Education	NATIONAL INSTITUTE OF TECHNOLOGY, ARUNACHAL PRADESH (ESTABLISHED BY MINISTRY OF HUMAN RESOURCE DEVELOPMENT, GOVT. OF INDIA)	Ethics
In GOD's own land, a fusion of scholastic students, innovative & motivated researchers & teachers and fast moving visionary leaders.	 **COURSE STRUCTURE & SYLLABUS FOR M-TECH IN RENEWABLE ENERGY AND ENERGY MANAGEMENT**	Steeping Stone and Sky reaching ladder to success
Research	PO- Yupia, Dist. – Papum Pare, Arunachal Pradesh, Pin – 791 112 Ph No : 0360-2284801/2001582 Fax No : 0360-2284972 Email – nitarunachal@gmail.com	Service to Society

NATIONAL INSTITUTE OF TECHNOLOGY

(Established by Ministry of Human Resources Development, Govt. Of India)
Yupia, District: Papumpare, Arunachal Pradesh–791112
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Syllabus for M. Tech in REEM

Prof. (Dr.) Chandan Tilak Bhunia, Ph.D [Engg.], FIETE, FIE (I), SMIEEE

DIRECTOR

FORWARD

To **achieve the target of being a global leader in the field of Technical Education**, there is some sort of time bound urgency **to work quickly, massively and strongly**, in respect of National Institute of Technology, Arunachal Pradesh being an **" Institute of National Importance"** (by an Act of Parliament) and being **established only in three years back in 2010**. I have therefore adopted a **'B' formula** as stated below to achieve the primary goal of producing world class visionary Engineers and Exceptionally brilliant Researchers and Innovators:

B- FORMULA

- **Best for Teaching**
- **Best for Research**
- **Best for Entrepreneurship & Innovation**
- **Best for Services to Society**

In implementing the **'B' formula** in letter and spirit, the framing of syllabi has been taken **as important legitimate parameter**. Therefore, extraordinary **efforts and dedications were directed for the last one year to frame** a syllabi **in a framework perhaps not available in the country as of today**.

Besides attention on **'B' formula** institute has given considerable importance to the major **faults of current Technical Education while framing the syllabus**. The major stumbling blocks in Technical Education today are:

I. The **present system is producing "Academic Engineers" rather than "Practical Engineers".**
II. The present system of education makes the **students to run after jobs rather than making them competent to create jobs.**
III. There is lack of **initiative to implement the reality of "Imagination is more important than knowledge".**

Taking due consideration of the findings made above, to my mind a credible syllabi has been framed in the institute in which the major innovations are introduction of:

I. **I-Course (Industrial Course) one in each semester at least one, which is targeted to be taught by the Industrial Expert at least up to 50% of its component.**
II. **Man making and service to society oriented compulsory credit courses of NCC/NSS, values & ethics.**
III. **Compulsory audit course on Entrepreneurship for all branches.**
IV. **Many add-on courses those are (non-credit courses) to be offered in vacation to enhance the employability of the students.**
V. **Many audit courses like French, German, and Chinese to enhance the communication skill in global scale for the students.**
VI. **Research and imagination building courses such as Research Paper Communication.**
VII. **Design Course as "Creative Design".**

Further, the syllabi has been framed **not to fit in a given structure as we believe structure is for syllabus and syllabus is not for structure. Therefore, as per requirement of the courses, the structure, the credit and the contact hours has been made available** in case to case.

The syllabus is also innovative as it includes:

I. **In addition to the list of text and reference books, a list of journals and magazines for giving students a flexible of open learning.**
II. **System of examination in each course as conventional examination, open book examination and online examination.**

Each course has been framed with definite objectives and learning outcomes. Syllabus has also identified the courses to be taught either of two models of teaching:

I. **J.C.Bose model of teaching where practice is the first theory.**
II. **S.N.Bose model of teaching where theory is the first practice.**

Besides the National Institute of Technology, Arunachal Pradesh has initiated a scheme of **simple and best teaching** in which for example:

I. **Instead of teaching RL, RC and RLC circuit separately, only RLC circuit will be taught and with given conditions on RLC circuits, RL and RC circuits will be derived and left to the students as interest building exercise.**
II. **Instead of teaching separately High Pass Filter, Band Pass Filter and Low Pass Filter etc.; one circuit will be taught to derive out other circuits, on conditions by the students.**

I am firmly confident that the framed syllabus will result in **incredible achievements, accelerated growth and pretty emphatic win over any other systems** and therefore **my students will not run after jobs rather jobs will run after my students.**

For the framing of this excellent piece of syllabus, **I like to congratulate all members of faculty, Deans and HODs in no other terms but "Sabash!".**

Prof. Dr. C.T. Bhunia

Director, NIT, (A.P.)

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TEACHING GUIDELINES

In order to achieve the desired goal of excellence and innovations in each and every function of National Institute of Technology, Arunachal Pradesh and to implement 'B' Plan in totality, I call upon my distinguished members of Faculty to invest some of their valuable business time in doing Research on Teaching. In this context, I put forward the following general guidelines for teaching practices in the institute:

1) **J.C. Bose Model of Teaching:** As an example, In the Basic Electronics course instead of first teaching the colour codes of the resistors in a theoretical class, teacher may carry few resistors to class and note down on the blackboard the colours of resistors and their values. Thereafter, the teacher may ask the students to device the color code creating enthusiasm among students. Similarly, instead of teaching the characteristics of PN junction diode, teacher may guide the students in a laboratory to draw the characteristics curve, then may advise the students to analyse the behaviour of characteristics. Thereafter, the teacher may teach the theory of PN junction diode.

2) **S.N. Bose Model of Teaching:** This is the conventional model of teaching where theory is first practice but even then I suggest some unique ideas to improve imaginative power and creativity of students in the subject. For example, instead of teaching two algorithms for conversion of decimal to binary, one for integral part and another for fractional part, I call upon the teachers to design a single algorithm for both the purposes for inspiring teaching.

3) I also believe that noble teaching **will be simple and in simpler way.** Therefore, I call upon the teachers not to teach bandpass filter, low pass filter, high pass filter separately. Teachers may design a single circuit for all filters and put on condition thereon can derive separately circuits for separate filters. Similarly, instead of teaching RL, RC and RLC circuits separately, I call upon the teachers to teach only RLC circuit and then putting suitable condition on RLC circuit; RL and RC circuits may be derived and taught.

4) **Last but not the least,** I call upon the teachers to **solve all the problems of all chapters of the main text book prescribed for a subject** in a teaching-learning process – 50% to be solved by teachers (may be of even ones) and 50% may be solved by students (may be odd ones).

I solicit and anticipate full cooperation from all my brilliant pool of young and energetic faculty members to practice the nobel and novel teaching procedures explained above without fail. Once **procedures implemented by teachers are documented,** we may proceed to file a patent on **Research in Teaching on behalf of NIT, Arunachal Pradesh.**

Prof. Dr. C.T. Bhunia

Director, NIT, (A.P.)

