## M.Tech RENEWABLE ENERGY

| Type | Course Code | Course Title | No. of Credits | L | T | P | Max. Marks | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | CFA | ESE | Total |
| **Semester I** | | | | | | | | | |
| Core I | 18REEP0101 | Solar Energy | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Core II | 18REEP0102 | Wind, Small Hydro and New Renewable Energy | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Elective I | 18REEP01EX | Major Elective 1 | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Elective II | 18REEP01EY | Major Elective 2 | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Core | 18REEP0103 | Solar Energy Lab | 2 | 0 | 0 | 4 | 60 | 40 | 100 |
| Core | 18REEP0104 | Wind Energy Lab | 2 | 0 | 0 | 4 | 60 | 40 | 100 |
| Core | 18REEP0105 | Research Methodology and IPR | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Audit Course I | 18GTPP0001 | Gandhi in Every Day Life (Compulsory Non Credit Course) | 0 | 2 | 0 | 0 | 50 | 0 | 50 |
| | | **Total** | **24** | **22** | **0** | **8** | **370** | **380** | **750** |
| **Semester II** | | | | | | | | | |
| Core III | 18REEP0206 | Power Systems for Renewable Energy Sources | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Core IV | 18REEP0207 | Waste to Energy | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Elective III | 18REEP02EX | Major Elective 3 | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Open Elective | | Non Major Elective | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Core | 18REEP0208 | Waste to Energy Lab | 2 | 0 | 0 | 4 | 60 | 40 | 100 |
| Core | 18REEP0209 | Energy Auditing of MSMEs (Field Visit) | 2 | 0 | 0 | 4 | 60 | 40 | 100 |
| Core | 18REEP0210 | Mini Project | 2 | 0 | 0 | 4 | 0 | 50 | 50 |
| Modular Course | 18REEP02MX | Modular Course | 2 | 2 | 0 | 0 | 50 | 0 | 50 |
| Audit Course II | 18ENGP00C1 | Communication & Soft Skills (Compulsory Non Credit Course) | 0 | 2 | 0 | 0 | 50 | 0 | 50 |
| | | **Total** | **24** | **20** | **0** | **12** | **380** | **370** | **750** |
| **Semester III** | | | | | | | | | |
| Core | 18REEP0311 | Summer Internship | 2 | 0 | 0 | 0 | 50 | 0 | 50 |
| Elective IV | 18REEP03EX | Major Elective 4 | 4 | 4 | 0 | 0 | 40 | 60 | 100 |
| Elective V | 18REEP03EY | MOOC 1 | 2 | 2 | 0 | 0 | 50 | 0 | 50 |
| Elective VI | 18REEP03EZ | MOOC 2 | 2 | 2 | 0 | 0 | 50 | 0 | 50 |

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|---|---|---|---|---|---|---|---|---|---|
| Core | 18REEP0312 | Rural Energy Planning (Field Visit) | 2 | 2 | 0 | 4 | 0 | 50 | 50 |
| Dissertation | 18REEP0313 | Phase I | 10 | 0 | 0 | 20 | 150 | 50 | 200 |
| Extension | 18EXNP03V1 | Village Placement Programme | 2 | 0 | 0 | 0 | 50 | 0 | 50 |
| | | **Total** | **24** | **10** | **0** | **24** | **390** | **160** | **550** |
| **Semester IV** | | | | | | | | | |
| Dissertation | 18REEP0414 | Phase II | **16** | **0** | **0** | **32** | **150** | **50** | **200** |
| | | | **16** | | | | | | |
| | | **Total** | **88** | | | | | | |

**Courses for 18REEP01EX**

| | |
|---|---|
| 18REEP01E1 | Energy Auditing and Management |
| 18REEP01E2 | Combined Heat and Power |
| 18REEP01E3 | Thermodynamic Analysis of Energy Systems |

**Courses for 18REEP01EY**

| | |
|---|---|
| 18REEP01E4 | Advanced Numerical Analysis |
| 18REEP01E5 | Discrete Mathematics |
| 18REEP01E6 | Computational Fluid Dynamics |

**Courses for 18REEP02EX**

| | |
|---|---|
| 18REEP02E1 | Energy Economics and Policies |
| 18REEP02E2 | Energy Modeling and Project Management |
| 18REEP02E3 | Environmental Impact Assessment |

**Courses for18REEP02MX**

| | |
|---|---|
| 18REEP02M1 | Rooftop Solar Photovoltaic Entrepreneur |
| 18REEP02M2 | Solar Proposal Evaluation |
| 18REEP02M3 | Energy Auditing Instrumentation |

**Courses for18REEP03EX**

| | |
|---|---|
| 18REEP03E1 | Rural Electrification: Technologies and Economics |
| 18REEP03E2 | Smart Grid |
| 18REEP03E3 | Green Buildings |

## 18REEP0101 SOLAR ENERGY

**Course Objectives:**

- ✓ to describe the fundamentals of Solar Physics
- ✓ to demonstrate the solar thermal and electrical gadgets for the societal needs

**Unit I**

Solar angles, day length, angle of incidence on tilted surface; Sun path diagrams; Shadow determination; Extraterrestrial characteristics; Effect of earth atmosphere; Measurement & estimation on horizontal and tilted surfaces; Analysis of Indian solar radiation data and applications.

