TEACHING SCHEME AND COMPLETE SYLLABUS

POSTGRADUATE PROGRAMMES

[M.Tech. in Energy Technology]

Session: 2017-18 (Onward)

Centre for Energy and Environmental Engineering

National Institute of Technology

Hamirpur, Himachal Pradesh, India– 177 005

Web Site: http://www.nith.ac.in

CENTRE FOR ENERGY AND ENVIRONMENTAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, HAMIRPUR

HIMACHAL PRADESH, INDIA-177005

Post Graduate Programmes

[M.Tech. in Energy Technology]

The Centre for Energy and Environmental Engineering established at the National Institute of Technology, Hamirpur, in the year 2009 started Post Graduate programmes in M.Tech [Energy Technology] w.e.f. July 2010.

Objectives:

1. To educate the students in the latest developments in Energy to meet the Global Climate and Energy Security challenges
2. To train students to undertake R & D and Policy research in various fields of Energy especially in Energy Efficiency, Solar Energy, Wind Energy, Bio- Energy, Bio-fuels, Nuclear Energy, Hydro Energy, Co-generation, Waste heat Recovery and other New and Alternate Energy options to facilitate long-term reductions in greenhouse gas emissions, and impacts of Climate Change.
3. To make available highly trained professionals for the Institutions / Energy Industry in the country and worldwide.

The Centre offered Post Graduate Programme, M.Tech. in Energy Technology w.e.f July 2010

M.Tech [ENERGY TECHNOLOGY]

Eligibility: the Applicant must have a Bachelor's degree in the following Engineering/Technology discipline:

- Electrical Engineering/ Electrical and Electronics Engineering.
- Electronics and Communication Engineering
- Mechanical Engineering
- Energy Engineering

Type of Academic Programme and Annual Intake:

Post Graduate programme M.Tech in Energy Technology, with Annual intake of 25 students: General: 10, SC: 3 ST: 02, OBC: 05, Sponsored: 05.

Learning Methodology

The learning methodology will consist of class room teaching through lectures, tutorials, seminars and group discussions. In order to give practical insight, experiments will be conducted in the laboratories of the Centre. The training in Industries / R & D Institutions will also be undertaken to understand various aspects of Industrial production of Renewable Energy Technologies as well as latest research and development being carried out by leading Institutions and Industry.

Fee Structure: The fee structure for the programme will be in accordance with regular PG Programme norms of NIT, Hamirpur.

Courses of Study

The Courses are designed for awarding M.Tech [Energy Technology] degree after two year duration of study. The Core Courses and Elective Courses have been structured in such a manner that the students with different backgrounds will have the option to choose the elective courses so as to become specialized in a specific field.

Centre for Energy and Environmental Engineering, NIT –Hamirpur (HP)

M. Tech (Energy Technology)

Teaching Scheme

(i)Year I - Semester I

S. No.	Subject Code	Title	L	T	P	Credit	Hours /Week
1.	EN-600	Foundation for Energy Systems Technology	3	0	0	3	3
2.	EN-601	Solar Photovoltaic Technology	3	0	0	3	3
3.	EN-602	Bio-Energy Systems Technology	3	0	0	3	3
4.	-----	**Elective-I**	3	0	0	3	3
5.	-----	**Elective-II**	3	0	0	3	3
6.	EN-603	Energy Laboratory - I	0	0	3	2	3
Total			**15**	**0**	**3**	**17**	**18**

(ii)Year I - Semester II

S. No.	Subject Code	Course Title	L	T	P	Credit	Hours /Week
1.	EN-604	Solar Thermal Technology	3	0	0	3	3
2.	EN-605	Wind Energy Technology	3	0	0	3	3
3.	EN-606	Energy Efficiency and Management	3	0	0	3	3
4.	------	**Elective-III**	3	0	0	3	3
5.	------	***Open Elective-I (From Other Departments)**	3	0	0	3	3
6.	EN-607	Energy Laboratory- II	0	0	3	2	3
Total			**15**	**0**	**3**	**17**	**18**

***The student will have to take an Open Elective offered by other Departments during Semester**

(iii)Year II – Semester III

S. No.	Subject Code	Course Title	L	T	P	Credit	Hours /Week
1.	EN-799	Self study Course	0	0	0	2	3
2.	EN-800	Seminar	0	0	3	2	3
3.	EN-801	**Dissertation –1[to continue in the IVth semester]**	0	0	0	12	24
Total			**0**	**0**	**3**	**16**	**30**

(iv)Year II - Semester IV

S. No.	Subject Code	Course Title	L	T	P	Credit	Hours /Week
1.	EN-801	**Dissertation – [Continued from IIIrd semester]**	-	-	-	20	40
		Total				**20**	**40**

List of Electives for M.Tech [Energy Technology]

S.No.	Subject Code	Course Title	L	T	P	Credit	Hours /Week
1.	EN-700	Solar Passive Building Technology	3	0	0	3	3
2.	EN-701	Bio-Fuels	3	0	0	3	3
3.	EN-702	Energy Generation from Waste	3	0	0	3	3
4.	EN-703	Energy and Climate Change Concerns	3	0	0	3	3
5.	EN-704	Hydro Power Management	3	0	0	3	3
6.	EN-705	Environment Policy and Environment Impact Assessment	3	0	0	3	3
7.	EN-706	Energy Economics	3	0	0	3	3
8.	EN-707	Waste Heat Recovery Systems	3	0	0	3	3
9.	EN-708	Green Building Architecture and Planning	3	0	0	3	3
10.	EN-709	Fuel Cells and Hydrogen Energy	3	0	0	3	3
11.	EN-710	Wind Energy Farm Development and Operation	3	0	0	3	3
12.	EN-711	Wind Power Generators	3	0	0	3	3
13.	EN-712	Industrial Applications of Nuclear Energy	3	0	0	3	3
14.	EN-713	Nuclear Power Technology	3	0	0	3	3
15.	EN-714	Materials for Energy Applications	3	0	0	3	3
16.	EN-715	Fuel Technology	3	0	0	3	3
17.	EN-716	Bio-Fuel Technology	3	0	0	3	3

M.TECH (ENERGY TECHNOLOGY) COURSE DETAILS

(i) M.TECH CORE COURSE DETAILS: SEMESTER-I

Course Code	Course Name	L	T	P	C
EN- 600	**Foundation for Energy Systems Technology**	**3**	**0**	**0**	**3**

1. Overview of Renewable Energy Systems and Applications

2. Solar Radiation:

Sun as Energy Source, Solar Radiation at The Earth's Surface, Solar Radiation Geometry, Solar Time and Equation of Time, Sun Earth angles, Sun path diagram, Sunshine hours, Measurement of Solar Diffuse, Global and Direct Solar Radiation, Equipments, Estimation Of Solar radiation on horizontal and tilted Surfaces, Global Solar radiation data, Indian Solar Radiation data analysis

3. Basic Concepts of Thermodynamics, Psychrometry

4. Basic Concepts of Fluid Mechanics:

Basic Concepts**, F**low through pipes, Fluid flow in solar water heaters

5. Basic Concepts of Heat transfer Concepts

Heat exchangers, overall heat transfer co-efficient, Design of single and multiple pass heat Exchangers, Heat Pipes, Heat Pumps and their applications in Solar Energy systems

6. Combustion

Basic physical laws governing combustion, air as a source of oxygen for combustion, combustion principles of solid-liquid-gaseous fuels, proximate and ultimate analysis of solid and gaseous fuels, Estimation of calorific values, combustion process, flame velocity, excess air requirements and estimation, flue gas analysis, combustion efficiency, stoichiometry, adiabatic flame temperature

Text Books /References:

1. RE Sonntag, C Borgnakke, GJ Van Wylen, *Fundamentals of Thermodynamics*, 6th Edition, (Wiley-India)
2. PK Nag, *Engineering Thermodynamics*, Third Edition (*Tata McGraw-Hill)*
3. YA Cengel and MA Boles, *Thermodynamics: An Engineering Approach*, 6th Edition (Tata McGraw-Hill)
4. SR Turns, *An Introduction to Combustion: Concepts and Applications*, 2nd Edition (McGraw Hill)
5. JB Jones and RE Dugan, *Engineering Thermodynamics*, PHI, New Delhi,
6. SP Sukhatme, *Solar Energy - Principles of thermal collection and storage*, 2nd edition, Tata McGraw-Hill, New Delhi
7. JA Duffie and WA Beckman, *Solar Engineering of Thermal Processes*, 2nd edition, John Wiley, NY
8. DY Goswami, F Kreith and JF Kreider, *Principles of Solar Engineering*, Taylor and Francis, Philadelphia

Course Code	Course Name	L	T	P	C
EN 601	Solar Photovoltaic Technology	3	0	0	3

1. Overview of Solar PV Research, Technology and Industry

2. Solar Cells

Conversion of Solar energy into Electricity - Photovoltaic Effect, Equivalent Circuit of the Solar Cell, Analysis of PV Cells: Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, Efficiency measurements, High efficiency cells, Recent developments in Solar Cells, Role of nano-technology in Solar cells

3. Fabrication Technology for Solar Cells

High efficiency multi-junction solar cell, Quantum well solar cell, Technology for the fabrication of thin film cells, Optical concentration, Effect of temperature on Cell performance, Thermo photovoltaic effect

4. Solar Photovoltaic System Design

Solar cell array system analysis and performance prediction, Shadow analysis: Reliability, Solar cell array design concepts, PV system design, Design process and optimization: Detailed array design, Voltage regulation, Maximum tracking, Quick sizing method, Array protection.

5. Solar Photo Voltaic System Testing

Sun Simulator, Testing and performance assessment of Solar PV generator, Electronic Control and Regulation, Power Conditioning, Converters and inverter, Concentrating system, System design and configuration

6. SPV Power Systems

Centralized and decentralized SPV systems, Stand alone, hybrid and, grid connected system, System installation, Operation and Maintenance, Application of PV for lighting, Water pumping. Refrigeration, Telecommunication, Cathodic Protection etc., Solar PV Power Plant-Status-Case Studies, Hybridization Engineering, Hybrid systems, Grid integration. Building Integrated PV Systems, PV market analysis and Economics of SPV systems,

Text Books/ References:

1. AL Fahrenbruch and RH Bube, *Fundamentals of Solar Cells: PV Solar Energy Conversion*, Academic Press, New York, 1983
2. T Bhattacharya, *Terrestrial Solar Photovoltaic*, Narosa Publishers Ltd, New Delhi LD Partain (ed), *Solar Cells and their Applications*, John Wiley and Sons, Inc, New York, 1995
3. RH Bube, *Photovoltaic Materials*, Imperial College Press, 1998
4. HS Rauschenbach, *Solar Cell Array Design Handbook*, Van Nostrand Reinfold Company, New York, 1980
5. R Messenger and J Vnetre, *Photovoltaic Systems Engineering*, CRC Press *Stand Alone PV Systems: A Handbook of Recommended Design Practices*, Report No SAND 87-7023, Sandia National Lab USA
6. F Kreith and JF Kreider, *Principles of Solar Engineering*, McGraw-Hill (1978)
7. J Twidell and T Weir, *Renewable Energy Resources*, Taylor and Francis (Ed), New York, USA, 2006

Course Code	Course Name	L	T	P	C
EN 602	**Bio- Energy Systems Technology**	**3**	**0**	**0**	**3**

1. Bio Energy Status

Bio Energy Resources, World Bio Energy Potential, India's Bio Energy Potential, Current Technology and Research Status

2 .Thermo-chemical conversions:

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

3. Bio- Energy Systems

Energy Efficient Wood Stoves : Traditional Stoves , Energy Efficient Cooking and Space heating Stoves, Metal Stoves Improved Gasifier Stoves , Current Research Status, Pollution due to smoke emissions ,

Bio- gas Systems : Technology of Bio-gas production, Biogas Plants , Digester types, Digester design, Chemical kinetics and mathematical modeling of bio- methanation process, Dung, Vegetable Waste and Night Soil and Municipal Waste based Bio -gas plants, Bio gas as fuel for transportation ,Lighting , Running Dual Fuel Engines**,** Electricity generation**,** Bio gas Bottling Plant Technology, Application of Bio gas slurry in agriculture , Design of Biogas for cold climates

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

4. Environmental Policy Issues of Bio- Energy systems

Text Books /References:

1. KC Khandelwal, SS Mahdi, *Biogas Technology - A Practical Handbook*, Tata McGraw Hill, 1986
2. RC Maheswari, *Bio Energy for Rural Energisation* , Concepts Publication, 1997
3. J Twidell and T Weir, *Renewable Energy Resources*, Taylor and Francis (Ed), New York, USA, 2006
4. B Sorensen, *Renewable Energy*,2nd Ed, Academic press, New York, 2000
5. G Boyle (Ed), *Renewable energy: Power for a sustainable future*, Oxford, OUP, 1996
6. Thomas B Johansson et.al, (Ed), *Renewable energy: Sources for Fuels and electricity*, Earthscan Publishers, London, 1993
7. S Silveira , *Bioenergy - Realizing The Potential* ELSEVIER, 2005
8. DD Hall and RP Grover, *Biomass Regenerable Energy*, John Wiley, New York, 1987
9. AS Pietro, *Biochemical and Photosynthetic aspects of Energy Production*, Academic Press, New York, 1980

Course Code	Course Name	L	T	P	C
EN-603	**Energy Laboratory-I**	**0**	**0**	**2**	**2**

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

1. Solar Radiation Data Monitoring and Analysis:

Sunshine hour duration, Direct Solar Radiation, Global Solar Radiation, Diffuse Solar Radiation, Net radiation [W/m^2], Outgoing radiation [W/m^2] , Infra red radiation,Diffuseradiation from global and direct radiation at a given zenith angle

2.Solar Photovoltaic:

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

3.Bio-mass Energy:

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

4.Fuel Properties and Analysis:

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

(ii).M.TECH CORE COURSE DETAILS: SEMESTER -II

Course Code	Course Name	L	T	P	C
EN 604	Solar Thermal Technology	3	0	0	3

1. **Over view of Solar thermal Energy Research Technology, and Industry**

2. **Flat-plate Collectors**
   Liquid Flat Collector, Materials for Flat plate Collectors **,** Energy balance for Flat Plate Collectors, Overall Heat Loss Coefficient , heat transfer between Parallel surfaces , Heat capacity effect, Testing methods, Types of Flat Plate Collectors: Liquid Flat Plate Collectors, Air flat-plate Collectors-Thermal analysis, Evacuated tubular collectors. Design of solar heating system

3. **Solar Thermal Energy Storage**

   Solar Energy Storage, Sensible storage, Latent heat storage, Thermo-chemical storage, Design of storage system

4. **Concentrating Collector Designs**

   Classification, design and performance parameters, tracking systems, Compound parabolic concentrators, parabolic trough concentrators, Concentrators with point focus, Heliostats

5. **Vapor absorption Refrigeration cycle**

   Water, ammonia and lithium bromide-water absorption refrigeration systems, Solar operated refrigeration systems, solar desiccant cooling, Current Status of Solar cooling

6. **Industrial Applications of Solar Heat**:

   Temperature requirements, consumption pattern, Solar Passive Heating and Cooling, Solar Thermal Power Plant, Modeling of Solar Thermal Systems, Solar Desalination, Solar Drying, Solar Cooking, Solar Greenhouse technology: Fundamentals, design, modeling and applications in agriculture and space heating

7. **Design of Solar Heating Systems:**

   Design and Sizing of Solar Heating Systems f – chart method and utilizability methods of solar thermal system evaluation

8. **Introduction to Solar Energy Soft wares**

Texts Books/References:

1. SP Sukhatme, *Solar Energy: Principles of Thermal Collection and Storage*, Tata McGraw-Hill,1984
2. JA Duffie and WA Beckman, *Solar Engineering of Thermal Processes*, John Wiley, 1991
3. B Sorensen, *Renewable Energy*, (2nd Ed), Academic press, New York, 2000
4. Garg HP, J Prakash, *Solar Energy: Fundamentals and Applications*, Tata McGraw Hill, New Delhi, 1997
5. DY Goswami, F Kreith and JF Kreider, *Principles of Solar Engineering*,Taylor and Francis
6. GN Tiwari, S Suneja, *Solar Thermal Engineering System*, Narosa Publishing House, New Delhi, 1997

Course Code	Course Name	L	T	P	C
EN 605	Wind Energy Technology	3	0	0	3

1. Wind Energy Basics

Global circulation, Forces influencing Wind - Pressure gradient force and Coriolis force, Local and Regional Wind systems, Atmospheric Boundary Layer, Atmospheric Stability, Surface Wind, Characteristic variables of wind and other related atmospheric parameters, Wind Data

2. Power in the wind

Power extracted from wind – stream tube model, linear momentum theory, power coefficient, Betz limit. Extreme winds calculation of theoretical power developed by the wind turbine

3. Wind Energy Atlas

Use of Wind Energy Data, Wind Speed Statistics, Weibull, Rayleigh and Normal distributions, Topographic Maps, Wind data of India

4. Measurement and Instrumentation

Concept of Measurement System, Anemometers, Wind sensing systems, Recording systems, Global Positioning System,

5. Wind Turbines

Types, Rotor elements, Horizontal and vertical axis wind turbines, slip stream theory. Calculation of axial thrust and efficiency, Pitch and stall regulation, Lift and drag coefficients, thrust and torque calculations, Tip losses, Characteristics of horizontal axis wind turbines and power curve. Concepts of blade design, Wind pumps. Matching of pump and turbine characteristics

6. Wind Turbine Siting

Basic approaches to Siting, Siting in homogeneous terrain and complex terrain

7. Wind Power farm Design

On land and offshore micro siting, Wind turbine energy production and Capacity Factor

8. Environment Safety

General Principles, guidelines and acceptable limits,Noise and Electro Magnetic Interference due to wind mills

Text Books /References:

1. *Meteorological Aspects of the Utilization of Wind as an Energy Source*, Technical Note No 175, World Meteorological Organization
2. EH Lysen, *Introduction to Wind Energy*, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, May 1983
3. T Burton, *Handbook of Wind Energy*, John Wiley and Sons
4. GL Johnson, *Wind Energy Systems*, Printice Hall Inc, New Jersy, 1985
5. www.windpower.dk
6. EH Lysen, *Introduction to Wind Energy*, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, May 1983
7. E Hau, *Wind Turbines- Fundamentals: Technologies, Application, Economics*, Springer -Verlag Berlin -Heidelbeg, 2000
8. *DNV- Riso Guidelines for Design of Wind Turbines*, 2nd Edition, Riso NationalLaboratory, Denmark, 2002
9. Hansen, Martin, O, L, *Aerodynamics of Wind Turbine*, James and James (Science Publishers) Ltd, London 2000

Course Code	Course Name	L	T	P	C
EN 606	Energy Efficiency and Management	3	0	0	3

1. Energy Efficiency

Energy Conservation, Need for Energy Efficiency , Indian Energy Conservation Act 2001 and its Features, Energy Star Rating of buildings and Equipments, Bureau Of Energy Efficiency Guidelines and Programmes

2. National Energy Building Code

Energy Building Code, Guidelines: Thermal Insulation, Heating, Ventilation and Air Conditioning System, Building Lighting Design: Lighting levels, light efficient options, CFL, LEDs, Fixtures, Day lighting timers, Building Energy Management

3. Energy Efficiency Improvement in Electrical Systems

Improving Energy Efficiency in Electrical Systems, Electrical load management, maximum demand control.

Power Factor: Power factor, power factor correction, selection and location of capacitors, performance assessment of PF capacitors and energy conservation opportunities

Electric Motors : motor efficiency, factor affecting motor performance, Energy saving opportunities in motors, energy efficient motors, soft starter with energy savers, motor efficiency measurements.

Transformers: Energy efficient transformers, factor affecting the performance of transformers

Electric Distribution: Energy conservation opportunities, cables, switch gears, distribution losses, energy conservation in house electrical distribution system

Compressed Air Systems: compressor efficiency, efficient compressor operation, leakage test, factors affecting the performance and energy savings

Pumps and Pumping System: Energy conservation opportunities, Agricultural pumps, Solar PV Pumps

Fans and Blowers: Energy Efficient system operation, flow control strategies and energy conservation opportunities, Solar PV fans

4. Energy Conservation in Boilers, Steam Turbines and Industrial heating Systems

5. Energy Audit

Energy Management in Buildings and Industry, Energy Audit: Methodology, Data Collection, Techno-economic Analysis, Energy Audit Measurements **:** Energy Audit Instruments**,** Combustion Analysis, Temperature , Pressure Flow, Humidity, Energy, Power, Light Level measurements, HVAC, Furnaces and Ovens, Boilers and Steam Lines, Air Compressor and Compressed Air Distribution Lines, Chillers and Chilled Water Distribution Lines, Process Water Generation and Distribution Lines, Electrical Distribution, Transformers and Lines, Pumps, Fans and Blowers, Cooling Towers, Electrical Motors, Waste Heat Sources, Material Transport, Peak Load Equipments, Duties and responsibilities of Energy managers and Auditors ,Case Studies of Energy Audit.

Text Books/References

1. LC Witte, PS Schmidt, DR Brown, *Industrial Energy Management and Utilization*, Hemisphere Publication, Washington, 1988
2. *Industrial Energy Conservation Manuals*, MIT Press, Mass, 1982
3. IGC Dryden, Butterworths (Ed), *The Efficient Use of Energy*, London, 1982
4. WC Turner (Ed), *Energy Management Handbook*, Wiley, New York, 1982
5. *Technology Menu for Efficient energy use- Motor drive systems*, Prepared by National Productivity Council and Center for Environmental Studies- Princeton University, 1993
6. Frank, Kreith, Ronald E West *Hand Book of Energy Efficiency*, CRC Press
7. Bureau of Energy Efficiency Study Material for Energy Managers and Auditors Examination Paper I to IV
8. BG Desai, BS Vaidya DP Patel and R Parman,Savings Electricity in Utility Systems of Industrial Plants Efficient use of electricity in industries
9. *Instructions to Energy Auditors*, Vol - I and Vol - II National Technical Information Services US Deptt of Commerce Springfield, VA 22161
10. *Energy Auditing*, The Fairmont Press Inc Published by Atlanta, Georgia

Course Code	Course Name	L	T	P	C
EN 607	Energy Laboratory -II	0	0	2	2

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

1. Solar Thermal Measurements and Analysis : Experimental study of thermal performance of Solar water heater, Evacuated tube Solar Collector, Solar Still, Thermal Performance of Solar drying System , Thermal testing of a box type Solar Cooker, Concentrator Type and Community Solar Cookers , Designing and Testing of Innovative Solar thermal Systems

2.Energy Performance of Buildings: **Solar Passive buildings :** Testing & Performance evaluation of Solar air heating systems: Solar Trombe wall, Thermosyponing Heating Panels, Attached green houses;Lighting Measurements & Analysis, Measurement and analysis of heat gain and air-conditioning load in a building, day lighting in a building: sky luminance, daylight from illumination from window and skylight

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

4.Wind Energy Measurements: Wind speed, Wind Direction, Data Measurement and Analysis, Performance evaluation of Wind Energy System, Wind Potential Assessment

5. Bio Energy Systems

Experimental study on thermal performance and efficiency of Biomass Energy systems : Gasifier ,Sampling and analysis of air and flue gas from biomass energy systems : Gasifier, combustor and cook stoves,Biogas production by anaerobic digestion and analysis, Bio-gas Plant comparision , Experimental Study of Cow dung, Vegetable Waste, Municipal Waste for Biogas production.