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Syllabus for M. Tech in REEM

INDEX

SEMESTER – I

Course Code	Course Name	P	T	L	Cr.
EE 901	Energy Systems	0	0	3	3
EE 902	Solar Power Generation	2	0	3	4
EE 903	Wind Power Generation	2	0	3	4
EE 904	Hydro Power Generation	2	0	3	4
EE 905	Other Sources of Energy	0	0	3	3
MAS 901	Applied Engineering Mathematics	0	0	3	3
TOTAL		**6**	**0**	**15**	**21**

SEMESTER – II

Course Code	Course Name	P	T	L	Cr.
EE 906	Energy Management & Auditing	0	0	3	3
EE 907	Applied Power Electronics & Drives	2	0	3	4
EE 908	Environmental Impact Assessment	0	0	3	3
EE 909	Smart Grids	2	0	3	4
EE 9xx	Elective	2	0	3	4
HSS 901	Industrial Management	0	0	3	3
TOTAL		**6**	**0**	**18**	**21**

SEMESTER – III

Course Code	Course Name	P	T	L	Cr.
EE 910	UG Teaching Practice (Specified by Guide)	6	0	0	3
EE 911	Seminar	6	0	0	3
EE 912	Dissertation (Continued to 4th Semester)	24	0	0	12
TOTAL		**2**	**0**	**18**	**19**

SEMESTER – IV

Course Code	Course Name	P	T	L	Cr.
EE 913	Dissertation	0	30	0	30
TOTAL		**0**	**30**	**0**	**30**

ELECTIVE PAPERS

Subject Code	Subject	P	L	T	Credit
EE 914	Distribution Generation	2	0	3	4
EE 915	HVDC Transmission System	2	0	3	4
EE 916	Generalized Theory of Electrical Machines	2	0	3	4
EE 917	Power Quality Issues & its Remedial Measures	2	0	3	4
EE 918	FACTS Controllers & HVAC Transmission System	2	0	3	4
EE 919	Hybrid System of Conventional Energies	2	0	3	4
EE 920	Micro-Grids Systems	2	0	3	4
EE 921	Rural Electrification & its Management	2	0	3	4

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Syllabus for M. Tech in REEM

Name of the Module: Energy Systems
Module Code: EE 901
Semester: 1st
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Objective:

The course objectives aim to sensitize students on:

1. various renewable energy resources available in the country, their potential, exploitation/achievements etc.,
2. solar energy radiation on the earth surface and outside earth atmosphere, solar radiation measurement and estimation etc.,
3. wind resource assessment, site selection for wind turbines, wind systems, physics of wind and wind measurements and instruments,
4. small hydro resource assessment, hydrographs, estimates for flow, head, and power site selection,
5. geothermal, wave, tidal and OTEC resources assessment, estimation of power potential, site selection,
6. bio-energy resource assessment, physical and chemical properties, composition.

B. Learning Outcomes:

Students successfully completing this module will be able to:

1. work on research topics of different sources of non-conventional energy systems,
2. analyse the energy scenario of our country,
3. impart knowledge on different ways of energy generation.

C. Subject Matter:

UNIT I:

Introduction: Sources of renewable energy –solar, wind, small hydro, biomass, geothermal and ocean energy, energy flow in ecosystem.

Solar Energy Resources: Solar radiation: spectrum of electromagnetic radiation, solar radiation data requirements, sun structure and characteristics, solar constant, spectral distribution, sun earth geometric relationship, solar angles, sun's trajectories in different seasons, zenith solar time, air mass, beam, diffuse and total solar radiation, irradiance, insolation, solar radiation on different surfaces at different angles, extraterrestrial radiation.

Attenuation of solar radiation by the atmosphere, albedo, beam and diffuse components of hourly and daily radiation, clearness index. Radiation augmentation, radiation on the moving surfaces. Utilizability radiation.

Measurement of solar radiation: Instruments-sunshine recorder, pyranometer, pyrheliometer, albedometer. Radiation measurement stations in India, solar radiation data, graphs.

Prediction of available solar radiation: models and methods for estimating solar radiation, estimation of global radiation, estimation of diffused components, solar mapping using satellite data, Typical Meteorological Year**.** Solar time, sidereal time, universal standard time, local standard time, Equation of time.

UNIT II:

Wind resource assessment, site assessment, micrositing, global wind system.

Physics of wind: Wind systems, geostrophic winds, frictional force, boundary layer wind, monsoon system, sea and land system, mountain valley system, katabatic wind, desert wind,

mechanics of wind, wind power density, atmospheric boundary layer, height extrapolation of wind speeds, and wind flow over hills and mountains.

Wind systems in India: Sea and land systems, mountain wind systems, and monsoons. Wind measurements, instrumentation, and data characteristics: Wind resource map of India, screening probable sites and various indicators involved, instrumentation, wind speed measurement, data presentation, wind distribution, wind rose.

Spatial wind resource assessment tools: Wind Atlas Analysis and Application Programme (WAsP) model, satellite data and GIS based techniques.

UNIT III:

Small Hydro Systems: Indian resource potential and exploitation, power potential estimation, hydrographs.

Resource assessment: Methods for determining head and flow, head and flow measurements, site evaluation, cartography, geotechnical studies.

Geothermal & Ocean Energy:

Heat mining, potential sites, Darcy's law, volcano related heat resources, sedimentary basins, hot dry rocks, estimation of wave power, tidal power sites, scatter diagram of wave heights, Ocean Thermal Energy Conversion resource map.

UNIT IV:

Biomass resources- plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis.

Biomass resource assessment: Estimation of woody biomass, non woody biomass and wastes, ASTM standards.

Bulk chemical properties: Moisture content, proximate and ultimate analyses, calorific value, waste water analysis for solids.

Chemical composition of biomass: Cellulose, hemicelluloses and lignin content in common agricultural residues and their estimation, protein content in biomass, extractables, COD.

D. Books:

1. *Donald Klass: Biomass for Renewable Energy, Fuels, and Chemicals, (Entech International Inc., USA)*
2. *Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore (TERI Press, 2008).*
3. *JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition (John Wiley & Sons)*
4. *S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition (Tata McGraw Hill, 2008)*
5. *TERI Energy Data Directory (TEDDY) 2009 (TERI Press, 2009)*

E. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

F. Journals:

1. *International journal of renewable energy resources.*
2. *International Journal of non-conventional energy resources.*
3. *AT &T Technical Journals.*

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Syllabus for M. Tech in REEM

Name of the Module: Solar Power Generation
Module Code: EE 902
Semester: 1st
Credit Value: 3 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Objective:

The course is designed to meet the objectives of:

1. to develop capability in the students to design solar thermal and solar photovoltaic power generating units in various modes for example: standalone, grid connected, hybridization,
2. financial and related environmental implications of the two systems, Case studies and actual application of available software for design of solar power systems are also covered.

B. Learning Outcomes:

Upon completion of the subject, students will be:

1. adequately trained to research Solar Photovoltaics Systems.
2. skilled both theoretically and practically to use this subject for the application in solar power generation systems.

C. Subject Matter:

UNIT I:

Solar radiation – Review. Models for radiation analysis and beam radiation calculations. Solar concentrators: Parabolic trough, parabolic dish: continuous type and Fresnel type Tracking mechanisms: single axis and double axis trackings Solar thermal technologies: Solar Parabolic trough: design considerations, tracking and control systems, thermal design of receivers, Solar parabolic dish: design considerations, Sterling engine, Brayton cycle, tracking and control systems, Solar tower concepts: tower design, heliostat design, receiver types, tracking and control systems, Material and product/technology overview for the above technologies. Advanced collectors and solar concentrators, Selective coatings.

UNIT II:

Emerging technologies: Linear Fresnel reflector, Solar chimney Solar pv power plants: Performance study, site selection and land requirement. Sizing and Reliability

UNIT III:

Solar PV power plants: Solar PV technologies overview - stationary and concentrated PV, inverter and control technologies, master slave inverter system design, standalone systems, grid connected systems, hybridization, synchronization and power evacuation, site selection and land requirements. Charge Conditioners, Interface Components, Balance of System Components.

UNIT IV:

Techno-economic analysis of solar thermal and solar PV power plants, Environmental considerations, green house gas calculations.

Application of softwares: TRNSYS, RETScreen, Solar advisor, Design of one each solar thermal and solar PV power.

D. List of Practical:

1. Determining the intensity of solar radiation.
2. Arrangement of Photovoltaic cells.
3. Setting up of the Photovoltaic panel with the help of the given settings to get the maximum exposure of the sunlight.
4. Measurement of V/I Characteristics of the mono-crystalline cells
5. Measurement of V/I Characteristics of Polycrystalline cells

6. Connecting of Photovoltaic cells in series and measuring their V/I Characteristics.
7. Connecting of Photovoltaic cells in Parallel and measuring their V/I Characteristics.
8. Connecting of Monocrystalline and polycrystalline cells in series and parallel and measuring their characteristics
9. Connecting a battery to the inverter and measuring the output using a meter
10. Connecting a battery to the inverter and observing the waveform using a oscilloscope
11. Doing exp no 8 & 9 with different loads.
12. Connecting a solar panel with inverter and measuring the output using meter.
13. Connecting a solar panel with inverter and observing the output using Oscilloscope.