Flat-plate Collectors **-** Effective energy losses; Thermal analysis; Heat capacity effect; Testing methods; Evacuated tubular collectors; Air flat-plate Collectors: types; Thermal analysis; Thermal drying.

Selective Surfaces -Ideal coating characteristics; Types and applications; Anti-reflective coating; Preparation and characterization.

**Unit II**

Concentrating Collector Designs - Classification, Tracking systems; Compound parabolic concentrators; Parabolic trough concentrators; Concentrators with point focus; Heliostats; Comparison of various designs: Central receiver systems, parabolic trough systems; Solar power plant; Solar furnaces; Vapour absorption refrigeration cycle; Water, ammonia & lithium bromide-water absorption refrigeration systems; Solar operated refrigeration systems; Solar desiccant cooling. Solar Thermal Energy Storage - Sensible storage; Latent heat storage; Thermo-chemical storage. Solar still; Solar cooker: Solar pond.

**Unit III**

Solar Passive Building - Thermal comfort; Criteria and various parameters; Calculation of solar radiation on buildings; building orientation; Introduction to design of shading devices; Overhangs; Factors that effects energy use in buildings; Ventilation and its significance; Air-conditioning systems; Passive Cooling And Heating Concepts - Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; 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.

**Unit IV**

Solar Cell Physics –P-N junction: homo and hetro junctions, Metal-semiconductor interface; 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, Tandem structure. SPV Applications - Centralized and decentralized SPV systems; Stand alone, hybrid and, grid connected system, System installation, operation and maintenances

**Unit V**

Right quality of solar module by identifying the key technical parameters in data Specification Sheets - Right quality of Inverter by identifying the key technical parameters in data

Specification Sheets - Right quality of Mounting Structure by identifying the key technical parameters in data Specification Sheets. Right quality of battery by identifying the key technical parameters in data Specification Sheets. Identify market price of different components of Solar PV system. Prepare an estimate for a solar project - Prepare a cost benefit analysis for a rooftop solar PV plant. - Identify different business models in solar rooftop Sector - Identify the policy, regulations and procedures for solar rooftop sector in the local market

**Text Book:**


1. Garg H P., Prakash J., *Solar Energy: Fundamentals & Applications*, Tata McGraw Hill, New Delhi, 1997
2. S P Sukhatme, *Solar Energy,* Tata McGraw Hill, 2008
3. J F Kreider and Frank Kreith, *Solar Energy Handbook*, McGraw Hill, 2000


**References:**


1. D Y Goswami, Frank Kreith and J F Kreider,*Principles of Solar Engineering*, Taylor& Francis, 1998
2. Tiwari G.N., Suneja S., *Solar Thermal Engineering System*, Narosa Publishing House, New Delhi, 1997.
3. Alan L Fahrenbruch and Richard H Bube , *Fundamentals of Solar Cells: PV Solar Energy Conversion,*Academic Press, New York , 1983
4. Larry D Partain (ed.), *Solar Cells and their Applications,*John Wiley and Sons, Inc, New York, 1995
5. Richard H Bube, *Photovoltaic Materials*, ImperialCollege Press, 1998
6. H S Rauschenbach, *Solar Cell Array Design Handbook*, Van Nostrand Reinfold Company, New York, 1980.


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Understand the physics of solar energy
- ✓ Evaluate the solar thermal devices.
- ✓ Optimize the solar thermal power generating system.
- ✓ Design the solar PV system for rural households.
- ✓ Interpret from field experience for solar PV market analysis including government schemes & policies.

## 18REEP0102 WIND, SMALL HYDRO AND NEW RENEWABLE ENERGY

**Course Objectives:**

- ✓ to describe the fundamentals and main characteristics of wind energy conversion techniques
- ✓ to analyze the potential of small hydro power generation
- ✓ to explore the possibility of usage of biofuel
- ✓ to study the fundamentals of new renewable energy technologies like fuel cell, geothermal energy, Ocean energy etc.,

**Unit I**

Wind Energy Conversion - Wind energy conversion principles; General introduction; Types and classification of WECS; Power, torque and speed characteristics. – Site Selection Criteria – Advantages – Limitations – Wind Rose Diagram – Indian Wind Energy Data – Organizations like NIWE etc., Wind Energy Conversion System - Design - Aerodynamic design principles; Aerodynamic theories; Axial momentum, blade element and combine theory; Rotor characteristics; Maximum power coefficient; Prandlt's tip loss correction.