(iii).M.TECH CORE COURSE DETAILS: SEMESTER -III

Year II – Semester III

S. No.	Subject Code	Course Title	L	T	P	C	Hours/ Week
1.	EN-799	Self Study Course	0	0	0	3	3
2.	EN-800	Seminar	0	0	3	2	3
3.	EN-801	**Dissertation Phase –1 [to continue in the IVth semester]**	0	0	0	12	24
Total			**0**	**0**	**3**	**17**	**30**

EN-799: Self Study: - The faculty adviser will decide a specific problem and the students are required to study the subject. They are required to submit a syllabus in consultation with faculty adviser at the end of the second semester. Syllabus will be internally assessed by the faculty adviser and course coordinator and same will be approved in the department post-graduate committee.

EN-800: SEMINAR: - Each Student is required to present a seminar on a scheduled date and a typed copy of the seminar report is to be submitted. Assessment is based on the presentation and contents of seminar report

(iv). M.TECH CORE COURSE DETAILS: SEMESTER -IV

Year II - Semester IV

S. No.	Subject Code	Course Title	L	T	P	C	Hours/ Week
1.	EN-801	**Dissertation -Phase-II** [Analysis, Presentation ,Viva]	-	-	-	20	40
		Total				**20**	**40**

EN-801: DISSERTATION PRELIMINARY/ FINAL DISSERTATION

Each student is to carry out the dissertation work for which topic will be assigned at the end of the second semester.

The main objective of dissertation work is to provide scope for original and independent study/research, to develop a theme and to demonstrate ability of using analytical approach independently. The theme or topic of dissertation should be within the framework of P.G. Programme.

Thesis is prepared by each student under the supervision of the faculty advisor and to be submitted as per the specified time and the student has to defend his/her work at the viva-voce examination fixed by the Institute.

(V). M.TECH. ELECTIVE COURSES DETAILS:

Course Code	Course Name	L	T	P	C
EN 700	**Solar Passive Building Technology**	**3**	**0**	**0**	**3**

1. I**ntroduction**
   Bio-climatic classification of India, Passive Solar Passive Building and Green Building Concepts, National Building Code, Energy Star Rating , Policies on Energy Efficient and Green buildings

2. **Passive Heating Concepts**
   Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces, Solar Green Houses, Solar Wall, Solar Trombe wall

3. **Passive Cooling Concepts**
   Evaporative cooling, radiative cooling, Application of wind, water and earth for cooling, Shading, paints and cavity walls for cooling, Roof radiation traps, Earth air-tunnel systems for cooling

4. **Thermal Analysis and Design for Human Comfort**
   Thermal comfort, Criteria and various parameters, Psychometric chart, Thermal indices,Climate and comfort zones, Concept of sol-air temperature and its significance, Calculation of instantaneous heat gain through building envelope, Calculation of solar radiation on buildings, Building orientation, Introduction to design of shading devices, Overhangs, Factors that affect energy use in buildings, Ventilation and its significance, Air-conditioning systems,

5. **Heat Transmission in Buildings**
   Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, Wall and windows, Heat transfer due to ventilation/infiltration, internal heat transfer, solar temperature, Decrement factor, Phase lag, Day lighting, Estimation of Building loads: Steady state method, network method, numerical method, correlations

6. **Passive Solar Designs of Building**
   Thumb rules for design of buildings and building codes, Typical design of selected buildings in various climatic zones, Simulation Software's for carrying out thermal design of buildings and predicting performance

Text Books/ References:

1. MS Sodha, NK Bansal, PK Bansal, A Kumar and MAS Malik, *Solar Passive Building, Science and Design*, Pergamon Press, 1986
2. JR Williams, *Passive Solar Heating*, Ann Arbar Science, 1983
3. RWJones, JD Balcomb, CE Kosiewiez, GS Lazarus, RD McFarland and WOWray, *Passive Solar Design Handbook*, Vol 3, Report of US Department of Energy (DOE/CS-0127/3), 1982
4. J Krieder and A Rabi, *Heating and Cooling of Buildings: Design for Efficiency*, McGraw-Hill, 1994
5. RD Brown, TJ Gillespie, *Microclimatic Landscape Design*, John Wiley and Sons, New York, 1990
6. Climatology, DS Lal, Sharda Pustak Bhawan, Allahabad, 2003
7. TA Markus, EN Morris, *Building, Climate and Energy*, Spottwoode Ballantype Ltd, London, 1980

Course Code	Course Name	L	T	P	C
EN 701	**Bio- Fuels**	**3**	**0**	**0**	**3**

1. Bio-mass Resources
Formation of Bio- mass, Photosynthesis, Biomass Resources and classification, Physio - chemical characteristics, Biomass productivity: Energy plantation for power programme, International and National Potential and Status of Bio-fuels, Petro crops, Jatropa, Algae, Biomass briquetting

2. Chemical Conversion
Hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Solvolysis of wood, Chemicals from biomass

3. Thermo chemical Conversion
Thermal Decomposition Mechanisms of Bio-Renewable, Hydrothermal Liquefaction of Bio-renewable Feedstocks, Direct Liquefaction

4. Liquid Bio-fuels
Bio-diesel: History, Production methods of Bio-diesel: Fuel quality, standards and
Properties, Availability of Raw materials for bio-diesel, Applications, Bio-diesel potential in India
Bio-ethanol: Bio-ethanol feedstocks, Fuel Properties of ethanol, Ethanol from Biomass, Bio-ethanol production by fermentation of Carbohydrates,
Alternate fuels to Gasoline: Analysis of gasoline-alcohol mixtures, vegetable oil and diesel fuel mixtures, Hydrogen, Methane and Other Energy Fuels
Energy from Algae: Algae Cultivation, Photo-bioreactors, Harvesting, Sewage and Waste water growth conditions, algae biomass, algal meal/cake, Integration of CO_2 emitting industries for growth of Algae, Industrial production and Marketing strategy , Other applications of Algae : food, pigment etc.