E. Books:

1. *Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. VVN Kishore (TERI Press, 2008).*
2. *CS Solanki: Solar Photovotaics – Fundamentals, Technologies and Applications, (PHI Learning)*
3. *JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition (John Wiley & Sons)*
4. *S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition (Tata McGraw Hill, 2008)*

F. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

G. Journals:

1. *International journal of renewable energy resources.*
2. *International Journal of non-conventional energy resources.*
3. *AT &T Technical Journals.*

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Syllabus for M. Tech in REEM

Name of the Module: Wind Power Generation
Module Code: EE 903
Semester: 1st
Credit Value: 3 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Objective:

The course is designed to meet the objectives of:

1. to develop capability in the students to design wind power generation systems and make students aware with the challenges of the field,
2. to give students in depth understanding of wind generators, their integration to electric grid, related technical and economic challenges.

B. Learning Outcomes:

Upon completion of the subject, students will be:

1. adequately trained to research Wind power generation systems,
2. skilled both theoretically and practically to use this subject for the application in wind power generation systems.

C. Subject Matter:

UNIT I:

Introduction: Review of wind resource assessment, basic laws and concepts of aerodynamics (2-D, 3-D aerodynamics). Description and performance of the horizontal–axis wind machines, description and performance of the vertical–axis wind machines. Site Selection – Wind climatology, terrain features, surface roughness etc. Micro siting of wind turbines, site Identification, wind mast installation. Annual Energy Output estimation Uncertainties in estimation. Probabilities of Estimation. Betz criterion, Analysis of wind regimes – statistical analysis of wind regimes, Dynamics of data acquisition. Time distribution, Frequency distribution. Statistical Modelling.

UNIT II:

Wind Power Project Planning & Structuring:
Bank ability of Projects: Promoters, Financing, Balance Sheet, Non-Recourse or Project Finance, Leasing, Taxation Issues.
Electricity off Take Arrangements & Structures:
PPA with utility, Captive, Group Captive, Open Access & Merchant Sale
Project Contracts:
Wind Turbine Supply Contracts, Works Contracts, E&C Contract, O&M Contract

UNIT III:

Risk Mitigation Indemnities & Liabilities Power Curve Measurement, Project Management: Project Implementation Activities, Pert/ CPM/ MS Projects, Quality Assurance in Project Implementation. Evaluation & analysis, Implementation & monitoring, Performance indices.

UNIT IV:

Wind Turbine Generators: Induction, Synchronous machine, constant V & F and variable V & F generations, Reactive power compensation.
Site Selection, Concept of wind form & project cycle, Cost economics & viability of wind farm,

D. List of Practical:

1. Study of the aero generator operation in function of the wind speed variation.
2. Generator angle of incidence variation.
3. Operation differences using the three available blades configurations (aero generator with 6, 3 or 2 blades).

4. Operation differences depending on the angle of the blades.
5. Load variation influence on the aero generator.
6. Study of the voltage, power and current.
7. Study of V, I, W in function of different loads.
8. Efficiency experimental determination (depending on: number of blades, angle of the blades, generator´s angle; among others).
9. Wind energy measurement.
10. Familiarization with the regulator parameters.
11. Study of the power generated by the aero generator depending on the wind speed.
12. Study of the power generated by the aero generator depending on the air incident angle.
13. Connection of loads to direct voltage.
14. Study of the grid utility inverter.

E. Books:

1. *Johnson GL. Wind Energy Systems, (Electronic Edition), Prentice Hall Inc, 2006*
2. *Mathew S. Wind Energy: Fundamentals, Resource Analysis and Economics. Springer, 2006*
3. *Burton T. Sharpe D. Jenkins N. Bossanyi E. Wind Energy Handbook. John Wiley, 2001*
   Jha AR. Wind Turbine Technology, CRC Press, Taylor & Francis, 2011
4. *Jain P. Wind Energy Engineering. McGraw-Hill 2011*
5. *Nag P K. Power Plant Engineering, 3rd Edition, Tata McGraw Hill, 2008.*
6. *Bansal RK. A textbook of fluid mechanics and hydraulic machines. Laxmi Publications, 2005, New Delhi*
7. *Hussian Z. Abdullah MZ. Alimuddin Z. Basic Fluid Mechanics and Hydraulic Machines.*

F. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

G. Journals:

1. *International journal of renewable energy resources.*
2. *International Journal of non-conventional energy resources.*
3. *AT &T Technical Journals.*

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Syllabus for M. Tech in REEM

Name of the Module: Hydro Power Generation
Module Code: EE 904
Semester: 1st
Credit Value: 3 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Objective:

The course is designed to meet the objectives of:

1. to make students aware about the uses of small and micro hydro plants,
2. identification of hydro as a competitive conventional source of energy.

B. Learning Outcomes:

Upon completion of the subject, students will be:

1. adequately trained to research hydro power generation systems.
2. skilled both theoretically and practically to use this subject for the application in hydro power generation systems.
3. made aware about the implications and new techniques for their mitigations, for the operation of a hydro power plant.

C. Subject Matter:

UNIT I:

Introduction to Hydropower, Hydrology – descriptive hydrology, hydrograph, mass curve, storage, dams,

Classification of Hydropower Plants, Small Hydropower, Systems: Overview of micro, mini and small hydro systems Status of Hydropower Worldwide

Advantages and Disadvantages of Hydropower, Selection of site for hydroelectric plant, Hydrological cycle, Essential elements of a hydroelectric power plant.

UNIT II:

Classification of Fluids, Characteristic of Water, units of Pressure, Pascal's law, applications of Pascal's law, Hydraulic press, Pressure measurement Types of fluid flow, stream line and turbulent flow Velocity Equation, Bernoulli's Equation, Power Equation, Continuity Equation, Cavitations, venturi meter, orifice meter, Pitot tube.

UNIT III:

Components of hydropower plants Hydraulic Turbines: Types and Operational Aspects Classification of Hydraulic Turbines, Theory of Hydroturbines; Francis, Pelton, Kaplan and Propeller Turbine; differences between impulse and reaction turbines; Operational Aspects of Turbines Efficiency and selection of turbines, Types of generators - synchronous and induction, transformers, protection & control, transmission and distribution system. Dam and Spillway, Surge Chambers, Penstock, Tailrace.

UNIT IV:

Site selection, environmental aspect, run-of-the-river and storage schemes; diversion structures, power channels, desilting arrangements, forebay tank and balancing reservoir, penstock and power house; transmission and distribution system.

Economics: cost structure, Initial and operation cost. Environmental issues related to small and large hydropower plants, Potential of hydro power in North East India.

D. List of Practical:

1. To perform a detailed study on the pumped storage hydro power plant,
2. To operate the given hydropower plant and find out the terminal voltage and frequency,
3. To synchronize the given power plant with grid system,
4. Determine the active , reactive and apparent power of given power plant,

5. Detect of mains harmonics oscillations and neutral conductor current,
6. To regulate the power both in generator and motor of given power plant,

E. Books:

1. *Jiandong T. Mini hydropower. John Wiley, 1997*
2. *Wagner H. Mathur J. Introduction to Hydro energy Systems : Basics, Technology and Operation,Springer, 2011*

F. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

G. Journals:

1. *International journal of renewable energy resources.*
2. *International Journal of non-conventional energy resources.*
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Syllabus for M. Tech in REEM

Name of the Module: Other Sources of Energy
Module Code: EE 905
Semester: 1st
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Objective:

The course is designed to meet the objectives of:

1. to make students aware of the energy scenario and the environmental aspects related to the utilization of energy sources,
2. To make students familiar with non-conventional sources of energy.

B. Learning Outcomes:

Upon completion of the subject, students will be:

1. adequately trained to research in area of alternative sources of energy.
2. skilled both theoretically and practically to address the issue of energy crisis with emerging technologies of energy generation.