**Unit II**

Design of Wind Turbine - Wind turbine design considerations; Methodology; Theoretical simulation of wind turbine characteristics; Test methods. Wind Energy Application - Wind pumps: Performance analysis, design concept and testing; Principle of WEG; Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy utilization; Wind energy in India; Case studies.

**Unit III**

Small Hydropower Systems - Overview of micro, mini and small hydro systems; Hydrology; Elements of pumps and turbine; Selection and design criteria of pumps and turbines; Site selection and civil works

Speed and voltage regulation; Investment issues load management and tariff collection; Distribution and marketing issues: case studies; Potential of small hydro power in India. – SHP – Renovation and Modernization – Testing Methods

**Unit IV**

Bio fuels – Edible –Petro crops – Analysis of Indian non edible oil sources – Example of biodiesel crop – Jatropha curcas – Tree description – Jatropha curcas for rural development – environmental protection – Bio ethanol – production from conventional as well as unconventional sources. - Bio diesel – Technology for production of bio diesel - Transesterification – Process – Usage of Methanol – Glycerine – Storage and Characterisation of biodiesel – Biodiesel engine development – modification – Environmental and health effects of biodiesel – R&D in biodiesel – disposal of cake – value addition of byproducts

**Unit V**

Ocean Energy Potential - OTEC- International – National Scenario - Principles and Prospective Locations – Open – Closed Loop Cycle - Tidal Energy- Global Technological Development - Estimation of Tidal Power - Different Types of Turbine - Geothermal- Potential – Layout - MHD – Tehcnology and Bottlenecks - Thermionic- Thermoelectric energy conversion system

Fuel Cells – Proton exchange membrane fuel cells (PEMFCs) - Phosphoric acid fuel cell (PAFC) Solid acid fuel cell (SAFC) - Alkaline fuel cell (AFC) - High-temperature fuel cells - Electric storage fuel cell - Comparison of fuel cell types- Batteries – Micro Algae – Biodiesel from Algae

**Text Book:**


1. G L Johnson, *Wind Energy Systems*, Prentice Hall Inc, New Jersey, 1985.
2. David A. Spera, (Editor) *Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering,* American Society of Mechanical Engineers; (1994)
3. Tong Jiandong(et al.) , *Mini Hydropower ,* John Wiley, 1997


**References:**


1. Erich Hau,*Wind Turbines: Fundamentals, Technologies, Application and Economics,* Springer Verlag; (2000)
2. Paul Gipe , Karen Perez, *Wind Energy Basics: A Guide to Small and Micro Wind Systems,* Chelsea Green Publishing Company; (1999)
3. J. F. Manwell, J. G. McGowan, A. L. Rogers, *Wind Energy Explained ,* John Wiley & Sons; 1st edition (2002)
4. Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi, *Wind Energy Handbook ,* John Wiley & Sons; 1st edition (2001)
5. Mukund R. Patel, *Wind and Solar Power Systems ,* CRC Press; (1999)
6. John F. Walker and Nicholas Jenkins, *Wind Energy Technology,* John Wiley, 1997


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Develop basic knowledge about Wind energy conversion Technology and its terminologies.
- ✓ Design and assess the small wind turbine and its performance.
- ✓ Enumerate the Small mini Hydro plants for Energy generation.
- ✓ Selecting the Hydro power plant capacity for the given circumstances.
- ✓ Develop the basic technological idea about various New & Renewable energy conversion Technology.

## 18REEP01E1 ENERGY AUDITING AND MANAGEMENT

**Course Objectives:**

- ✓ to familiarize with energy management
- ✓ to carryout energy analysis of thermal system
- ✓ to study the energy conversion in electrical utilities
- ✓ to increase the rational use of energy in process / product industries.

**Unit I:**

Energy Conservation Act-2001 and its Features. Energy management and audit : Definition, energy audit – need, types of energy audit, energy management (audit) approach – understanding energy costs, benchmarking, energy performance Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments

Global environmental concerns : United nations framework convention on climate change (UNFCC), Kyoto protocol, conference of parties (COP), clean development mechanism (CDM), prototype carbon fund (PCF), sustainable development.

**Unit II:**

Basics of energy & its various forms : Thermal basics – fuels, thermal energy content of fuels, temperature and pressure, heat capacity, sensible & latent heat, evaporation, condensation, steam, moist air, humidity and heat transfer, units and conversion. – Thermodynamic properties of pure substances in solid, liquid and vapor phases, P-V-T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts

Boilers : Types, combustion in boilers, performance evaluation, analysis of losses, feed water treatment, blow down, energy conservation opportunities.