5. Environmental Impact of Bio- fuels on Agriculture in India and World wide

6. Bio-fuel Economy and Policy

Text Books/ References

1. D Pimentel, *Bio-fuels, Solar and Wind as renewable energy systems: Benefits and Risks*, Springer, 2008
2. DM Mousdale, *Bio-fuels: biotechnology, chemistry, and sustainable development*, CRC Press, 2008
3. A Demirbas, *Bio-diesel: A realistic fuel alternative for diesel engines*, Springer, 2008
4. Anthony San Pietro, *Biochemical and Photosynthetic aspects of Energy Production*, Academic Press, New York, 1980
5. Thomas B Johansson et.al, (Ed), *Renewable energy: sources for fuels and electricity*, Earthscan Publishers, London, 1993
6. Robert A Andersen (Editor), *Algal Culturing Techniques*, University of Wisconsin Press, ISBN 0-299-10560-1, USA (3rd edition), 1987
7. JS Burlew, Algal Culture, from laboratory to pilot plant, Carnegie Institution of Washington, 1964
8. GW Prescott, *The Algae: a review*, Houghton Mifflin, 1968
9. Research papers on Bio-fuels

Course Code	Course Name	L	T	P	C
EN 702	Energy Generation from Waste	3	0	0	3

1. Solid Waste Sources

Solid Waste Sources, types, composition, Properties, Municipal Solid Waste: Physical, chemical and biological properties , Waste Collection and, Transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction , Managing Waste, Status of technologies for generation of Energy from Waste

2. Waste Treatment and Disposal

Aerobic composting, incineration, Furnace type and design, Medical waste /Pharmaceutical waste treatment Technologies, incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration

3. Land Fill method of Solid waste disposal

Land fill classification, Types, methods and Sitting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, Movement and control of landfill leachate and gases, Environmental monitoring system for land fill gases

4. Energy Generation from Waste

Bio-chemical Conversion: Sources of energy generation, Anaerobic digestion of sewage and municipal wastes, Direct combustion of MSW-refuse derived solid fuel, Industrial waste, agro residues, Anaerobic Digestion: Biogas production, Land fill gas generation and utilization, Thermo-chemical conversion: Sources of energy generation, Gasification of waste using Gasifiers , Briquetting, Utilization and advantages of briquetting , Case studies of Commercial Waste to Energy Plants , Present status ,[National and International] of Technologies for Conversion of Waste into Energy, Design of Waste to Energy Plants for Cities, small Townships and Villages

5. Environmental benefits of Bio-chemical and Thermo-chemical conversion

Text Books/References:

1. C Parker and T Roberts (Ed), *Energy from Waste - An Evaluation of Conversion Technologies*, Elsevier Applied Science, London, 1985
2. KL Shah, *Basics of Solid and Hazardous Waste Management Technology*, Prentice Hall, 2000
3. M Datta, *Waste Disposal in Engineered Landfills*, Narosa Publishing House, 1997
4. G Rich et.al, *Hazardous Waste Management Technology*, Podvan Publishers, 1987
5. AD Bhide, BB Sundaresan, *Solid Waste Management in Developing Countries*, INSDOC, New Delhi,1983

Course Code	Course Name	L	T	P	C
EN 703	**Energy and Climate Change Concerns**	**3**	**0**	**0**	**3**

1. **Energy**

   Energy Sources:
   Definition, Units, Forms of Energy, Power, Origin of Fossil fuels**,** World and Indian Resources of Coal, Oil, Natural gas, Nuclear, Geothermal, Renewable Energy potential : Solar Energy, Wind Energy, Bio-Energy, Hydro, Tidal, Ocean , Nuclear Energy, Nuclear Fission and Fusion , Geothermal Energy, Magneto-hydro-dynamic (MHD) energy conversion, Fuel Cells ,Waste to Energy Conversion, Hydrogen energy

   Energy Scenario:
   Global Energy Scenario: Energy consumption pattern in various sectors, Impact on economy, India`s Energy Scenario, Urban and Rural energy consumption patterns, Impact of Energy on Development, Energy Infra structure in India, India's Solar Energy Mission Programmes , Targets and Present Status

2. **Energy Policy**
   Review of Energy policies of various countries**, I**ndian Energy Policy, Renewable Energy Policy and Programmes, Review of State Energy Policies and Programmes in India

3. **Impact of Energy Projects on Environment**
   Overview of global environmental problems, Environmental degradation due to Energy production and use, Pollution due to thermal power stations , Environmental aspects of Wind Energy Farms ,Environmental aspects of Nuclear power generation, Nuclear waste disposal, Impact of Hydro power generation on Ecology and Environment, Guidelines for Environmental impact assessment (EIA) of Energy Projects

4. **Climate Change Concerns**
   Green House Gas Emissions, Depletion of Ozone layer, Global Warming, Climate Change Concerns, Climate Change in India, Kyoto protocol, Clean Development Mechanism [CDM], Carbon Fund Concept of Carbon credit

5. **Climate Change Policy Issues**
   Impact of Climate Change on Glaciers, Rivers and Water Resources, Climate Change Policy Issues in Himalayas, International Status of Climate Change Policies, Indian Action Plan on Climate Change

Text Books /References

1. EH Thorndike, *Energy and Environment: A Primer for Scientists and Engineers*, Addison-Wisley Publishing Company
2. R Wilson and W J Jones, *Energy, Ecology and the Environment*, Academic Press Inc
3. DW Davis, *Energy: Its Physical Impact on the Environment*, John Wiley and Sons
4. *Energy and the Challenge of Sustainability, World Energy assessment*, UNDP, N York, 2000
5. AKN Reddy, RH Williams, TB Johansson, *Energy after Rio, Prospects and challenges*, UNDP, United Nations Publications, New York, 1997
6. N Nakicenovic, A Grubler and A McDonald (Ed), *Global Energy Perspectives*, Cambridge University Press, 1998
7. NH, Ravindranath, K Usha Rao, B Natarajan, P Monga, *Renewable Energy and Environment – A Policy Analysis for India*, Tata McGraw Hill, 2000
8. JM Fowler, *Energy and the Environment*, 2nd Ed, McGraw Hill, New York, 1984
9. T widell and T Weir, *Renewable Energy Resources*, E and F N Spon Ltd, London, 1986
10. ER Berman, *Geothermal Energy*, Noyes Data Corporation, New Jersey.

Course Code	Course Name	L	T	P	C
EN -704	Hydro Power Technology	3	0	0	3

1. Basic Hydro Power Concepts

History of Hydro Power development , Importance of Hydro energy in the National Economy, Hydro Power Concepts , World and, Indian Hydro Energy Potential , Calculation of Hydro energy Potential of a Water Source , Hydro Power R & D Centres/ Institutions, Component Manufacturing Industry at International and National level

2. Water Mills

Designs of Traditional Water Mills Worldwide , Improved Water Mills : Turbines 1-5KW, , Relevance for hilly regions, Design considerations of a Water Mill System , MNRE Scheme, Present Status of Improved Water Mills

3. Hydro Power Plants

Design considerations of a Hydro Energy Power Plant ,Components of hydroelectric power plant, Various types of Turbines, hydro potential and exploitation in India, Micro hydal Power Projects , Major hydroelectric Power Plants in India, Hydro power projects in Western Himalayas, Environmental Impact of Large Hydro power Projects, Case studies

4. Economics, Policy, Organization, Regulations

Economic and financial assessments, planning process, Economics of hydro policies and initiatives of Government for promotion of hydropower, organizations involved in hydropower development, Financing of hydropower projects, Legal issues, , Implications of hydropower development from privatization,Sustainable use of natural resources and its implications on project economy, Implications on project development from Environmental Impact Assessment [EIA processes, Design, cost estimates and cost benefit analysis, Economic risk- and sensitivity analyses, corporate social responsibility

Text Books/References

1. G Brown, *Hydro Electric Engineering*: Vol. I, II, III
2. Nigam, *A Hand Book of Hydro Electric Engineering*, Nem Chand.
3. B Honningsvåg, *Hydropower in the New Millennium*, Proceedings of the 4th International Conference on Hydropower Development, Hydropower '01, Bergen, Norway, Taylor and Francis, 20-22 June 2001
4. F Koester, *Hydroelectric Developments and Engineering: A Practical and Theoretical Treatise on the Development, Design, Construction, Equipment and Operation of Hydroelectric Transmission Plants*, D. Van Nostrand Co.,Original from the New York Public Library, 1909
5. BR Gupta, Generation Electrical Energy, S. Chand & Co.