C. Subject Matter:

UNIT I:

Need of energy systems and materials, Application to supplement and expedite energy conservation efforts, Addressing environmental concern, Suitability as CDM.

Energy and its various forms, Commercial and Non-commercial energy, primary energy resources, commercial energy production.

Energy pricing, energy security, energy conservation and its importance, Electricity tariff, load management and maximum demand control, Thermal energy contents of fuel, heat capacity, sensible and latent heat, heat transfer, Stochiometric air-fuel ratio, Flue gas analysis.

UNIT II:

Hydrogen Energy:

Basics of Hydrogen Energy, Production methods, Storage and transportation, Applications.

Fuel Cell:

Principle of working, Basic thermodynamic and electrochemical, principles, Classifications, Applications for power generations

UNIT III:

Ocean Energy:

Ocean energy resources, Ocean energy routes, Ocean thermal energy conversion, Wave energy conversion, Tidal energy conversion.

Geothermal Energy:

Origin, Types of geothermal energy sites, Geothermal Power plants.

Ocean Thermal Energy Conversion (OTEC) – Principle of utilization, setting of plants and their economies, Tidal and wave energy - potential and conversion techniques

Geothermal Energy – Methods of harnessing the energy, potential in India

UNIT IV:

Magneto-hydrodynamic (MHD) energy conversion:

Principle of operation, Classifications, Features of MHD Systems.

Electrochemical Energy Storage System:

Batteries, Types, Working principles, Role of carbon nanotubes in electrode

Magnetic and Electric Storage System:

Super conducting magnetic energy storage (SMES) systems, Capacitor and super capacitor.

D. Books:

1. *Narayan R. Biswanathan B. Chemical and Electrochemical Energy Systems, University*

Press (India)Ltd. 1998.

2. *J W Twidell & A D Weir, Renewable Energy Resources, ELBS, 2006*
3. *Tiwari GN. Ghoshal MK. Fundamental of Renewable Energy Sources, Narosa, 2007.*

E. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

F. Journals:

1. *International journal of renewable energy resources.*
2. *International Journal of non-conventional energy resources.*
3. *AT &T Technical Journals.*
4. *IEEE Transactions on Renewable Energy Sources.*

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Syllabus for M. Tech in REEM

Name of the Module: Applied Engineering Mathematics
Module Code: MAS 901
Semester: 1st
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Objectives:

The course is designed to meet with the objectives of:

1. providing high quality education in pure and applied mathematics in order to prepare students for graduate studies or professional careers in mathematical sciences and related fields,
2. imparting theoretical knowledge and to develop computing skill to the students in the area of Science and Technology,
3. providing teaching and learning to make the students competent to their calculating ability, logical ability and decision making ability,
4. giving students theoretical knowledge of Calculus, Algebra and their practical applications in the various fields of Science and Engineering,
5. apply their knowledge in modern industry or teaching, or secure acceptance in high-quality graduate programs in Mathematics and other fields such as the field of quantitative/Mathematical finance, Mathematical computing, statistics and actuarial science.

B. Learning Outcomes:

Students successfully completing this module will be able to:

1. students will become more confident about their computing skill, logical skill and decision making skill,
2. students will find various applications of calculus and algebra in the practical fields science and engineering,
3. students will become more competent to analyze mathematical and statistical problems, precisely define the key terms, and draw clear and reasonable conclusions,
4. student will be able to use mathematical and statistical techniques to solve well defined problems and present their mathematical work, both in oral and written format, to various audiences (students, mathematicians, and non-mathematicians),
5. student will be able to understand, and construct correct mathematical and statistical proofs and use the library and electronic data-bases to locate information on mathematical problems,
6. student will be able to explain the importance of mathematics and its techniques to solve real life problems and provide the limitations of such techniques and the validity of the results,
7. student will be able to propose new mathematical and statistical questions and suggest possible software packages and/or computer programming to find solutions to these questions.

C. Subject Matter:

UNIT I:

Introduction and overview, Dominant balance and polynomial equations, Dimensions and Dimensional Analysis, Introduction to Numerical Asymptotics, Random polynomial equations and eigen values, First order ordinary Differential Equations, Simple Integrals, Higher order differential equations, Special Functions: Bessel and linear ODEs, Connections, Numerical and asymptotic, Nonlinear boundary value problems, Boundary Layers.

UNIT II:

Linear Partial Differential Equations, Diffusion, wave, Laplace and random walks and abstract final project, Green functions.

UNIT III:

Integral transforms and oscillatory integrals, Integral transforms of linear equations, evaluating integral transforms: Colors of the rainbow, Stationary phase, Saddle points.

UNIT IV:

Nonlinear Partial Differential Equations, A Nonlinear diffusion equation, A reaction diffusion equation, Burger's equation.

D. Books:

1. *Michael P. Brenner,* Physical Mathematics.
2. *G. F. Carrier, M. Krook and C. E. Pearson,* Functions of a Complex Variable, *McGrawHill, 1966.*

E. Magazines:

1. *Current Science (Indian Academy of Science).*
2. *The Mathematics Student (Math Student) (Indian Mathematical Society).*
3. *Mathematical Spectrum (The University of Sheffield).*
4. *Mathematics Magazine (Mathematical Association of America).*
5. *+Plus magazine (University of Cambridge).*
6. *Mathematics Today, London Metropolitan University.*

F. Journals:

1. *Journal of Engineering Mathematics, Springer.*
2. *Journal of Computational and Applied Mathematics, London Metropolitan University.*
3. *The Journal of Indian academy of Sciences.*
4. *Bulletin of Pure and Applied Sciences.*

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Syllabus for M. Tech in REEM

Name of the Module: Energy Management & Auditing
Module Code: EE 906
Semester: 2nd
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Objectives:

The course is designed to meet the objectives of:

1. to gather knowledge on energy auditing techniques used for non-conventional energy systems,
2. to work on efficient energy systems used in various non-conventional energy generation techniques.

B. Learning outcomes:

Upon completion of the course, students will be able to:

1. perform energy auditing tasks in different fields & development of energy efficient systems,
2. design and develop consumer products for the betterment of human kind.

C. Subject Matter:

UNIT I:

Energy Management

Scope of energy management, necessary steps in energy management programme, general principles of energy management, qualities of energy manager, functions of energy manager, language of energy manager.

Energy Audit

Energy surveying and auditing, objectives, uses of energy, energy conservation schemes, energy index, cost index, pie charts, Sankey diagrams, load profiles (histograms), types of energy audits-preliminary energy audit – detailed energy audit, questionnaire, energy audit instruments, Energy audit report writing.

Energy Conservation

Indian energy conservation act-2001, second law of thermodynamics, rules for efficient energy conservation of energy and materials, technologies for energy conservation (reducing demand using alternative supplies, load factor, balancing and energy storage), supply side options, demand side options, maximum demand controller, transmission and distribution side options.

Energy Efficient Motors

Constructional details, factors affecting efficiency, losses distribution, soft starters, variable speed drives.

UNIT II:

Power Factor

Causes and disadvantages of low power factor, methods to improve power factor, automatic power factor controllers.

Energy efficient lighting

Terminology, cosine law of luminance, types of lamps, characteristics, design of illumination systems, good lighting practice, lighting control, steps for lighting energy conservation.

Boilers

Fuels and combustion, type of boilers, performance evaluation, factors affecting boiler performance, data collection format for boiler performance assessment, case studies.

Steam distribution system Steam pipe sizing, proper selection of steam traps, optimum insulation, steam utilization, steam balance – energy saving opportunities.

Furnaces

Types and classification of furnaces, performance evaluation of a typical furnace, general fuel economy measures in furnaces, case studies.

Heat Recovery Systems

Sources of waste heat, guidelines to identify waste heat, grading of waste heat, feasibility study of waste heat recovery, gas to gas heat recovery, rotary generators, heat pipes, gas to liquid heat recovery, waste heat boilers.