**Unit III:**

Heat Transfer Fundamentals – Conduction – Convection – Radiation

Furnaces : Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery.

Insulation and Refractories: Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria, Refractory-types, selection and application of refractories, Heat loss

**Unit IV:**

HVAC and Refrigeration System: Vapor compression refrigeration cycle, Refrigerants, Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioning system performance and savings opportunities.

Vapor absorption refrigeration system**:** Working principle, Types and comparison with vapor compression system, Saving potential

**Unit :V**

Electricity basics – DC and AC currents, electricity tariff, load management and maximum demand control, power factor. Electric motors: Types, Losses in induction motors, Motor

efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, Energy saving opportunities with energy efficient motors. Energy Efficient Technologies in Electrical Systems**:** Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers

**Text Book:**


1. CB Smith, *Energy Management Principles*, Pergamon Press, NewYork, 1981
2. Bureau of Energy Efficiency: *Study material for Energy Managers and Auditors Examination*: *Paper I to IV*.2006
3. Hamies, *Energy Auditing and Conservation; Methods, Measurements, Management & Case study*, Hemisphere, Washington, 1980


**References:**


1. D Patrick and S W Fardo, *Energy Management and Conservation*, Prentice Hall Inc., 1996
2. Thuman A and Mehta D Paul, *Handbook of Energy Engineering*, The Fairmount Press., 1998
3. Kennedy, Turner and Capehart, *Guide to Energy Management*, The Fairmount Press., 1996
4. Wayne C Turner, *Energy Management Handbook*, The Fairmount Press., 2000
5. Kao Chen, *Energy Management in Illumination System*, CRC Press, 2000
6. Gellingn, Chamberli, *Demand Side Management: Concepts and methods*, Penwell, 1998
7. Charles M Cotlschalk, *Industrial Energy Conservation*, John Wiley & Sons, 2002


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Describe and formulate basic –auditing terms.
- ✓ Define and analyze the auditing approaches for a selective industry.
- ✓ Evaluate the performance analysis and optimization of thermal utilities.
- ✓ Formulate energy action planning for various types of industry.
- ✓ Describe and categorize the global environmental concerns for effective energy conservation and compare with international standards.

## 18REEP01E2 COMBINED HEAT AND POWER

**Objectives:**

- ✓ To impart importance of optimum utilization of heat and power in process and product industry
- ✓ To study the impact of CHP on environment
- ✓ To optimize the CHP usage

**Unit I**

Basic concepts of CHP- The benefits and problems with CHP -Balance of energy demand– Types of prime movers –Economics– CHP in various sectors

**Unit II**

Pinch Technology–significance– Selection of pinch temperature difference – Stream splitting – Process retrofit – Installation of heat pumps, heat engines - Grand composite curve.

**Unit III**

Insulation – Recuperative heat exchanger – Run –around coil systems – Regenerative heat exchangers – Heat pumps – Heat pipes –.Waste Heat Recovery **-**Cogeneration Technology

**Unit IV**

Sources of waste heat, Cogeneration - Principles of Thermodynamics - Combined Cycles-Topping - Bottoming - Organic Rankine Cycles- Advantages of Cogeneration Technology

**Unit V**

Application & techno economics of Cogeneration- Cogeneration - Performance calculations, Part load characteristics- financial considerations - Operating and Investments

**Text Book:**


***1.*** Eastop, T.D. & Croft D.R, "Energy efficiency for engineers and Technologists", 2nd edition, Longman Harlow, 1990.

***2.*** O'Callaghan, Paul W, "Design and Management for energy conservation", Pergamon, 1993.


**REFERENCES:**


1. Osborn, peter D, "Handbook of energy data and calculations including directory of products and services", Butterworths, 1980.
2. Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.
3. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987


**Course Outcomes**

At the end of the course learner will be able to

- ✓ List and analyze the possibilities of combined Heat and power generation methodology for various sectors.
- ✓ Develop and assess pinch technology with process retrofits.

- ✓ Enumerate and evaluate the critical thickness of insulation.
- ✓ List the economical features & factors involving in cogeneration techniques

## 18REEP01E3 THERMODYNAMIC ANALYSIS OF ENERGY SYSTEMS

**Course Objectives:**

- ✓ to understand and apply the concept of availability,
- ✓ to calculate the behaviour of real gases
- ✓ to predict the condition of systems and analyse them by the criteria of equilibrium
- ✓ to apply the concepts of advanced thermodynamics to combustion systems

**Unit I**

Reversible work - availability – irreversibility. Second law efficiency for a closed system and steady – state control volume. Availability analysis of simple cycles. Thermodynamic potentials. Maxwell relations. Generalized relations for changes in entropy - internal energy and enthalpy-Cp and CV. Clausius Clayperon equation, Joule – Thomson coefficient. Bridgeman tables for thermodynamic relations

**Unit II**

Different equations of state – fugacity – compressibility. Principle of corresponding States - Use of generalized charts for enthalpy and entropy departure. Fugacity coefficient, Lee – Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition. Partial molar properties. Ideal and real gas mixtures. Equilibrium in multi-phase systems

**Unit III**

First and second law analysis of reacting systems - Adiabatic flame temperature – entropy change of reacting systems. Criterion for reaction equilibrium. Equilibrium constant for gaseous mixtures and evaluation of equilibrium composition.

