability analysis in both time and frequency domain • Understand the data acquisition principles with its application
	Elective-I **Economics & Planning of Energy System**	MEEM-301(3)	**Students should be able to:** • Understanding of economic and ability to apply economic and financial evaluation of energy projects. • Learn different economic models and statistical approaches can be deliberated. • familiar with tools of Decision making and uncertainty in the technology implementation • To provide relevant inputs on energy economy-environment interaction related policy studies

	Elective-I **Industrial & Commercial Applications of Renewable Energy Sources**	MEEM-301(4)	**Students should be able to:** • Understand the need of energy conversion and the various methods of energy storage • Explain the field applications of solar energy • Identify Winds energy as alternate form of energy and to know how it can be tapped • Explain bio gas generation and its impact on environment • Understand the Geothermal &Tidal energy, its mechanism of production • and its applications • Illustrate the concepts of Direct Energy Conversion systems & their applications • Demonstrate need of different renewable energy sources and their importance • Estimate alternate energy sources India
	Elective-I **Solid Waste Management**	MEEM-301(5)	**Students should be able to:** • Understand various aspects of a sustainable integrated solid waste management system. • Understand characterization of solid waste along with proximate, ultimate analysis of the waste. • Calculate energy content of the solid waste and develop suitable treatment method. • Able to make route optimization for a municipal solid waste collection, transport system and landfill site selection, it'd design. • Learn all terminology, rules, regulations, economical aspects related to solid waste management. • Understand various types, treatment, handling and disposal of hazardous wastes.
	Elective-II **Energy Efficiency in Electrical Utilities**	MEEM-302(1)	**Students should be able to:** • Define and identify the concept of generation, transmission and distribution of energy • Understand the concept of power factor improvement and its benefit • Comprehend the importance of distribution and transformer losses • Understand the methods of improving energy efficiency in different electrical systems. • Understand the concepts of different energy efficient devices.
	Elective-II **Environmental Audit & Impact Assessment**	MEEM-302(2)	**Students should be able to:** • Have an in-depth understanding of the processes associated with EIA, environmental auditing, and environmental management systems • Have an in-depth understanding of the current legislative requirements of environmental impact assessment and environmental auditing in India • Have the ability to identify the potential impacts of proposed developments and propose solutions to address these impacts in a range of contexts • Have an ability to develop the appropriate documentation for an environmental impact statement

			• Have an ability to develop an appropriate response to an environmental audit • Have an ability to develop an appropriate environmental management system
	Elective-II **Project Evaluation & Management**	MEEM-302(3)	**Students should be able to:** • Understand project characteristics and various stages of a project. • Understand the conceptual clarity about project organization and feasibility analyses Market, Technical, Financial and Economic. • Analyze the learning and understand techniques for Project planning, scheduling and Execution Control. • Apply the risk management plan and analyze the role of stakeholders. • Understand the contract management, Project Procurement, Service level Agreements and productivity. • Understand the How Subcontract Administration and Control are practiced in the Industry.
	Elective-II **Environmental Modeling & Simulation**	MEEM-302(4)	**Students should be able to:** • Understand mathematical and statistical concepts required for model development. • Understand different environmental systems, their components, processes and their interconnections. • Perform data exploration and visualization • Understand the importance and implications of quantifying uncertainty in environmental assessment, modelling • Test model performance in terms of statistical error estimation.
	Elective-II **Solar Thermal Technologies**	MEEM-302(5)	**Students should be able to:** • Understand availability of solar radiation, solar geometry, instrument used for measuring solar radiation • Explain working, construction and performance evaluation of solar thermal devices • Describe and analyze of various thermal energy storage systems • Analyze and design solar thermal systems for appropriate application • Have appropriate knowledge on solar energy based thermal power plant.
03	**Seminar**	MEEM-303	**Students should be able to:** • Prepare and Deliver Seminars to Develop Communication Skills. • Develop the ability to Speak and Debate with an Appreciation. • Collaborate with others as they work on Intellectual Research Projects.

04.	**Dissertation Part –I (literature Review/Problem Formulation /Synopsis)**	MEEM-304	**Students should be able to:** • Estimate the authority of information from various sources e.g., Peer-Reviewed Journals Research Articles or Magazines. • Organize information systematically and formulate questions for Research of an Appropriate Scope, based on Information/Research Gaps or by Reexamining Existing Information. • Develop plans and find out the Gap in the relevant research area and to develop a plan to achieve the Project's Goals. • Break work down into objectives and determine relevant procedures. • Gain experience in Writing a Scientific Proposal in the form of Synopsis with the Relevant Outcomes and Significances of the Proposed Work. • Prepare appropriately to participate effectively in Class Discussion. • Follow Discussions, Oral Arguments, and Presentations, noting main points or evidence and tracking threads through different comments. Confront and offer substantive replies to others Arguments, Comments, and Questions from the Audience.