UNIT III:

Cogeneration

Definition and need, basics of thermodynamic cycles, classification of cogeneration systems, steam turbine, gas turbine, typical heat to power ratio in various industries, operating strategies for cogeneration plant, typical cogeneration performance parameters, relative merits of cogeneration systems.

Cooling towers

Classification of cooling towers, selection and usage of cooling towers, factors affecting cooling tower performance, performance evaluation of cooling tower at site, energy saving opportunities in cooling tower.

UNIT IV:

Pumps

Classification of pumps, centrifugal pump, system characteristics, pump operating point, factors affecting pump performance, pump efficiency, effect of over-sizing the pump, effect of speed variation/impeller diameter change, energy performance and evaluation of pumping system at sites, flow control strategies, meeting the fixed flow reduction, meeting the variable flow reduction.

Generation

Energy conservation options in buildings Financial Analysis

Fixed and variable costs, interest charges, simple payback period, return on investment, net present value, internal rate of return, discounted cash flow methods, factors affecting analysis.

D. Books:

1. *LC Witte, PS Schmidt and DR Brown: Industrial Energy Management and Utilization*
2. *(Hemisphere Publishing Corporation, Washington, 1998).*
3.
4. *W Trinks, MH Mawhinney, RA Shannon, RJ Reed, JR Garvey: Industrial Furnaces, Sixth Edition, (John Wiley & Sons, 2003)*
5.
6. *JL Threlkeld: Thermal Environmental Engineering, Second Edition (Prentice Hall, 1970)*
7.
8. *YP Abbi and Shashank Jain: Handbook on Energy Audit and Environment Management, (TERI Press, 2006)*
9.
10. *WC Turner: Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007)*
11.
12. *George Polimeros: Energy Cogeneration Handbook, (Industrial Press, Inc., New York, 1981)*

E. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

F. Journals:

1. *International journal of renewable energy resources.*
2. *International Journal of non-conventional energy resources.*
3. *AT &T Technical Journals.*
4. *IEEE Transactions on Renewable Energy Sources.*

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Syllabus for M. Tech in REEM

Name of the Module: Applied Power Electronics & Drives
Module Code: EE 907
Semester: 2nd
Credit Value: 3 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Objectives:

The course is designed to meet the objectives of:

1. To gather knowledge on power electronics equipment used for non-conventional energy systems.
2. To work on electrical machine drives in various non-conventional energy generation techniques.

B. Learning outcomes:

At the end of this module, students are expected to be able to

1. Design of power electronics converters for various renewable energy systems.
2. Design and develop consumer products for the betterment of human kind.

C. Subject Matter:

UNIT I:

Energy Management

Introduction: Power Electronics, requirements and application areas, Brief idea of Power Electronics application in areas like Power System, Motion Control, Heating, Automotive, Electric Welding, Renewable energy sources etc., Concept of power processing.

Signal Processing: Concept of Signal Processing and its requirements in PES Analog signal processing circuits like precision rectifier, Log and Antilog Amplifier, Voltage multiplier, Divider, peak detector etc., Switched Capacitor circuits concept and realization of simple circuits, Analog computation, solution of simultaneous equations and differential equations through analog circuits, ADC and DAC, V/F, F/V Converters, PLL, Timing Circuit, Multivibrators, Timer, PWM techniques

UNIT II:

Filters Circuits: Analog filter circuits, Filter response types, BP, HP, Notch, LP, Band Stop filter and basic circuits, Special filter circuits like state variable filter, biquad filter etc, Switched Capacitor filter circuit, Basic Power Modulator: (Basic power Diagram, working, advantages and disadvantages and classification only), Controlled & Uncontrolled rectifier Circuits, Inverter, Cyclo-converter

DC to DC converter, Power System Applications Introduction: Power system problems Concept and working of HVDC Transmission, Power factor correction, Static VAR Compensation, Active power filter, Interconnection of renewable energy sources and Energy storage system to the utility grid. Heat Recovery Systems, Sources of waste heat, guidelines to identify waste heat, grading of waste heat, feasibility study of waste heat recovery, gas to gas heat recovery, rotary generators, heat pipes, gas to liquid heat recovery, waste heat boilers.

UNIT III:

Power Supply and energy storage: Concept, working and types of SMPS and UPS Battery principle, Battery types, construction, applications, Charging methods and charging circuits for battery, Power Supply applications in various electronics systems, Industrial Applications: Induction Heating and dielectric heating, Electric Welding, Electroplating Ultrasonic

UNIT IV:

Consumer Electronics Applications: High Frequency Fluorescent lighting, LED lighting, fan regulator, Space Heating , Air Conditioning, Induction Cooking, Motor Drives and Applications: Working principle of AC and DC Motor drives • Automation in industry and motor drives

applications like flow control, robot control, Electric Train, battery operated vehicles, conveyer belt, elevator, hoist etc.

D. List of Practical:

1. Determination of complete torque speed characteristics of three phase induction machine in braking, motoring and generation regions and its calibration.
2. Understanding the effect of rotor resistance on the load characteristics of a wound–rotor induction motor.
   Determination of equivalent circuit parameters, prediction of performance. Verification from actual load test. (b) Separation of losses of Induction motors and estimation of efficiency.
3. Speed control of Induction motor–Conventional, electronic. Solid state speed control using (i) V constant, (ii) V/f constant, (iii) slip–energy injection.
4. Load characteristic of Induction generator working in (i) Grid connected mode (ii) Self Determination of equivalent circuit parameters of a single phase Induction motor. Prediction of torque–speed characteristic. Verification from load test.
5. Determination of torque step rate characteristic of a stepper motor. Determination of operating range.
6. Load characteristic of universal motor, operating and and ac supply Comparison of performance.
7. Experimental determination of performance characteristics of two phase servomotor.
8. Load characteristic of hysteresis motor and shaded pole motor.
9. Characteristic of permanent magnet motor.
10. Characteristic of switched reluctance motor.

E. Books:

1. *Mc Pherson George, "Introduction to Electric Machines and transformers", John Wiley and Sons, 1980.*
2. *Nasser Syed,A., "Electric Machine and Transformer", New York, Macmillan, 1984.*
3. *Sen., P.C., "Thyristor DC Drives", New York Wiley, 1991.*
4. *Fitzgerald, Kingsley C. and Umans,S.D., "Electric Machinery",(5th Ed.,),McGraw-Hill 1992.*
5. *Clayton, A.E., "Performance and Design of Direct Current Machines",3rd Ed. Pitman 1961.*
6. *R. S. Ramshaw, "Power Electronics Semiconductor Switches", Champman & Hall, 1993.*
7. *N. Mohan, T. M. Undeland and W. P. Robbins, "Power Electronics, Converter, Application and Design", Third Edition, John Willey & Sons, 2004.*
8. *M. H. Rashid, "Power Electronics, circuits, Devices and Applications", Pearson, 2002, India.*
9. *K. Billings, "Switch Mode Power Supply Handbook", McGraw-Hill, 1999, Boston.*
10. *I. Pressman, "Switch Mode Power Supply Design", McGraw-Hill, 1999, New York.*
11. *N. G. Hingorani and L. Gyugyi, "Understanding FACTS", IEEE Press, Delhi, 2001.*
12. *B. K. Bose, "Power Electronics and Variable Frequency Drive", Standard Publishers Distributors, 2000.*
13. *Bin Wu, "High-Power Converters and AC Drives", IEEE Press, A John Wiley & Sons, Inc Publication, New York,2006.*
14. *G. T. Heydt, "Electric Power Quality", Stars in a Circle Publications, second edition, 1994, Avarua, Rarotonga, Cook Islands.*
15. *R. C. Duagan, M. F. Mcgranaghan and H. W. Beaty, "Electric Power System Quality", McGraw-Hill, 2001, 1221 Avenue of the Americas, New York.*
16. *Vijay K. Sood, "HVDC and FACTS Controllers - Applications of Static Converters in Power Systems", Kluwer Academic Publishers, Masachusetts, 2004.*
17. *J. Arrillaga, Y. H. Liu and N. R. Waston, "Flexible Power Transmission-The HVDC Options", John Wiley & Sons, Ltd, Chichester, UK, 2007.*

F. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

G. Journals:

1. *The journal of the institute of electrical and electronics engineers, Japan.*
2. *Electrical Power Systems Research, Elsevier Journal.*
3. *Energy Conversion, IEEE Journal*
4. *Power Electronics Letter, IEEE.*
5. *IEEE Transactions on Power Electronics, IEEE.*
6. *International Journal of Power Electronics and Drives Systems.*
7. *Power System Control, Elsevier Trans*
8. *Automatic Control, IEEE*

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Syllabus for M. Tech in REEM

Name of the Module: Environmental Impact Assessment
Module Code: EE 908
Semester: 2nd
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Objectives:

The course is designed to meet the objectives of:

1. to gather knowledge on various factors of power generation that affects environment,
2. to develop the zeal of sustainable development among students.