Course Code	Course Name	L	T	P	C
EN 705	**Environment Policy and Environment Impact Assessment**	**3**	**0**	**0**	**3**

1. Overview of Environment Policies and Programmes
Global**,** National Conservation Strategy and Policy on Environment,

2. Environmental Impact Assessment
Principles, Origin and development of EIA Environmental Impact Analysis, Essential components of EIA, Project Screening , Baseline study , Impact Identification, Impact prediction , Evaluation and Mitigation. Methodology matrix method, Network, Overlay, Problems of EIA in developing countries,

3. **Environmental Impact of large Projects**
Positive and Negative Impacts, Primary and Secondary Impacts, Impacts on Physical, Chemical, Biotic and Social Environment, Environmental Impact Statement and Environmental Management Plan for Selected Industries, Impact of Hydro projects and Cement Plants on Ecology and Environment in Himalayan Region

4. Case Studies
EIA Case Studies of Major Hydro power Projects and Cement Plants

5. Concepts of the Environmental Audit

5.1 Environmental Audit: Definition, Benefits, Objectives, Need for Environmental Audit

5.2 Legislation: Rules and Regulations, Gazette, Notification on Environmental Statement, Latest Amendments, Guidelines for Environmental Audit

5.3 Methodology

- Pre-audit activities, Preliminary Information, Audit Team.
- Activities at the site, Material Balance Waste Flow, Monitoring, Field Observations, Draft Report.
- Post-Audit Activities, Synthesis of Data Evaluation of Waste Treatment Facilities, Final report, Action plans, Follow up actions.
- Material and Energy Flow Assessment, Preparation of Audit Report
- Water Consumption
- Guidelines to Environmental Safe Layouts to Minimize Losses and Waste :Control Mechanism :Waste water reduction, Air emission reduction
- Preparation of Audit Report
- Case Studies

Text Books/References

1. Environmental Impact Assessment, Clark D Brain, Biesel Donald
2. EIA for Developing Countries, Biswas Asit K
3. *EIA Guidelines*, Notification of Govt of India Impact Assessment Methodologies and Procedures, 1994
4. W Canter (2nd Edition) *Environmental Impact Assessment*
5. Auditing for Environmental Quality Leadership Willing, T-Johan
6. Environmental Audit Mhastear A K
7. H Barton and N Brudes, *A Guide to local Environmental Auditing*, Earthscan Publications Ltd, 1995

Course Code	Course Name	L	T	P	C
EN 706	Energy Economics	3	0	0	3

1. Introduction

Law of demand, Elasticities of demand, Theory of firm: Production function, output maximization, cost minimization and profit maximization principles. Theory of market, National income and other macroeconomic parameters

2. Basic concepts of Energy Economics

Calculation of unit cost of power generation from different sources with examples Ground rules for investment in Energy sector, Payback period, NPV, IRR and Benefit-cost analysis with example

3. Socio-economic evaluation of Energy Conservation Programmes

Net Social Benefit incorporating Free riding concept and Rebound affects Energy-GDP elasticity,

4. Overview of Energy Policies

National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy

5. Models and Analysis of Energy Demand

Analysis of Environmental Pollution through decomposition of different sectors using I-O model, Interdependence of energy, economy and environment, Modeling concepts and application of SIMA model and I-O model for energy policy analysis,

Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India.

Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India

Text Books/References:

1. EA Diulio, *Macroeconomic Theory*, Schaum's Outline Series, 2nd Ed, McGraw-Hill Publishing Company (1990)
2. R Loulou, P R Shukla and A Kanudia, *Energy and Environment Policies for a sustainable Future,* Allied Publishers Ltd, New Delhi, 1997
3. J Parikh, *Energy Models for 2000 and Beyond*, Tata McGraw-Hill Publishing Company Ltd, New Delhi,1997

Course Code	Course Name	L	T	P	C
EN 707	Waste Heat Recovery Systems	3	0	0	3

1. Energy Pattern

Patterns of energy use, Types of waste heat recovery. Assessment of waste heat recovery, Sources of waste heat, Quality of waste heat, High, Medium and Low Temperature Heat Recovery, potential for energy conservation, Waste heat recovery from micro turbines, Waste Heat co generation

2. Optimum use of Energy Devices

Optimum use of energy resources, total energy approach, Coupled cycles, combined plants and cogeneration systems, Heat Wheel, Heat Pipes, Economizer, Heat Exchanger, Heat Pump, Need for energy storage, thermal electrical, magnetic and chemical energy storage systems, Utilization of industrial waste heat, gas-to-gas, gas-to-liquid and liquid-to-liquid , Low Temperature Waste Heat Utilization

3. Heat recovery Systems

Heat recovery systems, Recuperators and regenerators, heat pipes, Thermoelectric industrial waste heat analysis/characterization, waste heat recovery boilers, Creation of Electricity by Waste Heat Recovery, Fluidized bed heat recovery, shell and tube heat exchangers, Prime mover exhausts, Incineration plants, heat pump systems, thermoelectric devices, Utilization of low grade reject heat from power plants, Calculation of Heat Loses, Case Studies

Text Books/ References:

1. S Mukherjee, P Roy**,** *Mechanical Sciences Engineering Thermodynamics and Fluid Mechanics*, Prentice Hall, India
2. Narayanan, B Lakshnikutty, KV Narayanan **,***Stoichiometry and Process Calculations*, PHI
3. Singh, *Electric Power Generation Transmission and Distribution*, PHI
4. Bala Krishnamoorthy ,*Environmental Management*, PHI
5. Srinivasan, *Environmental Engineering*, PHI

Course Code	Course Name	L	T	P	C
EN 708	**Green Building Architecture and Planning**	**3**	**0**	**0**	**3**

1. Parameters of Climate, Role of climate in the design of buildings. Climatic zones of India, Detailed study of climatic design of indigenous shelters in response to different climatic zones of India
2. Building envelope, fenestrations and other building elements. Incorporation of Solar passive design features :Solar passive heating , cooling , natural day lighting
3. Energy conservation, Building Materials and construction techniques for achieving energy efficiency. Day lighting concepts, Energy efficient Illumination
4. Introduction to BEE, Energy Conservation Building Code, Energy simulation. Introduction of microclimate and the role of landscape and integration of solar passive heating and cooling feature in buildings
5. High performance envelope design, Study of the LEED and TERI (GRIHA) parameters and certification of Green Buildings
6. Basic concepts of Intelligent buildings

Text Books/ References:

1. I Koenigsberger, et.al *Manual of Tropical housing and Building* Longman Group Ltd London (now published by Orient Longman Ltd, Madras, India),1974
2. Oliver and Daniel, D Chiras *Natural Resource Conservation Management for a sustainable future,* Prentice Hall International Ltd, London, 1992
3. USAID International resource book, *Energy Conservation Building design Tip Sheet - Building Lighting Design,* 2008

Course Code	Course Name	L	T	P	C
EN 709	**Fuel Cells and Hydrogen Energy**	3	0	0	3

1. Fuel Cells

1.1. Fuel Cell Basics

Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cells Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells fuel cell electrochemistry - Nernst equation, Electrochemical kinetics, Butler-Volmer equation

1.2. Fuel cell types

Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential

1.3. Fuel cell design and components

Cell components, stack components, system components Overview of intermediate/high temperature fuel cells - Solid oxide fuel cells (SOFC), Molten carbonate fuel cells (MCFC), Phosphoric acid fuel cells (PAFC) Polymer Electrolyte fuel cells ,Heat and mass transfer in polymer electrolyte fuel cells, water management in PEFCs, Current issues in PEFCs, Direct methanol fuel cells (DMFC) - Electrochemical kinetics methanol oxidation, Current issues in MFCs, Fuel crossover in DMFCs, Water management in DMFCs, high methanol concentration operation, limiting current density