Course Outcomes (COs)

Semester -IV

S. No.	Name of the Course	Course Code	Course Outcomes
01.	**Dissertation Part-II**	MEEM-401	• The purpose of this course is to help students Organize Ideas, Material and Objectives for their Dissertation and to begin development of Communication Skills and to Prepare the students to present their topic of Research and Explain its Importance to their Fellow Classmates and Teachers. • Understand the basic concepts of Ethics in Proper Conduct of Research. • Understand about Plagiarism in Research and how it should be avoided. • Gain a clear idea about the importance of proper Data Documentation. • Students will have a clear idea about the Research Methodologies that need to be adopted during their Research Plagiarism, Regulatory Principles, Safety in Research, Ethics in RE Research, Research Principles of Data Documentation, Protocol Development, Research Questions and Hypothesis Driven Research. After Completion of this course the students should be able to demonstrate the following abilities: • Formulate a Scientific Question. • Present Scientific Approach to solve the Problem. • Interpret, Discuss and Communicate Scientific Results in Written form. • Gain experience in writing a Scientific Proposal, • Thesis and Research Article. • Learn how to Present and Explain their Research Findings to the audience effectively.

SEMESTER-I

MEEM 101: APPLIED MATHEMATICS

Applications of Laplace Transform in solving Ordinary Differential Equations, Simultaneous Differential Equations, Difference Equations, Integral Equations.

The Z- Transform: Some Elementary Concept, Definition, Properties, Inverse Z-Transform, Convolution Theorem. Fourier Transforms: (Sine, Cosine) & Properties

Numerical Solution of an Ordinary Differential Equations, Numerical solutions of Partial Differential Equations (Laplace, Heat & Wave Equations), Gauss's Quadrature Formula.

Probability Distributions: Binomial, Poisson & Normal; Sampling (Large Sampling): Types of Sampling, Mean and Standard Deviation in simple Sampling of Attributes, Tests of Significance of Large Samples, Standard Error, Probable error, Comparison of Two Large Samples.

Mathematical Modeling: Modeling through Ordinary Differential Equations of First Order – Linear Growth and Decay (Population Growth Models, Effects of Immigration and Emigration on population Size), Non-linear Growth and Decay (Logistic Law of population Growth, Spread of Technological Innovations and Infectious Diseases).

Reference Books:

1. Sastry, S.S. (2006). *Introductory methods of numerical analysis.* Prentice-Hall of India Pvt.Ltd
2. Kanti B. Datta(2012) Mathematical Methods of Science and Engineering, Cengage Learning.
3. Mathematical Modeling by J.N. Kapur , Wiley Eastern Limited .
4. Ray,Sharma,Chaudhary, Mathematical Statistics, Ram Prases & Sons.
5. Ramana, B.V. *Higher Engineering Mathematics.* Tata McGraw-Hill Publishing Company
6. Kreszig, Ervin.(1998) *Advance Engineering Mathematics(8th ed.)*. Wiley publication.
7. Engineering Mathematics By Babu Ram, Pearsons
8. Fourier Transforms by J. N. Sheddon
9. A. G. Hamilton: Linear Algebra, Cambridge University Press
10. B.S. Grewal "Numerical Methods in Engineering & Science".
11. V. Rajaraman "Computer Oriented Numerical Methods".
12. Iyenoyr M.K. Jain & R.K. Jain "Numerical Methods for scientific and engineering computation", Wiley Eastern (New Age)
13. E.V. Krishnamurthy & S.K. Sen "Computer Based Numerical Algorithms".

MEEM 102: Power Generation, Transmission & Distribution

Electrical Energy Generation, concepts, various types of generating stations and their locations. Study of Thermal, Hydel, Nuclear and Non-Conventional energy generation schemes. Block diagram of various power stations- schemes and sub systems.

Steam Power Plants: Types of power plants, steam power plant: Design Operation & Thermodynamic Analysis, steam turbine power output, Power Plant Performance Monitoring & Testing, Heat Rate, Efficiency, Optimization of Performance

Steam Generators: Boiler and steam Generator construction types, Energy Balance and efficiency of steam Generator, Furnace & burners, steam Generators with fluidized based Combustion (FBC): fluidized bed types; emissions reduction in Fluidized bed furnaces, Steam turbines, Condensers, feed Water Heaters and Cooling Water systems

Gas Turbine Power Plants: Air standard joule Cycle, Actual efficiency of the Gas Turbine Power Plant, Enhancing the Gas Turbine Plant Performance: increasing the compression Pressure Ratio and Turbine Inlet Temperature

Hydro Power Generation, Hydro Turbine, Large medium and small hydro power station, Micro Hydel Nuclear power generation and peaceful uses of nuclear energy.

Generation: synchronous generator, operation, power angle characteristics, and the infinite bus concept, dynamic analysis and modeling of synchronous machines, excitation systems, prime mover governing systems, automatic generation control, auxiliaries.

AC transmission: Overhead cables, transmission line equations, regulation & transmission losses, performance estimation, reactive power compensation, flexible AC transmission, skin, proximity and Ferranti effects, corona phenomena, critical voltages and power loss. HVDC transmission.

Distribution system: distribution system, conductor's size, Kelvin's law performance calculations and analysis, distribution inside industrial & commercial buildings entrance terminology, substation & feeder circuit design considerations, distribution automation.