B. Learning outcomes:

At the end of this module, students are expected to be able to

1. EIA Assessment of an energy generation project.
2. design and develop consumer products for the betterment of human kind.

C. Subject Matter:

UNIT I:

Environmental impact assessment (EIA): Introduction, definitions and concepts, rationale and historical development of EIA, need for EIA

Broad components of EIA:

Initial environmental examination, environmental impact statement, environmental appraisal, environmental impact factors and areas of consideration, pertinent institutional information, unique pollution problems, existing visual quality, public participation techniques. Composite consideration, potential cultural resources, potential visual impacts, geographical study area.

Methodologies:

Measurement of environmental impact, organization, scope and methodologies of EIA pertinent environmental factors. Six generic steps, descriptive checklists, simple interaction matrix, stepped matrix, uniqueness ratio, habitat evaluation system. Public involvement techniques, comprehensive environmental impact study, various project types, archaeological properties, leachate testing, evaluation species, proposing agency, EIA Models.

UNIT II:

Status of EIA in India: EIA Regulations in India, Terms of Reference on EIA for Hydropower Projects and other projects. Case studies from hydropower projects, hazardous industries and mining.

Environmental Impact Assessment process:

Screening, preliminary assessment, formation of an EIA team, scoping, main EIA, identification, prediction, evaluation, mitigation, documentation, public hearing process, Acts,rule and notification while granting clearance, composiyon of expert committees for EIA, EIA around the world, Trans boundary EIA, Car

UNIT III:

Environmental and climatic impacts of energy systems, Coal cycle (mining, transport, storage and handling), Oil and Gas cycle, Environmental aspects of fossil fuel based power generation, hydroelectric power and Nuclear power Sectoral issues: Transport and domestic- emission factors, calculations for regional analysis, Principals of environmental modeling and impact prediction, Pollution control technologies and options.

UNIT IV:

Environmental pollution control and management principles, Water quality parameters, pollution sources, impacts and principles of treatment technologies, Air quality parameters, basic chemistry of pollutants, sources and impacts, control technologies, Solid waste: types, sources and properties, resource and energy recovery, other disposal methods, Strategies for prevention and control of

pollution; regulatory and economic instruments; Minimum National Standards (MINAS) and its philosophy, concept of EIA, environmental audit, ISO 14000, Life Cycle Assesment and carrying capacity based regional planning. International negotiations, agreements and institutions pertaining to climate change.

D. Books:

1. *L. W. Canter, Environmental Impact Assessment, 2nd Ed., McGraw-Hill, 1997.*
2. *P. Judith and G. Eduljee, Environmental Impact Assessment for Waste Treatment and Disposal Facilities, John Wiley & Sons, 1994.*
3. *G. Burke, B. R. Singh and L. Theodore, Handbook of Environmental Management and Technology, 2nd Ed., John Wiley & Sons, 2000.*
4. *C. H. Eccleston, Environment Impact Statements: A Comprehensive Guide to Project and Strategic Planning, John Wiley & Sons, 2000.*
5. *R. Welford, Corporate Environmental Management - Systems and Strategies, Universities Press, 1996.*
6. *K. Whitelaw and Butterworth, ISO 14001: Environmental System Handbook, 1997.*
7. *The Economist Intelligence Unit, Best Practices - Environment, Universities Press, 1993.*
8. *R. Therivel, John Glasson, Andrew Chadwick, Introduction to Environmental Impact Assessment (Natural and Built Environment), Routledge, 2005*

E. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

F. Journals:

1. *The journal of the institute of electrical and electronics engineers, Japan.*
2. *Electrical Power Systems Research, Elsevier Journal.*
3. *Energy Conversion, IEEE Journal*
4. *Power Electronics Letter, IEEE.*
5. *IEEE Transactions on Power Electronics, IEEE.*
6. *International Journal of Power Electronics and Drives Systems.*
7. *Power System Control, Elsevier Trans*
8. *Automatic Control, IEEE*

Name of the Module: Smart Grid
Module Code: EE 909
Semester: 2nd
Credit Value: 4 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Objectives:

The course is designed to meet the objectives of:

1. to introduce the concept of smart grid,
2. to discuss the future trends of power system industry.

B. Learning outcomes:

At the end of this module, students are expected to be able to

1. understand the practices of Smart Grid.
2. design and develop consumer products for the betterment of human kind.

C. Subject Matter:

UNIT I:

Review Basic Elements of Electrical Power Systems:- Smart Grid Definitions
Smart Grid Technologies, Smart Customer, How dependent we are on Power Grid, The Origins of the Power Grid, Renewable Resources: Wind and Solar, Carbon Footprint.

UNIT II:

Desirable Traits of a Modern Grid:- Reliable, Secure, Economic, Efficient, Environmentally Friendly, Safe, Cyber Security Challenges in Smart Grid ,Load Altering Attacks , Micro grids, Electric Vehicle Integration,

UNIT III:

Principal Characteristics of the Smart Grid:- Self Healing Grid, Motivates and includes the Customer, Resists Attack, Provides Power Quality for Modern needs, Accommodates all Generation and Storage Options, Enables Markets, Optimizes Assets and Operates Efficiently. Common reusable building blocks, Standardized interfaces.

UNIT IV:

Key Technology Areas:- Sensor Networks ,Phasor Measurement Units, Communications Infrastructure ,Fault Detection, Applications and Challenges, . Integrated Communications, Sensing and Measurement/Advanced Metering, Advanced Components. Types of Elements: Smart Meters, Sensors, Relays, Reclosers, Smart Transformers, Phasor Measurement Units, Customer Equipment, Smart Grid Control Layer, Smart Grid Applications Layer

D. Books:

1. *"Electric Power Distribution Automation, Protection and Control", by James A. Momoh Edition 2008.*
2. *"Smart Grid Fundamentals of Design & Analysis" by James A. Momoh, edition 2012.*
3. *"Smart Grid (R)Evolution: Electric Power Struggles" by Jennie C. Stephens and Elizabeth J. Wilson,2015-02-07*
4. *"Data Privacy for the Smart Grid" by Rebecca Herold and Christine Hertzog,2015*
5. *"Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities" by Peter , Fox Penner*

E. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

F. Journals:

1. *The journal of the institute of electrical and electronics engineers, Japan.*
2. *Electrical Power Systems Research, Elsevier Journal.*
3. *Energy Conversion, IEEE Journal*
4. *Power Electronics Letter, IEEE.*
5. *IEEE Transactions on Power Electronics, IEEE.*
6. *International Journal of Power Electronics and Drives Systems.*
7. *Power System Control, Elsevier Trans*
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Syllabus for M. Tech in REEM

Name of the Module: Industrial Management
Module Code: HSS 901
Semester: 2nd
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Objectives:

The course is designed to meet the objectives of:

1. Imparting theoretical lectures with case discussion.
2. Providing teaching with inclusive learning.
3. Making students aware about the importance of this subject in their future career.

B. Learning outcomes:

At the end of this module, students are expected to be able to

1. Students will work with efficiency as they had knowledge about the subject.
2. With the backup knowledge their performance will be definitely much better in their workplace.