**Unit IV**

Combustion of Hydrocarbon Fuels. Heat of reaction, combustion and formation. Stoichiometric, fuel rich and oxygen rich reactions. Heating value of fuels. Application of energy equation to the combustion process. Explosion limits, flames and flammability limits. Diffusion and premixed flames.

**Unit V**

Combustion in IC Engines and Gas turbines. Knocking and Detonation and control. Design principles of combustion chambers for IC Engines and Gas turbine. Arrangements of gas turbine combustion chambers for power and comparative analysis.

**Text Book:**

1. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
2. Kuo, K.K., Principles of Combustion, John Wiley and Sons, 2005

***REFERENCES:***

1. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995.
2. Winterbone D E, Advanced Thermodynamics for Engineers, Arnold, 1997.
3. Ganesan, V., Gas Turbines, Tata McGraw Hill, 2011.
4. Ganesan,V., Internal Combustion Engines, Tata McGraw Hill, 2006

5. Natarajan, E., Engineering Thermodynamics – Fundamentals and Applications, Anuragam 2014.
***6.*** Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 2001.

**Course Outcomes**

At the end of the course students will be able to

- ✓ Calculate the availability of the systems and cycles
- ✓ Analyse the engineering systems to improve and optimize its performance
- ✓ Understand the working and design principles of combustion systems

## 17REEP01E4 ADVANCED NUMERICAL ANALYSIS

**Course Objectives:**

- ✓ to develop of theory and practice in the use of advanced numerical methods for efficient solution of differential equation in renewable energy engineering.
- ✓ to formulate the renewable energy device performance in the form of numerical equations

**Unit I**

Solving a system of simultaneous equations; elimination method – the Gaussian elimination and Gauss - Jordan method – Iterative methods – Gauss Jacobi iteration – Gauss Seidel iteration - Relaxation method.

**Unit II**

Interpolation and curve fitting : Lagrangian polynomials - Divided difference – Interpolation with cubic spline - Least square approximation of functions.

Numerical Solutions of nonlinear system of equations – Fixed points for fucntions of several variables – Newton's method – Quasi Newton Methods – Steepost Descent Techniques – Homotopy and continuation methods

**Unit III**

Numerical differentiation and integration: Numerical differentiation – derivatives using Newton's forward and backward formula – Derivatives using Striling's formula – Trapezoidal rule – simpson's $1/3^{rd}$ rule – 3/8 rule – Weddles's rules – Errors in quadrature formula. – Moulton method.

Numerical Matrix Eigen value problems – Eigen value problems arising in practical applications – Localization of eigen values – compting selected eigen values and eigen vectors – the power method – the inverse iteration - the Rayliegh Quotient interations – Similarity tranformations and eigen value computations

**Unit IV**

Numerical solution of ordinary differential equations: the Taylor series method – Picard's method Euler and modified Euler methods – Runge – Kutta methods – Milne's method – The Adams – Moulton method

**Unit V**

Numerical solution of Partial differential equations – Introduction - Difference quotients – Geometrical representation of partial differential quotients – Classification of partial differential equations - Elliptic equations – Solutions to Laplace's equation by Liebmann's iteration process – Poission's equations and its solutions – Parabolic equations – Crank – Nicholson method - Hyperbolic equations.

**Text Book:**

1. Curtis. F. Gerald, Patrick & O. Wheatley, Applied Numerical Analysis, $5^{th}$ Edition, Pearson Education, New Delhi, 2005.

   Unit 1: Chapter 2: Sections 2.3, 2.4, 2.10, 2.11

Unit 2: Chapter 3: Sections 3.1, 3.2, 3.3, 3.4, 3.7.

2. V.N Vedamurthy & N.Ch.S.N.Iyengar, Numerical Methods, Vikas Publishing house, pvt. Ltd,2000.
   Unit 3: Chapter 9: Sections 9.1 to 9.4,9.6 to 9.12.
   Unit 4: Chapter 11: Sections 11.4 to 11.20.
   Unit 5: Chapter 12: Sections 12.1 to 12.9.