References:

1. Power Generation Technology-Dr.V.K.Sethi, Sudit Publication
2. Thermal Power Technology - Dr.V.K.Sethi, Sudit Publication
3. Generation, distribution and utilization of electrical energy by C.L. Wadhwa, New Age International.
4. Elements of power system analysis- William Stevenson Mc-Graw Hill
5. Modern power system analysis- I..S. Nagrah and D.P. Kothari, Tata Mc Graw Hill.
6. Power system analysis- John Grainger and willian Stevenson, Mc- Graw Hill.
7. Electrical power transmission system: Analysis and Design- Turan Gonen, John Wiley & sons.
8. Theory and problems of electric power systems by S. A. Nasqr

MEEM 103: Solar Power Generation

Solar Power: Introduction, Solar Photovoltaic, History and projection, Advantage & disadvantage of Photovoltaic Systems, Application of Photovoltaic Systems, Overview of SPV programme in India, Solar potential, solar mission of GoI, Role of MNRE, IREDA etc., Energy from Sun, Insolation available on earth; Global Radiation distribution on an inclined plane.

Solar Photovoltaics: Basic principle of power generation in a PV cell; Band gap and efficiency of PV cells; Component of PV System, Solar Cells; Types; Working; I-V characteristics; losses. Solar PV panel; Balance of Systems; Fabrications of Modules; Economics of PV Systems; Future prospects; Applications of Photovoltaic: Domestic lighting Systems; Remote Applications; Hybrid; Grid linked PV Systems.

Designing of Solar Photovoltaic Systems: Designing of PV systems, need for different cell design, the technology route for making solar cells, costing of PV systems, Operation & Maintenance of PV Systems; Battery Storage: Types and Properties of monocrystalline, polycrystalline and multicrystalline cells, Amorphous silicon thin film cells; Photovoltaic materials.

CSP technologies: Parabolic trough collector technology, Linear Fresnel collector technology, solar tower technology and Stirling dish technology; the solar resource, CSP plant design and performance; Solar field sizing, latest trends in design of Mega Solar Power Plants.

Solar Thermal: thermal storage; Solar thermal applications - water and space heating; solar ponds; dryers; distillation; solar cooker; Passive solar design; solar thermal collectors - Glazing, evacuation, selective surfaces, concentrators; case studies of solar power plants.

References:

1. Solar Energy fundamentals & applications; by H.P. Garg, J Prakash
2. Solar Energy Technologies; by Chetan Solanki, IIT, Bombay
3. Solar Electricity; by Wiley
4. From Sunlight Electricity by Shirish Sinha Teri
5. Concentrating Solar Power: RENEWABLE ENERGY TECHNOLOGIES: COST ANALYSIS SERIES, *Volume 1: Power Sector,* Issue 2/5 IRENA 2012

MEEM 104: HYDRO & NUCLEAR POWER GENERATION

Fundamental of Hydraulic Engineering – Water resource and its potential. Hydrology- Hydrological cycles, hydrograph, steam flow characteristics, flow duration curve, mass curve storage, pond age, site selection. Environmental Impacts and its mitigation- Burdens and impacts identification, impacts in the construction phase; Hydropower Economics.

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

Nuclear Engineering:
Introduction, Why Nuclear Power for Developing Countries, Radioactivity and Radioactive Change Rate of Radioactive Decay, Irradiation of Medical products and other application of artificial radioactive, Mass – Energy Equivalence, Binding Energy, Release of Energy by Nuclear Reaction, types of Nuclear Reactions, Initiation of Nuclear Reaction, Nuclear Cross – section, Nuclear Fission, The Fission Chain Reaction, moderation, Fertile Materials and Breeding. Fick's law.

Nuclear Materials: Introduction, Fuels, Cladding and Structural Materials Coolants, Moderating and Reflecting Materials, Control Rod Materials, Shielding Materials; Fuel rod design.

Safety Rules: Personal Monitoring, Radiation Protection (Radiation Workers, Non-Radiation Workers, Public at large), Radiation Dose (Early effect, Late effect hereditary effect); Nuclear Safety regulation & Standards;

Nuclear Reactors:
Introduction, General Components of Nuclear Reactor, General Problems of Reactor Operation, Different Types of Reactors, Pressurised Water Reactors (PWR), Boiling Water Reactors (BWR), Heavy Water – cooled and Moderated CANDU (Canadian Deuterium Uranium) Type Reactors, Gas-cooled Reactors, Breeder Reactors, Reactor Containment Design, Location of Nuclear Power Plant, Nuclear Power Station in India, India's 3-stage Programme for Nuclear Power Development; Peaceful application of Nuclear Energy –Power Generation and Isotope application; case studies of Nuclear power plants.

Reference:

1. Layman's Guidebook on how to develop a small hydro site
2. Finn R. Forsund – Hydropower Economics
3. Hydro Power an Indian Perspective Author-Cum-Editor Dr. B.S.K. Naidu , Director General , NPTI.
4. Micro Hydroelectric Power Stations – By L.Monition, Power Stations- By L.Monition , Mle Nir, J.Roux translated by Joan Mc Mullan, John Wiley & Sons.
5. Nuclear Physics by J.B. Rajam
6. Introduction to Nuclear reactor theory, Wesley, 1966 by J.R. Lamrash
7. M.M. E1-Wakil: Nuclear Power Engineering, McGraw Hill, 1962.
8. R.L. Murray: Introduction to Nuclear Engineering, Prentics Hall, 1961.