C. Subject Matter:

UNIT I:

Concept of Management: Various approaches to management , management as an art, a Science and a profession, Managerial Skills, Process Management, Planning Mission, Goals, Strategy, Program and Procedure; Decision making process, decision making under risk and uncertainty, Models of decision making.

UNIT II:

Principles of Organization: Organizational Structure, Span of control, Staffing function with emphasis on performance appraisal, training and development.

UNIT III:

Direction and Coordination: Motivation and Leadership, Control function- Process and Techniques

UNIT IV:

Production Management: Types of Production, Locational Decision, Plant Layout and Design, Production. Planning Scheduling and Control: Work Study, Method Study and Wage, Payment Schemes and Bonus, Productivity concept and measurement. Material management: Inventory Planning, Procurement functions, Procedures and Control, Storing planning procedure and control, Issue and Pricing, Inventory Control Techniques, Value Analysis and Engineering.

D. Books:

1. *Badiru, A, 2005, Hand Book of Industrial and System Engineers, CRC press.*
2. *Blanchand, B & Fabrycky, W, 2005, System Engineering Analysis (4th Ed.), Prentice Hall.*
3. *Turner, W, et. al, 1992, Introduction to Industrial and System Engineering (3rd Ed.), Prentice Hall.*

E. Magazines:

1. *IEEE Spectrum.*
2. *Electronics for you.*
3. *Electropages.*

F. Journals:

1. *Group and Organization Management.*
2. *Journal of Organizational Behavior.*
3. *Journal of Management*

ELECTIVES

Name of the Module: Distributed Generation
Module Code: EE 914
SEMESTER:
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Content:

UNIT-I:

Introduction: Course description. The electric grid vs. microgrids: technical and historic perspective. The "Energy Internet." Distributed Generation units. Micro turbines, reciprocating engines, wind generators, photovoltaic generators, fuel cells, and other technologies.

UNIT-II:

Energy Storage: Batteries, fly-wheels, ultra capacitors, and other technologies. Power electronics interfaces: Multiple and single input dc-dc converters. AC-DC and DC-AC.

UNIT-III:

Power architectures: Distributed and centralized. Dc and ac distribution systems. Stability and protections.

UNIT- VI:

Control: Distributed, autonomous, and centralized systems, Operation, Economics, Reliability and availability.

B. Reference books:

1. *G. Masters, Renewable and Efficieg24*
2. *Electric Power Systems, Wiley Inter Science.*
3. *D N Gaonkar, Distributed Generation, Intech Open.*

Name of the Module: HVDC Transmission System
Module Code: EE 915
SEMESTER:
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Content*:*

UNIT I:

Evolution of HVDC Transmission, Comparison of HVAC and HVDC systems, Type of HVDC Transmission systems, Components of HVDC transmission systems.

UNIT II:

Analysis of simple rectifier circuits, Required features of rectification circuits for HVDC transmission, Analysis of HVDC converter, Different modes of converter operation, Output voltage waveforms and DC voltage in rectification, Output voltage waveforms and DC in inverter operation, Thyristor voltages, Equivalent electrical circuit.

UNIT III:

HVDC system control features, Control Modes, Control Schemes, Control comparisons. Converter mal-operations, Commutation failure, Starting and shutting down the converter bridge.

UNIT IV:

Converter protection. Smoothing reactor and DC Lines, Reactive power requirements. Harmonic analysis, Filter design, Component Models for the Analysis of AC DC Systems. Power flow analysis of AC-DC systems, Transient stability analysis, Dynamic stability analysis, Multi-terminal HVDC system, Advances in HVDC transmission, HVDC system application in wind power generation.

Protection against over current and over voltage in converter station, Generation of Harmonics, adverse effects of harmonics, Calculation of voltage & Current harmonics, Effect of Pulse number on harmonics

B. Reference Books:

1. *KR Padiyar, "HVDC Power Transmission Systems", Willey Eastern Limited, Second edition.*
2. *J Arrillaga, "High Voltage Direct current Transmission", Peter Peregrinus Ltd, UK.*
3. *EW Kimbark, "Direct Current Transmission", Wiley-Interscience, New York.*
4. *SN Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi 2nd edition, 2008.*

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Syllabus for M. Tech in REEM

Name of the Module: Generalized Theory of Electrical Machines
Module Code: EE 916
SEMESTER:
Credit Value: 4 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Content:

Unit I

Generalized Theory: Conversions - Basic two pole machines - Transformer with movable Secondary -Transformer voltage and speed voltage - Kron's primitive machine - Analysis of Electrical machines.

Unit II

Linear Transformations: Invariance of Power - Transformations from displaced brush axis, three phases to two phase, Rotating axes to stationary axes-Transformed impedance matrix – Torque calculations.

Unit III

DC Machines: Generalized Representation - Generator and motor operation - Operation with Displaced brushes - Steady state and transient analysis - Sudden short circuit - Sudden application of inertia load - Electric braking of DC motors.

Unit IV

AC Machines: Synchronous Machines: Generalized Representation - Steady state analysis – Transient analysis - Electromechanical transients. Induction Machines: Generalized Representation performance equation - steady state analysis - Transient analysis - Double cage Machine - Harmonics - Electric braking.

Special Machines: Generalized Representation and steady state analysis of Reluctance Motor – Brushless DC Motor – Variable Reluctance Motor – Single phase series motor.

Scalar and Vector control of machines, sensorless control and flux observers.

B. Reference Books:

1. *Gupta J B." Theory & Performance of Electrical Machines", S. K. Kataria & Sons, New Delhi, 2010*
2. *Bimbhra P.S., "Generalized Circuit Theory of Electrical Machines", Khanna Publishers Limited, 5th Edition, 4th Reprint, New Delhi, 2000.*
3. *John Salmon "Applications of General Theories to Electrical Machines Contributions to their Design and Performance", Troubadour Publishing Ltd, Leicester, 2008.*
4. *Bandyopadhyay M. N., "Electrical Machines: Theory and Practice" PHI Learning, NewDelhi, 2009*

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Syllabus for M. Tech in REEM

Name of the Module: Power Quality Issues and Its Remedial Measures
Module Code: EE 917
Semester:
Credit Value: 4 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Contents:

UNIT-I

Introduction of the Power Quality problem, Terms used in Power Quality: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring. Sources for Electric Power Quality problem in power system: poor load power factor, Non linear and unbalanced loads

UNIT-II

Long Interruptions: Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption.

Short interruptions: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions,. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

Grounding requirement, typical grounding problems, solutions to grounding problems.

UNIT III

Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Effect of sag on AC motor drives, single-phase domestic and office loads, monitoring and mitigation of voltage sag.

HARMONICS: Origin of harmonics – effect of harmonics on adjustable speed ac drives – harmonic reduction using PWM and harmonic injection

UNIT-IV

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

Power Quality and EMC Standards: Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, Power Quality surveys.

A. Reference books:

1. *"Understanding Power Quality Problems" by Math H J Bollen. IEEE Press.*
2. *David D. Shipp and William S. Vilcheck, "Power Quality and Line Considerations for Variable Speed AC Drives", IEEE Transactions on Industry Applications, Vol. 32, March / April – 1996*
3. *Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.*
4. *Roger.C.Dugan, Mark.F.McGranagham, Surya Santoso, H.Wayne Beaty, "Electrical Power Systems Quality", McGraw Hill, 2003.*
5. *G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition).*
6. *Jos Arrillaga, Neville R. Watson, " Power System Harmonics"- John Wiley & Sons, 2003.*

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Syllabus for M. Tech in REEM

Name of the Module: FACTS Controllers & HVAC Transmission systems
Module Code: EE 918
Semester:
Credit Value: 4 [P = 2; T = 0; L = 3]
Module Leader:

A. Course Contents:

UNIT I

Introduction to FACTS: Transmission Interconnections, Flow of Power in an AC system, Loading Capability and controllable parameters, Basic FACTS Controllers: brief description, benefits.