**REFERENCES**


1. Richard L. Burden & J.Douglas Faires, Numerical Analysis, 7th Ed., Thomson Brooks , 2001
2. Biswa Nath Datta, Numerical Linear Algebra, 2nd Ed., PHI Learning P Ltd., 2013
3. M.K.Jain, S.R.K Iyengar & R.K.Jain, Numerical Methods for Scientific and Engineering Computation, 3r Edition, Wiley Eastern Edition, New Delhi,2003.
4. R.L.Burden & J.Douglas Faires, Numerical Analysis, Thompson Books, USA,2005.


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Apply mathematical concepts and principles in renewable energy technology.
- ✓ Perform abstract mathematical reasoning.
- ✓ Understand the application of Fourier transform in engineering application.
- ✓ Apply conformal mapping for heat flow & fluid flow problems.
- ✓ Develop Finite difference methods for elliptical and parabolic equations.

## 17REEP01E5 DISCRETE MATHEMATICS

**Course Objectives:**

- ✓ To impart various concepts about permutations, combinations and theory of numbers.

**Unit I:** Four basic counting principles - Permutations of sets -Combinations (subsets) of sets - Permutations of multisets -Combinations of multisets - Pigeonhole principle: simple form - strong form - Pascal's triangle - The binomial theorem - Unimodality of binomial coefficients - The multinomial theorem - Newton's binomial theorem.

**Unit II:**The inclusion – exclusion principle – Combinations with repetition - Derangements – Permutations with forbidden positions – Some number sequences – Generating functions – Exponential generating functions – Solving linear homogeneous recurrence relations and non-homogeneous recurrence relations.

**Unit III:** Divisibility theory in the integers:Early number theory -The division algorithm - The greatest common divisor - The Euclidean algorithm -The Diophantine equation. Primes and their distributions:The fundamental theorem of arithmetic -The sieve of Eratosthenes -The Goldbach conjecture.

**Unit IV:** The theory of congruence: Basic properties of congruence - Linear congruence and the Chinese Reminder Theorem -Fermat's Theorem: Fermat's little theorem and pseudoprimes - Wilson's theorem - The Fermat-Kraitchik factorization method.

**Unit V:**Number theoretic functions: The sum and number of divisors - The Mobius inversion formula.Euler's generalization of Fermat's theorem:Euler's Phi function-Euler's theorem - Some properties of Phi function. Primitive roots: The order of an integer modulo *n* - Primitive roots for primes - Composite numbers having primitive roots.

**Text Books:**

1. Richard A. Brualdi, **Introductory Combinatorics,** 5 th edition, Pearson Education Inc, England, 2010.
   Unit 1: Chapter 2: Sections 2.1 - 2.5. Chapter 3: Sections 3.1, 3.2. Chapter 5: Sections 5.1 – 5.5.
   Unit 2: Chapter 6: Sections 6.1 - 6.4. Chapter 7: Sections 7.1 -7.5.
2. David M. Burton, **Elementary Number Theory**, 6th Edition, Tata McGraw Hill, New Delhi, 2006.
   Unit 3: Chapter 2: Sections 2.1 - 2.5, Chapter 3: Sections 3.2 - 3.3.
   Unit 4: Chapter 4: Sections 4.2, 4.4, Chapter 5: Sections 5.2 - 5.4.
   Unit5: Chapter 6: Sections 6.1, 6.2, Chapter 7: Sections 7.2, 7.3,
   Chapter 8: Sections 8.1 - 8.3.

**References:**


1. C. Berg, **Principles of Combinatorics**, Academic Press, New York, 1971.
2. S. Lipschutz& M. Lipson, **Discrete Mathematics**, Tata McGraw-Hill Publishing Company, New Delhi, 2006.

3. J. Truss, **Discrete Mathematics for Computer Scientists**, Pearson Education Limited, England, 1999.
4. Tom. M. Apostol,**Introduction to Analytic Number Theory**, Springer, New Delhi, 1993.
5. Thomas Koshy, **Elementary Number Theory**, Elsevier, California 2005.
6. N. Robbins, **Beginning Number Theory**, 2nd Edition, Narosa Publishing House, New Delhi, 2007.

**Course Outcomes:**

At the end of the course learner will be able to

- gain knowledge of permutations, combinations and its properties
- acquire knowledge of applications of permutations and combinations
- acquire concepts of divisibility and related algorithms
- proficient in congruence properties
- acquire knowledge of number theoretic functions

## 17REEP01E6 COMPUTATIONAL FLUID DYNAMICS

**Course Objectives:**
To provide brief introduction of Computational Fluid Dynamics along with chemical engineering application specifically, analysis of fluid mechanics and heat transfer related problems.

**Unit I**
Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Engineering, CFD software packages and tools.

**Unit II**
Principles of Solution of the Governing Equations: Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation.

**Unit III**
Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation. Solution Algorithms: Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.