MEEM 105: Environmental Issues, Policy, Standards & Regulations

Global Environmental Concerns: The Scenario, The Changing Global atmosphere &common concerns. United Nations Framework Convention on Climate Change (UNFCC), Kyoto Protocol, Conference of Parties (COP), Various Clean Development Mechanism (CDM), Prototype Carbon fund (PCF), Earth Summit, Sustainable development**.**

Green Certificate: The Global Program for protected area management, Strategies for environmental improvement plan. Organizations working in the field of energy and environment - UNEP, IPCCC, CPCB etc. Basic features of ISO 14000.

Water Quality: Parameters: Physical, Chemical and Bacteriological. Potable Water Standards, Waste Water Effluent Standards. Minimal National Standards (MINAS).

Environment Policies: Water Act 1974, The Air Act, 1981, Environmental (Protection) Act. - 1986, M. P. State Environment Policy, Municipal Solid Waste (Management & Handling) Rules, 1998, Biomedical Waste (Management & Handling) Rules 1998.

References:

1. Environmental Issues and Polices, Prentice Hall—Stephon Ison, Stephen Peake, Stuart Wall
2. ISO 14000 Environmental Management by Goetsch, Davis. Prentice Hall
3. Standard methods for the Examination of Water and Wastewater. (1989).17thEd. APHA, Washigton. D.C., 2-12
4. Energy Management by Paul O'Callaghan –McGraw Hill
5. Cleaner Production – Energy Efficiency Manual for GERIAP, UNEP, Bangkok prepared by National Productivity Council
6. Training material on 'Environmental concerns' prepared by National Productivity Council
7. Parivesh, October 2002 – Central Pollution Control Board
www.epa.org
www.uneptie.org
www.cpcb.nic.in
www.wri.org
www.safeclimate.net
www.globalwarming.org, Bureau of Energy Efficiency 186

SEMESTER-II

MEEM 201: Clean Coal & Green Power Technology

Clean Coal Technologies- Super Critical Power cycles, Integrated Gasification Combined Cycles, circulating fluidized bed combustion and gasification, Gas cleaning systems and environmental issues, Principles of Waste Heat Recovery and Co-Generation, Analysis of Heat Recovery Systems, Regenerators & Recuperators for waste Heat Recovery, Condensate and Back Pressure Steam Turbines, Design of Waste Heat Recovery Boilers, Combined Cycle Power Plants based on waste Heat Recovery

Zero Emission Technology
CO_2 Capture – Flue Gas Approach, Oxygen combustion Approach, Hydrogen/Syngas Approach.

Green Productivity: New Power cycles, Dry Ice co- generation, Biological CO_2 fixation with Algae, Zero Emission Technologies, Recycling of CO_2., Carbon Credits.
CO_2 Transportation, CO_2 Utilization & Storage: - Deep Saline Aquifers, Cost Considerations, CO_2 Capture, CO_2 Transportation, CO_2 Storage, Legal Issues, Environmental Health & Safety.

Advanced Energy Systems, Fluidized Bed Combustion, Atmospheric Fluidized Bed Combustion (AFBC), Pressurized Fluidized Bed Combustion (PFBC) and Circulating Fluidized Bed Combustion (CFBC), Clean Coal Technologies-Supercritical Cycles, Integrated Gasification Combined Cycle (IGCC), IGCC Power Plants, Flue Gas De-Sulfurization and Coal Beneficiation, IGCC Power Plant Cycle Efficiency, Cold and Hot Gas Clean-Up

Hydrogen, Fuel Cell, Thermoelectric Generator, MHD-generator, Fusion reactor: Hydrogen Production & Utilization as Energy Source; Fuel Cells; Types of Fuel cells; Fuel Cell Power Plant concepts.

References:

- Power Generation Technology-Dr.V.K.Sethi,Book Paradise
- Solar Energy Thermal Processes, J. A. Duffire and W. A. Beckmen .
- Applied Solar Energy, A. B. Meinel .
- Wind Power, V. D. Hunt.
- Energy and Environment, Himalya Publishing House, Mumbai, H.V. Jadhav.
- Biomass, Energy and Environment Oxford University Press, NH Ravindranath and DO Hall.
- Power Plant Engineering by Domkundwal
- A Rationale on Adoption of IGCC Technology for Indian Coals... By Dr V K Sethi & Dr D N Reddy
- Green Engineering (Environmental Conscious Design of Chemical Processes) by Allen & Shonnard
- Green Power: The Eco-friendly Energy Engineering by Nikolai V Khartchenko
- Power Plant Performance Monitoring by Gay, Palme,r Erbes\
- TEDDY: TERI Year Book Solutions for the 21st Century IEA Publications & TSR, USA

MEEM 202: Wind Power Generation

The Wind Energy Resource

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

Velocity and force vector diagrams of wind turbine blades, Aerodynamics of aero foil, lift forces, drag forces, stall, effect of Reynolds's number, actuator disc, momentum theory and Betz coefficient. Coefficient of power optimal choice of cut- in, rated and cut- out wind speeds, blade element theory, Residual velocity Capture-Contour Rotation.

Design Features

Vertical and horizontal axis turbines, design characteristics, multiple stream tube theory, vortex wake structure, tip losses, rotational sampling, wind turbine design programs aerodynamics loads, tower shadow, wind shear blade coning gyroscopic, transient and extreme loads.