2. Hydrogen Energy

Hydrogen: Its merit as a fuel, Applications

2.1 Hydrogen production methods

Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods

2.2. Hydrogen storage methods

Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium

Text Books/Reference:

1. J Larminie and A Dicks, *Fuel Cell Systems Explained*, 2nd Edition, Wiley,2003
2. Xianguo Li, *Principles of Fuel Cells*, Taylor and Francis, 2005
3. S Srinivasan, *Fuel Cells: From Fundamentals to Applications*, Springer €
4. O'Hayre, SW Cha, W Colella and FB Prinz, *Fuel Cell Fundamentals*, Wiley, 2005
5. A Faghri and Y Zhang, *Transport Phenomena in Multiphase Systems*, Elsevier 2006

Course code	Course Name	L	T	P	C
EN 710	Wind Energy Farm Development and Operation	3	0	0	3

1. Introduction

General Principles and Basic Concepts, Techno economic feasibility considerations., Government and Private Utilities, Rules and regulations, Guidelines, Constraints, .Land selection, Topography and Survey details

2. Micro -Siting and layouts

Methods and procedures, selection of equipment, Transportation, installation and commissioning Local infrastructure and Power evacuation, Grid quality and reliability, Wind electric conversion systems, Operation efficiency of wind turbine, Preventive, Breakdown and Predictive maintenances of WECS subsystems, Failure analysis, aging and rehabilitation

3. Effective Operation of Wind Energy Farms

Concept of central monitoring system, Modern developments and improvements, Systems and Practices followed in other countries. Estimation of energy production, capacity factor, capacity credit and energy credit, offshore wind farm development and special considerations, Operation and supervision of wind farm

4. Environmental Impact Wind Energy Farms

Methods of reducing noise and Electro Magnetic Interference due to Wind farm, Industry guidelines, Government rules and regulations, Earthling, fencing, lightning protection in wind farms. Environmental effect of wind farm, development like terrain conditioning, approach road construction and movements of heavy machineries like crane and trailers

Text Books/ References:

1. T Burton, *Handbook of Wind Energy*, John Wiley and Sons
2. www.windpower.dk
3. Gary L Johnson, *Wind Energy Systems*, Printice Hall Inc, New Jersy, 1985
4. EH Lysen, *Introduction to Wind Energy*, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, May 1983
5. 5. E Hau, *Wind Turbines- Fundamentals, Technologies, Application, Economics*, Springer -Verlag Berlin -Heidelbeg, 2000
6. DNV Riso, *Guidelines for Design of Wind Turbines*, 2nd Edition, Riso National Laboratory, Denmark, 2002
7. Hansen, Martin, O, L, *Aerodynamics of Wind Turbine*, James and James (Science Publishers) Ltd, London 2000

Course Code	Course Name	L	T	P	C
EN 711	**Wind Energy Generators**	**3**	**0**	**0**	**3**

1. Basics

Classification and basic principles of operation of DC and AC generators, Application areas

2. Induction generators

Construction and Principle of operation, Development of equivalent circuit, Power equations, Voltage control of self-excited generators. Grid connected single and double output generators.

3. Synchronous Generators

Construction and principle of operation, operating characteristics Power flow equations, Salient pole synchronous machines: Two-reaction theory and phasor diagrams, Power angle characteristics.

4. Special Machines

Permanent magnet synchronous machines, Principle of operation, Power input and torque expressions, phasor diagram, Voltage regulation and control. Permanent magnet brushless DC machines: Commutation in DC machine, mechanical and electronic commutators, Torque and EMF equation, Voltage regulation and control. Position sensors, Losses and efficiency of electric generators, Specification and Testing, High efficiency, generators.

5. Application of wind electric generation in off grid mode and hybridization, Electrical safety related to wind electric generator

Text Books/References:

1. IJ Nagarath and D P Kothari, Electric Machines, Tata McGraw Hill, 2nd Ed, 2003
2. TJE Miller, *Brushless Permanent Magnet and Reluctance Motor Drives*, Clareden Press, Oxford, 1989
3. GL Johnson, *Wind Energy Systems*, Prentice Hall Inc, New Jersey, 1985
4. IEC 61400 *Wind Turbine Generator Systems*
5. SA Nasar, I Boldea and LE Unnewehr, *Permanent Magnet, Reluctance and Self-synchronous motors*, CRC Press, London
6. AE Fitzgerald and C Kingsley Jr, *AC Machinery*, Mc Graw Hill Book CoInc, Tokyo

Course Code	Course Name	L	T	P	C
EN 712	Industrial Applications of Nuclear Energy	3	0	0	3

1. Health Physics

Introduction, radiation Safety, regulatory aspects, radiation biology, operational radiation protection, radiation protection monitoring, Biological effects of radiation, Radiation therapy sterilization plants

2. Nuclear detectors

Radiation Monitoring, G-M Counters: characteristics, counting statistics, Scintillation detectors and gamma spectrometry, Multichannel analysis, Semiconductor detectors for alpha and gamma spectrometry, Radioisotope applications, Computer simulation studies.

3. Industrial Applications

Radio gauges: Principles**,** Alpha particle gauges based on transmissions. Scattering and ionization effects, Beta transmission gauges for measurements of sheets thickness, density and composition analysis, X-ray fluorescence principles, Neutron gauges. Well logging. Gamma and neutron radiography, Radioisotope power packs. Non -destructive testing for flaws in metal structures and welding seals, quality control of materials

4. Food Sterilization for Preservation

Radiation processing of food, benefits and limitations, Safety and Nutritional Adequacy of Radiation Processed Foods, Economics, National and International Status of Technology

Low Dose Applications: Sprout inhibition in bulbs and tubers, Delay in fruit ripening, insect disinfestations: quarantine treatment and elimination of food borne parasites

Medium Dose Applications : Reduction of spoilage microbes to improve shelf-life of meat, poultry and sea foods under refrigeration, Elimination of pathogenic microbes in fresh and frozen meat, poultry and seafoods, Reducing micro organisms in spices to improve hygienic quality.

High Dose Applications: Sterilization of hospital diets, Sterilization of packaged meat, poultry/ Indian and International regulations for food processing

5. Radio Tracer Applications

Text Books/ References:

1. UR Lamarsh, *Introduction to Nuclear Engineering* 2nd Edition, MA Addison Wesley, 1983
2. JG Collier and GF Hewitt, *Introduction to Nuclear Power*, Hemisphere Publishing, New York, 1987
3. JJ Duderstadt and LJ Hamiition, *Nuclear Reactor Analysis* - John Wiley 1976
4. AE Walter and AB Reynolds *Fast Breeder Reactor*, Pergamon Press - 1981
5. S Glasstone and A Sesonske, *Nuclear Reactor Engineering* (3 rd Edition), Von Nostrand, 1981

Course Code	Course Name	L	T	P	C
EN 713	**Nuclear Power Technology**	**3**	**0**	**0**	**3**

1. Basic Nuclear Concepts
Atomic Structure, Nuclear models, Equivalence of mass and energy, binding energy, Radio activity, half life, mechanism of nuclear fission and fusion, decay chains, critical mass and composition, neutron reactions ,

2. Nuclear Fuels
Nuclear fuel reserves of Uranium and Thorium, Nuclear fuel cycles, characteristics, production and purification, other fuels Zirconium, Beryllium**,** Reprocessing of nuclear fuels, Thorium Utilization in India

3. Nuclear Reactors
Nuclear reactors and classification, boiling water reactors (BWR), pressurized heavy water reactor (PHWR), fast breeder reactor (FBR), basics of nuclear fusion reactor