**Unit IV**
CFD Solution Procedure: Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization.

**Unit V**
Case Studies: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.

**Text Book**


1. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill (1998).
2. Muralidhar, K.,andSundararajan,T. Computational Fluid Flow and Heat Transfer, Narosa Publishing. House (1995)


**References:**


1. Niyogi, P. Chakrabarty, S.K. and Laha, M.K., Introduction to computational fluid dynamics, Pearson education (2006).
2. LI J., G. H. Yeoh, C Liu. A Computational Fluid Dynamics, ELSEVER (2008)
3. Suhas V. Patankar. Numerical Heat Transfer and Fluid Flow, Taylor and Francis (1978).
4. S K Gupta. Numerical Methods for Engineers, New Age Publishers, 2nd Edition (1995).
5. Anderson J.D. Computational Fluid Dynamics, Mc-Graw Hills (1995).

6. Ranade, V.V., Computational flow modeling for chemical reactor engineering, Academic Press (2002).
7. J H Ferziger and M Peric, Computational Methods for Fluid Dynamics, Springer (2002).

**Course Outcomes:**

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

- ✓ Solve PDE.
- ✓ Use Finite Difference and Finite Volume methods in CFD modeling
- ✓ Generate and optimize the numerical mesh
- ✓ Simulate simple CFD models and analyze its results.

## 18REEP0103 SOLAR ENERGY LAB

**Course Objectives:**

- ✓ to carry out the performance evaluation of solar thermal system
- ✓ to optimize the performance of solar photovoltaic conversion devices
- ✓ to simulate the system using tools

1. Study on green house effect on solar flat plate collector
2. Estimation of instantaneous efficiency of a solar liquid flat plate collector
3. Study on solar flat plate collector in series and parallel combination
4. Estimation of efficiency of solar air heaters
5. Estimation of efficiency of solar still
6. Performance evaluation of concentrating solar collector
7. Performance evaluation of solar cooker
8. Estimation of efficiency of solar photovoltaic panels
9. Effect of Shadow & tilt angle on solar photo voltaic panel
10. Study on solar photo voltaic panel in series and parallel combination
11. Study on charging characteristics of a lead acid battery using solar photo voltaic panel.

**Course Outcomes**

At the end of the course learner will be able to
Evaluate the performance of

- ✓ Solar thermal system
- ✓ Solar PV system

## 18REEP0104 WIND ENERGY LAB

**Course Objectives:**

- ✓ To carry out the performance evaluation of wind electrical and mechanical devices
- ✓ To simulate and carryout the performance testing of Renewable Energy Devices using software tools

1. Estimation of cut in velocity of wind turbine generator
2. Evaluation of Tip Speed Ratio (TSR) with different wind velocities
3. Estimation of Coefficient of Performance of Wind Electric Generator
4. Evaluation of Power curve for wind turbine generator
5. Estimation of Charge controller of Wind Turbines
6. Performance evaluation of Wind turbine generator with various AC load condition
7. Performance evaluation of Wind turbine generator with various DC load condition
8. Performance Evaluation of Wind Water Pumping System
9. Study on Grid Integration of Wind Electric Generator
10. Studies on Micro Wind Turbine system
11. Simulation using Open Source Software (Spoken Tutorials, IIT, Bombay)

**Course Outcomes**

At the end of the course learner will be able to evaluate the performance of

- ✓ Wind Electric
- ✓ Wind Pumping

## 18REEP0105 RESEARCH METHODOLOGY & IPR

**Course Objectives:**

- ✓ To develop expertise and skills to undertake independent research in the renewable energy area
- ✓ To apply of statistical tools for the renewable energy system performance

**Unit - 1:** Scientific Research – methods of acquiring knowledge - Inductive and Deductive Reasoning, scientific method and its applications. Research Process: Selection of problem for Research, review of literature, formulation of Hypotheses, nature and types of Variable. New Developments in IPR: Administration of Patent System. New developments in IPR of Biological System, Computer Software etc. Traditional Knowledge Case Studies, IPR and IITs.

**Unit - 2:** Research Design and Methods: Purpose and preparation of research design. Types of research design – Historical, Descriptive, and Experimental. Field surveys, diagnostic and evaluation research. Qualitative and quantitative methods, problem-solving, development and interdisciplinary research.

**Unit - 3:** Tools and techniques of data collection – Observation, interview, Inquiry Forms, Psychological tests, Projective techniques, rating scales, Likert and Thurstone, Guttman type scales. Sociometry; Focus Group discussion, and PRA Validity, reliability and feasibility; Structure and qualities of a Research Report; Dissemination of research findings, Evaluation of Research Report.

**Unit - 4:** Data Analysis – Categorization, Presentation of data: Diagrams and Frequency distributions. Central measures, Dispersion measures, Skewness and kurtosis; Correlation and regression analysis, multiple correlation and regression, Factor analysis, and Discriminant analysis.