Operation and Controls Mechanisms

Power performance, pitch control, yaw control, aerodynamic braking, teeter mechanism, control policies and their effect on energy capture and mechanical stress on wind turbine components. Wind turbine dynamics with induction and synchronous generators. Power electronics interfaces for variable speed operation wind farm electrical design.

Economic, Environmental and Social issue

Planning/ Economic considerations for wind power generation, Environmental impact and assessment, noise impact electromagnetic interface. Site selection for wind farms, maintenance and operation. Case studies of wind power generation plants.

Books and References:

1. Wind Energy Technology – John F. Bakar & Jenkins.
2. Paul Gipe, wind Energy Comes of Age, John Wiley & Sons Inc.
3. L.L. Freris, Wind Energy Conversion System, Printice Hall.
4. Tony Burton et al, wind Energy Hand Book, John Wiley & Sons Inc.
5. Directory, Indian Wind power 2004, CECL, Bhopal.
6. Wind Energy,Theory & Application-Siraj Ahmed .

MEEM 203: FUEL TECHNOLOGY & AIR POLLUTION

Introduction: Types, composition, properties, resources and classification of solid fuels, Principal of combustion: Solid, Liquid, and gaseous fuels, coal as a source of energy and chemicals in India. Classification of coals, analysis of coal, Coal carbonization – Mechanism, Low temperature carbonization high temperature carbonization, Coal preparation, Natural Gases and its derivatives, Sources and potential, Combustion appliance for solid and gaseous fuels.

Origin of Petroleum: Production, Composition classification of petroleum, Indian Petroleum resources and their nature, Petroleum processing distillation cracking thermal and catalytic coking reforming. Fuel Oils, Octane number, properties and testing of petroleum and petroleum products, Liquefaction of coal, oil burners.

Gasoline: Production, Composition properties, knocking and Octane Number, Diesel fuels, Kerosene. Types of Gaseous Fuels, composition and calorific values, Natural gas, Liquefied petroleum gas, cleaning and purification of gaseous fuels; CNG, Nuclear fuel.

Biofuels: Introduction, classification, Importance, Production and applications; Production processes and technologies; Production of alcohol and biogas. Bio-diesel: Fundamentals; Trans- esterification of vegetable oils for biodiesel production; Characterization of biodiesel; **Biomass based Power Generation**, Combustion & Gasification Routes, Co-generation; Bagasse based Power Generation, BIG-GT system.

Air Pollution: Air Pollution and Air Pollutants – Classifications and Sources. Effects of Air pollutants on man, material and vegetation, Global effects of air pollution; Generation, transport and decay of air pollutants; Air pollution indices; air-fuel ratio; Control of particulates, Control Equipment, Sampling and monitoring methods.

References:

1. Coke, Cake and Coal Chemicals, by Wilson, P.J., Wells, G.H.-- McGraw Hill
2. Fuels and Fuel Technology, by Francis– Vol. I and II Pergamon Press
3. Fuels, Solid, liquid and Gaseous, by Brame, J.S. and King, J.C. -- St. Martin Press
4. Fuels and their combustion, by Haslam, R.T. Russal, R.P. -- .McGraw hill
5. Fuel & Combustion, 2nd by Samir Sarkar.– Orient Longman.
6. Air pollution By M.N.Rao and H.V.N.Rao – Tata Mc.Graw Hill Company.
7. Air pollution by Wark and Warner.- Harper & Row, New York.
8. An introduction to Air pollution by R.K. Trivedy and P.K. Goel, B.S. Publications.
9. Biomass as Fuel – L.P.White (Academic press1981)

MEEM 204: Energy Conservation, Management & Audit

Energy Scenario: Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change, Energy Conservation Act-2001 and its features.

Electrical Billing, Power Factor & Capacitors, Load Management, Energy Conservation in Motors & Transformers (Types, Characteristics), Pumps, Compressors, Blowers, Fan Cooling Towers.

Energy Conservation Opportunities in Compressed Air Distribution System, Lighting System, Energy Conservation through: Variable Speed Drives.

Energy Audit, Need, Types of Energy Audit, Energy Management Audit Approach, - Understanding Energy Costs, Matching Energy Use to Requirement, Maximizing System Efficiencies, Optimizing the Input Energy Requirements, Energy Audit Instruments.

Investment Need, Appraisal and Criteria, Financial Analysis Techniques-Simple Payback Period, Return on Investment, Net Present Value, Internal Rate of Return, Cash Flows, Risk and Sensitivity Analysis; Financing Options, Energy Performance Contracts and Role of ESCOs.

References:

- Energy Conservation in Process Industry, Kenny W.F.
- Energy Conservation & Utilization, Krenz H. Jerrold
- Waste Energy Utilization Technology, Kiang, Yen Hsiung
- Waste less Chemical Processing, Kafarov, V.V.
- Electrical Energy Utilization & Conservation, Tripathy, S.C.
- Efficient Electrical use by C.B. Smith
- Savings Electricity in Utility Systems of Industrial Plants by B. G. Desai, B.S. Vaidya
- Efficient Use of electricity in industries by B.G. Desai, B.S. Vaidya, M.P. Parmarad R. Parman
- Pump application desk Book by P.N. Garagy
- Electrical Power Distribution in Industrial plants by M.D. parmar
- Electronic Energy Utilization and Conservation by S.C. Tripaths
- Industrial Energy Management & Utilization, Hemisphere Publishing Corporation, Washington, G.L. Witte, Philips S. Scbmidt and Daid R. Brown.
- Principles of Management, Vol I, II,& III by S. Tarachand.