Voltage Sourced Converters: Single phase full wave bridge converter operation, single phase leg operation, square wave voltage harmonics for a single phase bridge, three phase bridge full wave converter, valve conduction process, 12 pulse operation and transformer connection, 24 and 48 pulse operation, three level voltage sourced converter, PWM converter, generalized technique of harmonic elimination.

Self and line commutated current sourced converter.

UNIT II

Static Shunt Compensators: SVC and STATCOM, Objectives, Controllable VAR generation, comparision

Static series compensators: GCSC, TSSC, TCSC and SSSC, Objectives, variable impedance type series compensators, switching converter type series compensators, external control for series reactive compensators

UNIT III

Static voltage and phase angle regulators: TCVR and TCPAR, objectives, hybrid phase angle regulators.

Combined compensators: UPFC and IPFC

UNIT IV

NGH-SSR Damping Scheme and Thyristor controlled braking resistor, sub synchronous resonance, design and operation aspects.

B. Reference books:

1. *Understanding FACTS: Concepts and technology of flexible AC transmission systems, Narain G. Hingorani, Laszlo Gyugyi, Wiley India.*
2. *Vijay K. Sood, "HVDC and FACTS Controllers - Applications of Static Converters in Power Systems", Kluwer Academic Publishers, Masachusetts, 2004.*
3. *J. Arrillaga, Y. H. Liu and N. R. Waston, "Flexible Power Transmission-The HVDC Options", John Wiley & Sons, Ltd, Chichester, UK, 2007.*
4. *Bin Wu, "High-Power Converters and AC Drives", IEEE Press, A John Wiley & Sons, Inc Publication, New York, 2006.*
5. *R. S. Ramshaw, "Power Electronics Semiconductor Switches", Champman & Hall, 1993.*
6. *N. Mohan, T. M. Undeland and W. P. Robbins, "Power Electronics, Converter, Application and Design", Third Edition, John Willey & Sons, 2004.*
7. *M. H. Rashid, "Power Electronics, circuits, Devices and Applications", Pearson, 2002, India.*
8. *K. Billings, "Switch Mode Power Supply Handbook", McGraw-Hill, 1999, Boston.*
9. *I. Pressman, "Switch Mode Power Supply Design", McGraw-Hill, 1999, New York.*
10. *K. Bose, "Power Electronics and Variable Frequency Drive", Standard Publishers Distributors, 2000.*

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Syllabus for M. Tech in REEM

Name of the Module: Hybrid System of Conventional Energies
Module Code: EE 919
Semester:
Credit Value: 4 [P = 2; T = 0; L = 3]
Module Leader:

A. Objectives:

UNIT-I

Introduction: Fossil fuel based systems. Impact of fossil fuel based systems. Non-conventional energy – Seasonal variations and availability. Renewable energy – sources and features. Hybrid Energy systems Distributed energy systems and dispersed generation (DG)

Traditional Energy Systems: Sources. Features and characteristics. Applications: Transport – bullock cart, horse carriage, camels; Agriculture – ox plough, water lifting devices; Human power – bicycle, cycle rickshaw etc.; House hold – cooking (bio mass), lighting etc.

Solar Thermal Systems: Solar radiation spectrum. Radiation measurement. Technologies. Applications: Heating, Cooling, Drying, Distillation, Power generation.

UNIT-II

Solar Photovoltaic Systems:

Operating principles. Photovoltaic cell concepts. Cell, module, array. Series and parallel connections. Maximum power point tracking. Applications: Battery charging, Pumping, Lighting, and Peltier cooling

Micro-Hydel: Operating principles. Components of a microhydel power plant. Types and characteristics of turbines. Selection and modification. Load balancing.

Wind: Wind patterns and wind data. Site selection. Types of windmills. Characteristics of wind generators. Load matching

UNIT-III

Biomass: Operating principles. Combustion and fermentation. Anaerobic digester. Wood gassifier. Pyrolysis. Applications: Biogas, Wood stoves, Bio diesel, Combustion engine.

Wave Energy Systems: Shoreline systems. Near shore systems. Off shore systems

Costing: Life cycle costing (LCC). Solar thermal system LCC. Solar PV system LCC. Microhydel LCC. Wind system LCC. Biomass system LCC

UNIT-IV

Hybrid Systems:

Need for Hybrid Systems. Range and type of Hybrid systems. Case studies of Diesel-PV, Wind-PV, Micro hydel-PV, Biomass-Diesel systems, electric and hybrid electric vehicles

B. Reference Books:

1. *J.A.Duffie & W.A. Beckman: Solar Engineering of Thermal Process*
2. *S.A.Kalogirou: Solar Energy Engineering*
3. *Anna Mani : Wind Energy Data for India*
4. *C-Wet : Wind Energy Resources Survey in India VI*
5. *S. Rangrajan : Wind Energy Resources Survey in India V*
6. *Sathyajith Mathew : Wind Energy*
7. *Prepared by WISE: Wind Power in India (5000MW BY 2015)*
8. *B.H.Khan: Non-Conventional Energy Sources*

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Syllabus for M. Tech in REEM

Name of the Module: Micro Grid Systems
Module Code: EE 920
Semester:
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Contents:

UNIT I

Basics of a microgrid :-

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, micro grids for hybrid renewable sources of energy.

UNIT II

DC micro grids:-

DC micro-grids, Power Electronics interfaces in DC, modes of operation and control of microgrid, grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

UNIT III

AC micro grids:-

Concept and definition of AC micro-grid, AC micro-grid drivers and benefits, review of sources of micro-grids, typical structure and configuration of a micro-grid, Power Electronics interfaces in AC micro-grids.

UNIT IV

Control and operation of microgrid:-

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

B. Reference Books:

1. *"Voltage Source Converters in Power Systems: Modeling, Control and Applications", Amirnaser Yezdani, and Reza Iravani, IEEE John Wiley Publications.*
2. *"Power Switching Converters: Medium and High Power", DorinNeacsu, CRC Press, Taylor & Francis, 2006.*
3. *"Solar Photo Voltaics", Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi, 2009*
4. *"Wind Energy Explained, theory design and applications," J.F. Manwell, J.G. McGowan Wiley publication*
5. *"Biomass Regenerable Energy", D. D. Hall and R. P. Grover, John Wiley, New York, 1987.*
6. *"Renewable Energy Resources" John Twidell and Tony Weir, Tyalor and Francis Publications, Second edition*

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Syllabus for M. Tech in REEM

Name of the Module: Rural electrification & its management
Module Code: EE 921
Semester:
Credit Value: 3 [P = 0; T = 0; L = 3]
Module Leader:

A. Course Contents:

UNIT-I:
Introduction to Energy World:
Sources of Energy, exploitation of different sources and use of energy, Convenience of use of electricity, Electricity from power plant to the end users, consumers from city to remotest corner of villages.

UNIT-II:
General Aspects of Energy Management:
Energy Scenario, Energy Management and Audit, Energy Action Planning, Electricity Regulations

UNIT- III:
Materials for overhead Lines:
Line support, different types of poles and towers, insulators, conductors, brackets, cross arms, earthing arrangement, stays and struts, bracings, different types of insulators for HT and LT lines, post insulator, disc insulator, different types of conductors, other line equipments, (clamp, strain clamp, parallel groove clamp), bolted clip, sleeve, aluminium tape and binding wire, line vibration, insulator hardware.

UNIT-IV:
Tools and equipments:
Screw Driver, pilers, cutting pliers, hammer, hand drill, hack, saw, tennon saw, knife, chisel, files, wrench and spanner, pipe wrench, standard wire guage, bench vice, micro meter, plumb bob, punching machine, chain pulley block, max puller, draw vice, hand glove, safety row, earthing rod with chain, energy meter, ammeter, volt meter, clip on ammeter.
Erection of overhead lines:
Selection of route and line survey, compliance of Indian electricity act and rules, scetch marking of pole locations, pole erection, stay erection, erection of cross arms and insulators, stringing of conductor, line joints, sag and its measurement, safety during stringing, fixing of line guards.

B. Reference Books:

1. *Zerriffi Hisham, Rural Electrification, Springer.*