4. Nuclear Power Plant -Waste Management and Safety
Nuclear Power Plant, Nuclear power plant safety systems, Nuclear Accidents - consequences –case study, criteria for safety, Nuclear Waste management, International Convention on safety aspects, radiation hazards and their prevention

5. Nuclear Infrastructure in India
Department of Atomic Energy (DAE), NPCIL, AERB, BARC, Indian Nuclear Industry, Economics of nuclear power plants, peaceful use of nuclear energy

6. **Nuclear Policy and Regulations**
Atomic Energy Act, India's Nuclear Energy Programme, Indian nuclear energy policy, International Atomic Energy Agency [IAEA] ,International Nuclear Energy Policies and Regulations, Weapons proliferation NPT, safe guards to prevent nuclear proliferation, Indian Nuclear deal and 123 agreement and present Status of International Nuclear Co-operation

7. Nuclear Radiation Applications
Radiation processing of food and allied products, applications of radio isotopes in Industry and Agriculture, Industrial radiotracer applications in Ground water exploration, Desalination

Text Books/References:

1. TJ Cannoly, *Fundamentals of Nuclear Engineering* , John Wiley (1978)
2. JR Lamarsh, *Introduction to Nuclear Reactor Theory*, Wesley, 1966
3. UR Lamarsh, *Introduction to Nuclear Engineering* 2nd Edition, MA Addison Wesley, 1983
4. JG Collier and GF Hewitt, *Introduction to Nuclear Power*, Hemisphere Publishing, New York, 1987
5. JJ Duderstadt and LJ Hamiition, *Nuclear Reactor Analysis* - John Wiley 1976
6. AE Walter and AB Reynolds *Fast Breeder Reactor*, Pergamon Press - 1981
7. S Glasstone and A Sesonske, *Nuclear Reactor Engineering* (3 rd Edition), Von Nostrand, 1981
8. RHS Winterton, *Thermal Design of Nuclear Reactors* - Pergamon Press - 1981
9. Lipschutz RD, *Radioactive Waste - Politics, Technology and Risk*, (1980), Ballingor, Cambridge MA

Course Code	Course Name	L	T	P	C
EN 714	Materials for Energy Applications	3	0	0	3

1. **Materials**
   Glazing materials, Properties and Characteristics of Materials, Reflection from surfaces, Selective Surfaces: Ideal coating characteristics, Types and applications, Anti-reflective coating, Preparation and characterization. Reflecting Surfaces and transparent materials, Types of Insulation and properties

2. **Physics of Solar Cells**
   Intrinsic, extrinsic and compound semiconductors, Electrical conductivity, Density of electrons and holes, Carrier transport: Drift, diffusion, Absorption of light, Recombination process, Materials for Photovoltaic's Conversion, Si and Non-Si materials, crystalline, semi-crystalline, Polycrystalline and Amorphous materials, p-n junction: homo and hetero junctions, Metal-semiconductor interface

3. **Technology for Si extraction**

   Purification, Method of doping and junction fabrication, Cell fabrication and metallization techniques: Preparation of metallurgical, electronic and solar grade Silicon, Production of single crystal Silicon: Procedure of masking, photolithography and etching, Design of a complete silicon, GaAs, InP solar cell

4. **Sensible Heat Storage Materials**
   Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage

5. **Phase Change Materials**
   Selection criteria of Phase change, Materials use in Solar heating or cooling, Research Status

6. **Piezoelectricity and Ferro electricity**
   Optical properties, Interaction of solids with radiation, Luminescence, Photoconductivity

Text Books/References

1. HP Garg et.al, *Solar Thermal Energy Storage*, D Reidel Publishing Co, 1985
2. V Alexiades and AD Solomon *Mathematical Modeling of Melting and Freezing process*, Hemisphere Publishing Corporation, Washington,1993
3. R Narayan, B Viswanathan, *Chemical and Electrochemical Energy System*, Universities Press, 1998
4. A Ter-Gazarian, *Energy Storage for Power Systems*, Peter Peregrinus Ltd London, 1994
5. B Kilkis and S Kakac(Ed), *Energy Storage Systems*, KAP, London, 1989
6. WD Callister, Jr, *Materials Science and Engineering: An Introduction*, John Wiley, New York, 1997
7. ZD Jastrzebski, The *Nature and Properties of Engineering Materials*, John Wiley, New York, 1987

Course Code	Course Name	L	T	P	C
EN 715	Fuel Technology	3	0	0	3

1. Physics and chemistry of combustion. Solid, liquid and gaseous fuels. Petroleum as a source of energy and chemicals, Petroleum refining, petroleum products and their specifications and characteristics.

2. Coal as a source of energy and chemicals. Coal preparations, carbonization, gasification and liquefaction to oil. Natural gas and its derivatives: Coal bed methane, producer gas, water gas, biogas, refinery gas, LPG, cleaning and purification of gaseous fuels. Combustion appliance for solid, liquid and gaseous fuels: stoves, burners, combustors and their efficiency. Introduction to nuclear fuels.

3. Stoichiometry and thermodynamics, theoretical and excess air for combustion, Reaction rate, Premixed and diffusion flames, Droplet combustion. Flue gas analysis.

Text Books :

1. Sharma S.P. & Chander Mohan, (1984); Fuels & Combustion, Tata McGraw Hill Publishing Co.Ltd.,
2. Sarkar Samir, (1990); Fuels & Combustion, 2nd Edition, Orient Longman,
3. Sharma, B. K, (1998); Fuels and Petroleum Processing, 1st ed. Goel publishing, Meerut

Course Code	Course Name	L	T	P	C
EN 716	Bio-fuel Technologies	3	0	0	3

1. **Biomass Briquettes:** Raw materials, Shapes, Briquette burning, Airflow, Ash Removal, Positioning in fire , Briquette Production: Material Processing, Pressing, Densification Technology: Screw Compaction or Extrusion, Briquette Machines, Mechanical Briquetting Press, Roller Press, Pellet Mill, Agglomeration, Densification System Variables: Process Variables, Feedstock Variables.
2. **Transportation Biofuels:** Ethanol and Biodiesel, Feedstocks for Ethanol and Biodiesel Production: Jatropa, Lignocellulose substrate, Algae; Heterotrophic Production of Algae, Harvesting, Drying and Processing of the substrate material; Challenges related to water removal from Biomass; Conversion Technologies, End Uses of Algae, Integrated Approach of Production.
3. **Current Practices for Lipid Extraction:** Extraction and Measurement of Total Lipids, Mechanical Disruption (i.e., Cell Rupture), Organic Co-solvent Mixtures, Application of Organic Two-Solvent Systems.
4. **Biodiesel Production Method:** Direct Transesterification of Lipids into Fatty Acid Methyl Esters (FAMES), Current Research Status of Biodiesel Production in India.

References:

1. Nalladurai Kaliyan, University of Minnesota "Densification of Biomass" UMI Microform 3302306, 2008
2. MD Ahiduzzaman "Production and Use of Biomass Briquette Fuel in Bangladesh LAP Lambert Academic Publishing, 2011.
3. James G Speight, Mustafa Balat, Ayhan Demirbas, Mrinal K Ghose The Biofuels Handbook, RSC Energy Series Royal Society of Chemistry, 2011.
4. Ashok Pandey, Christian Larroche, Steven C Ricke, Claude-Gilles Dussap, Edgard Gnansounou, "Biofuels: Alternative Feedstocks and Conversion Processes", Academic Press, 2011.
5. James E. Graham, Lee W. Wilcox, Linda E. Graham "Algae", 2nd Edition© 2008, Benjamin Cummings Publication, ISBN-10: 0321559657.