MEEM 205: Clean Development Mechanism

Major objective of CDM, Projects for benefit from CDM finance, CDM methodology, CDM opportunities & priorities in India, flow of fund in Kyoto protocol.

Status of CDM today, Technology assimilation, Transfer of technology, Flow of fund under CDM, Competitors and major developers in India.

Technology & Market Assessment of various Power plants- IGCC, Super Critical, Combined Cycle, CFBC and Novel Energy devices.

Analysis of selected CDM options: Micro- Hydro Power Generations, Biomass Power Generation, Wind Power Generation, Clean Coal Technology, Indicative Simplified Baseline and Monitoring Methodologies for selected Small Scale CDM project activity Categories.

Case Studies, Typical Case studies of BOF Gas Waste Heat Recovery, Optimal Utilization of clinker and Conversion, Example of Calculation.

References:

1. **CDM and JI in Charts:** IGES-Institute for Global Environmental Strategies, Ver-1.0 and Ministry of the Environment, Japan
2. **A Rational on CDM:** Dr. V. K. Sethi, Prof & Head (Energy Deptt.) RGTU, Bhopal

SEMESTER-III

MEEM 301 (1): Water and Waste Water Treatment

Waste Water: Primary Treatment; Equalization Basin, Screening, Comminuting, Grit Removal, Grease Removal & Skimming, Flow Measurement, Primary Sedimentation.

Secondary Treatment; Waste Water Microbiology: Growth & Food Utilization Activated Sludge Process, Extended Aeration, Trickling Filter, Ponds & Lagoons, Secondary Clarification.

Sludge Treatment & Disposal; Sludge Characteristics, Sludge Thickening, Sludge Digestion, Sludge Disposal: Sludge Incineration, Air Drying, Composting, ASTE Water Reuse & Application.

Advanced & Tertiary Treatment, Nutrient Removal, pH Control System, Neutralization Agents & Processes.

References:

1. Waste Waster Treatment by Hammer & Hammer
2. Design of Water Treatment Plants by Dr. A.g. Bhole- IWWA Nagpur centre
3. Hand book of Environmental Engineering Vol2, Lawrence K. Wang and Worman C. Pereira, The Human Press, Clifton, New Jersey (1980)
4. Handbook of Environment Engg, Vol. I Liptak
5. Environmental Engineering by Peavy , Rowe, Tchobanogolous
6. Waste Waster Treatment by Steel & Meghee
7. Waste water Treatment , Disposal & Reuse , Metcalf & Eddy
8. Manual on Water Supply & Treatment, CPHEEO, Ministry of Urban development, New Delhi, GOI.
9. Environmental Pollution Control Engineering, By C.S. rao
10. Theory & Practice of Industrial Waste Treatment, Addison Wesley Publishing Co. NY
11. Water & Waste Water Technology, Marle J. Hammer & Hammer
12. Waste Water Treatment by Liu, Liptak , Lewis

MEEM 301(2): Instrumentation and Control in Energy System -

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, Solar radiation measuring instruments, Meteorological data measurements, Energy auditing instruments,
Probe measurements in plasmas, general plasma spectroscopy, Laser interferometery developments, Plasma density and temperature measurement, Mass spectroscopy for plasma species.

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, 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 measurements of particulates, SOx, NOx, CO, O3, hydrocarbons, Waste water sampling, determination of organic and in-organic and in-organic substance, Physical Characteristic and bacteriological measurements, Solid waste measurements and disposal.

References:

1. Electrical Measurements & Measuring instruments by F W Golding
2. Principles of Measurements of Instrumentation by A S Morris
3. Instrumentation Measurement & Feedback by E Barry jones
4. Instrumentation Measurement & Analysis by B C Nakra

MEEM 301 (3): Economics & Planning of Energy System

Energy theory of value: Principles and systems of energy flows, Methods of energy analysis; Energy intensity method, process analysis input –output method based energy accounting. Energy cost of goods and services energy to produce fuels; coal, oil, natural Gas, Energy cost of various modes of passenger & freight transportation.

Industrial energy analysis; Aluminum, Steel, Cement, Fertilizers. Energetic of materials recycling, Energetic of Renewable Energy Utilization.

Energy and Exergy analysis of Thermal & Chemical Plants.

References:

1. Electrical Energy Systems: Theory & Introduction by L Olle Elgerd
2. Industrial Organization &Engineering Economics by T R Banga
3. Engineering Economics by R Pannersewan
4. Managerial Economics by Joel Deal

MEEM 301 (4): Industrial & Commercial Applications of Renewable Energy Sources

Renewable energy sources for Power Generation potential and application with regard to Indian power scenario.

Commercial & industrial energy demand; qualitative & quantitative features and characteristics. Renewable & electricity for growing economy.

Water heating, process heating and drying applications; solar biomass and geothermal energy based systems, combined space and building service hot water systems.

Electricity generation from renewable to meet commercial & industrial power requirement. Standalone & grid connected systems.

Ethanol & methanol from cellulosic biomass, Use of renewable in commercial & industrial building for load leveling, lighting and space heating and cooling.

Economics of renewable energy based commercial and industrial installations, case studies.

References:

1. Renewable Energy Technology and the Environment by Jayogh
2. Renewable Energy: Power for sustainable Future by Boyle
3. Renewable Energy sources by W John Twidell
4. Renewable Energy Technology – Ed. Pachauri, TERI
5. Renewable Energy Sources & their Environment Impact by S A Abbassi

MEEM 301 (5): SOLID WASTE MANAGEMENT

Integrated Solid Waste Management; Management option for solid Waste, Generation Rate Variation, Waste Reduction at the sources Collection Techniques Materials and resources Recovery/Recycling.

Municipal Solid waste: Characteristics (Physical, Biological and chemical); Transport of Municipal Solid Waste, Routing and Scheduling, Treatment Transformations and disposal Techniques (Composting, Vermi Composting, Incineration, Refuse Derived fuels)

Ultimate Disposal: Sanitary Landfills. Norms, Rules and Regulations, Land Fill method of solid waste disposal; Layout & preliminary design of landfills; Movement and control of landfill leachate & gases.

Waste to energy options: combustion (unprocessed and processed fuel), gasification, anaerobic digestion, pyrolysis.

Hazardous Waste: Sources, Generation and classification. Transportation, Treatment, & disposal methods.
Hazardous Waste Minimization Reuse& Recycling. Cleanup of Contaminated Waste Sites, Remediation of Hazardous waste contaminated soils, Engineering issues in waste remediation case studies.

References:

1. Solid Waste Management Collection :A.D. Bhide and B.B. Sudershan
2. Solid Waste Engineering Principles, Tecobanoglous G.
3. Handbook of Solid Management, Frank Kreith, Mcgraw Hill,Inc USA
4. Solid waste Management- A practical approach by Manoj Datta
5. Energy form solid waste by Jackson
6. Refuse recycling and recovery by John R. Holmes
7. Handbook of Solid Waste Management Frank Kreith, Mcgraw Hill, Inc USA
8. Hand Book Environmental Engineering Vo12, Lawrence K.Wang and Worman C. Pereira,The Human Press Clifton, New Jersey (1980)
9. Hand Book Environmental Engineering Vo1, I Liptak
10. Environmental Engineering by Peavy, Rowe Tchobanogolous
11. Manual on Solid Waste Management CPHEEO,GOI
12. Waste Management and Resource Recovery by Rhyner, Schwartz & Kohrell
13. Hazardous Air Pollutant Handbook Spicer Garden Holdren Kally Mukund
14. Basic Hazardous Waste Management by CRC Lews
15. An Introduction to Management & Regulation of Hazardous Waste by Moore
16. Basic Hazardous Waste Management by Willian C.Balckman ,Jr,Lewis (CRC)
17. Ramachandra T.V , 2006. Management of Municipal Solid Waste , Commonwealth of Learning, Canada and Indian Institute of Science, Bangalore.

MEEM 302(1): Energy Efficiency in Electrical Utilities -

Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses. Energy audit in Electrical Systems

Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities, HVAC and Refrigeration System: Vapor compression refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting Refrigeration and Air conditioning system performance and savings opportunities.

Vapor absorption refrigeration system: Working principle, types and comparison with vapor compression system, saving potential.

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

Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.

Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities assessment of cooling towers.

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. Energy audit in Mechanical Systems – Fans, Blowers, Compressors & Pumps.

References:

- Energy Auditing Made Simple by P Balsubramaniam
- Power Plant Performance by A B Gill
- An Introduction to Thermodynamics by Y V C Rao
- Energy Management by W K Murphy & G Mckay
- Energy Reduction through improved Maintenance Practices by Bannister
- Energy Efficiency in Electrical Utilities by BEE

MEEM 302 (2): Environmental Audit & Impact Assessment -

Introduction: Origin and Development of Environmental Impact Assessment. (EIA), Current Status of EIA.

Essential Components of EIA**:** Concepts, EIS, Disaster Management Plan Baseline Study, Impact Prediction, Mitigation & Enhancement, Monitoring, and Conclusion.

National environmental policy, Methodology of environmental impact studies, Methods of impact identification, Environmental setting, Production and assessment of impacts on the air environment, Prediction and assessment of impacts on surface water, soil and ground water environment, Socioeconomic environment, Evaluation alternatives, Public participation in environmental decision making. EIA Legislation.

Environment Impact Statement & Environmental Management Plan for Selected Industries-Case Studies on power plants, Cement industry, Iron & Steel, Chemical & Refinery.

Guidelines for Environmental Audit: Concepts and definitions of Environmental Audit, Audit objectives, Scope, Types of Audit, Need for Environmental Audit, Application**.**

Key steps to Environmental Audit: Pre, Onsite & Post Environment audit activities. Audit Procedure, Format of Environmental Audit.

References:

- Environment Impact Assessment, W. Canter (II Edition)
- EIA Guidelines 1994, Notification of Govt. of India Impact Assessment Methodologies Publications Ltd. (1995)
- Guidelines for environmental audit. By Central Pollution Control Board. DELHI, Place and Publisher: Delhi : CPCB
- Environmental audit and business strategy: Total quality approach by G. Ledgerwood, TERI
- A-Z organization of environmental audit by by A. Mehrotra, mpIIFM
- Environmental audit (an overview), , Ashok Keshav Mhaskar, CSE
- An outline of environmental audit by K. V. Bengeri, CSE
- Environmental audit (an overview) by A. K. Mhaskar, CSE
- Clarck KC Parks, B O, Crane ,MP "Geographic Information Systems and environmental Modeling" Prentice Hall of India Pvt Ltd.2002.
- Reddy, MA "Text book of remote sensing & GIS", BS publications 2001.

MEEM 302 (3): Project Evaluation & Management

Project Management: Definition and scope of project, technical design, financing, contracting, implementation and performance monitoring.

Implementation plan for top management, Planning Budget, Procurement Procedures, Construction, Measurement & Verification

Life cycle approach and analysis, conception, definition, planning, feasibility and analysis environmental impact analysis, project planning matrix, aim oriented project planning.

Network analysis for project management- PERT, CPM and CERT. Fuzzy logic analysis, stochastic based formulations.

Project evaluation techniques, funds planning, project material management, evaluation & analysis, Implementation & monitoring, Performance indices, case studies.

References:

1. Projects Planning Analysis, Financiy by Prassanna Chandra
2. Pert/CPM and Project Management by S K Bhattacharjee

MEEM 302 (4): Environmental Modeling & Simulation

Modeling- Classification of Models; Model Based on Transport Phenomena-Principal & Applications; Population Balance Models & Application; Empirical Models- Form of Empirical Model, Model Parameters Estimation.

Simulation- General Techniques of Simulation, Monte Carlo Methods Comparison of Simulation and Analytical Methods, Numerical Computational Techniques for Continuous and Discrete Models, Distributed by Models, Cobweb Models, Simulation Study.

Environmental Modeling-I- Development of Environmental Model, Characteristics of Aquatic Ecosystem, Overview of Groundwater Models and Model of Waste Water Treatment Plants. Introduction, Characteristics Features and Classification of Eco-Toxicological Models**.**

Environmental Modeling-II- Models of Atmospheric Pollution, general consideration on Modeling Air Pollution & Climate Change, Modeling Population Dynamics.

References:

- Process Modeling, simulation & Control for Chemical Engineers by W.L. Lyben – McGraw Hill
- Introduction to Simulation by T.A. Payer
- System simulation by G. Gordan- PHI
- Fundamentals of Ecological Modelling by S.E. Jorgesen-Elsevier publication.
- An Introduction to Mathematical Ecology by Pieloic E.C.- Wiley inter science Publication
- Energy Models beyond 2000 by Jyoti Parikh, Mumbai.
- Operational research by Aspani, Seisani,
- Energy Models by A.K.Desai
- Operational Research by Bafaa.
- Mathematical Modeling by J.N. Kapoor.

MEEM 302 (5): SOLAR THERMAL TECHNOLOGIES

Solar Thermal Systems

Solar still, Solar cooker, Solar pond, Greenhouse technology: Fundamentals, design, modelling and applications. Solar Thermal Power Systems; Flat Plate Collector, Hot Air Collector, Evacuated Tube Collector, Parabolic, Compound Parabolic and Fresnel Solar Concentrators, Central Receiver System, Thermal Analysis of Collectors Performance of Solar Collectors.

Properties and Characteristics of Materials

Reflection from ideal specular, ideal diffuse and real surfaces; Selective Surfaces: Ideal coating characteristics; Types and applications; Anti-reflective coating; Preparation and characterization.

Design & modelling of solar energy systems

Performances of solar collectors, F Chart method, φ– F Chart method; Utilizability modelling & simulation of Solar Energy Systems.

Thermal applications of solar energy:

Solar Water Heating Systems (Active & Passive), Solar Space Heating & Cooling Systems, Solar Industrial Process Heating Systems, Solar Dryers & distillation Systems, Methods of modelling and design of Solar heating system, Cooling requirements of buildings, Vapour absorption refrigeration cycle; Water, ammonia & lithium bromide-water absorption refrigeration systems; Solar desiccant cooling; thermal power generation.

Storage and Economic analysis

Solar Thermal Energy Types: Sensible storage; Latent heat storage; Thermo-chemical storage; Design of thermal storage system; Transport of energy.

Life cycle analysis of Solar Energy Systems; Time Value of Money; Evaluation of Carbon Credit of Solar Energy Systems. Case studies of solar thermal plants.

Reference Books:

1. J.A.Duffie & W.A. Beckman: Solar Engineering of Thermal Process
2. S.A.Kalogirou: Solar Energy Engineering
3. Principles of Solar Engineering – F. Kreith and J.F. Kreider, (McGraw Hill Pub.)
4. Solar Energy Handbook – Kreider and Kreith (McGraw Hill Book Company)
5. Solar Distillation : Malik, tiwari etc. (Pergamon Press1982)
6. Solar Energy Engineering – A.A.M. Sayigh