**Unit - 5:** Testing of Hypothesis and Tests of Significance: Basics and steps in hypothesis testing; Concept of Sampling distribution and Standard Error. Sampling and Data Collection: Probability and non-probability sampling techniques, sampling and non-sampling errors. Statistical Tests – large and small sample tests, Chi-square test, ANOVA.

**Text Book**


1. Aggarwal.Y.P, *Statistical Methods: Concepts, Applications and Computations,* New Delhi: Sterling Publishing Company, 1988.
2. Arun Kumar Singh, *Tests, Measurements and Research Methods in Behavioural Sciences,* New Delhi: Tata McGraw Hill, 1986.


**REFERENCES**


1. BritahaMikkelson, *Methods for Development Work and Research and a Guide for Practitioners.* New Delhi: Sage Publications, 1995.
2. Dooley, David, *Social Research Methods,* New Delhi: Prentice Hall, 1996.
3. Dwivedi.R.S, *Research Methods in Behavioral Sciences* Delhi: Macmillan, 1997.

4. Runyon.R.Petal, *Fundamentals of Behavioural Statistics,* New Delhi: McGraw Hill, 1996.
5. Garett.H.E, *Statistics in Psychology and Education,* Bombay: Vakils, Feffer and Simons, 1981.
6. Kerlinger.N, *Foundations of Behavioural Research,* Delhi: Surjeet Publications, 1983.
7. KuttanMahadeven and Parameswara Krishnan, *Methodology for Population Studies and Development*. New Delhi: Sage Publications, 1993.
8. Vijayalakshmi.G and Sivapragasam.C, *Research Methods: Tips and Techniques*, Chennai: MJP Publishers, 2009.
9. Halbert, *Resisting Intellectual Property,* Taylor & Francis Ltd, 2007.
10. Robert. P Merges, Peter.S Menell, Mark.A Lemley, *Intellectual Property in New Technological Age,* 2016.
11. T.Ramappa, *Intellectual Property Rights Under WTO* Chand, 2008., S.

**Course Outcomes**

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

- Identify and formulate a problem for research.
- prepare suitable research design, choose appropriate tools and techniques of data collection
- process the data collected and do analysis using appropriate statistical methods
- write research report independently and professionally

## 18GTPP0001 GANDHI IN EVERYDAY LIFE

**Course Objectives:**

- To understand and appreciate the principles and practices of Gandhi and their relevance in the contemporary times.
- To develop noble character and attitude to enable the students to cope up with the challenges of daily life.

**Unit - I** Understanding Gandhi: Child hood days, Student days, influence of Books and Individuals, Religion, Family, and Social factors. Gandhi as rebel, acquaintance with vegetarianism, as lawyer, encountering and transforming humiliation: in India, in south Africa - train incident, Coach incident, on path way, at court, attack by protesters. Gandhi as political leader and reformer.

**Unit - II** Management: Gandhi's experiments in managing family- Eleven vows, non-possession and sacrifice begin at home – Managing Ashram - community living, service and financial ethics – Managing Social movements- Transvaal March and Salt Satyagraha and nonattachment to position (Nishkama Seva).

**Unit - III** Conflict Reduction: Pursuance of truth and nonviolence ends and means, openness, transparence, love and kindness in handling relationship, nonviolent communication, practicing nonviolence in social and political issues (Satyagraha), conflict resolution practices, art of forgiveness and reconciliation and shanti sena.

**Unit - IV** Humanism: Trust in goodness of human nature, respect for individual and pluralistic nature of society, dignity of differences, equal regard for all religions (Sarvadharma Samabhava), castes, races, colours, languages etc., simple and ethical life, swadeshi and unity of humankind.

**Unit - V** Constructive programmes and contemporary issues: Concept of Sarvodaya, poverty, terrorism, environmental degradation, problems in sharing common resources, health systems and education, science and technology and centralization of power and governance.

**References:**


- M.K. Gandhi, (2012) *An Autobiography or The Story of My Experiments with Truth*, Navajivan Publishing House, Ahmedabad.
- (2003) *Satyagraha in South Africa*, Navajivan Publishing House, Ahmadabad.
- (1945) *Constructive Programme: Its Meaning and Place*, Navajivan Publishing House, Ahmadabad.
- (2003) *Key to Health*, Navajivan Publishing House, Ahmedabad
- (1949) *Diet and Diet Reform*, Navajivan Publishing House, Ahmadabad.
- *Basic Education*, Navajivan Publishing House, Ahmadabad.
- (2004) *Village Industries*, Navajivan Publishing House, Ahmadabad.
- (1997) *Hind Swaraj*, Navajivan Publishing House, Ahmadabad.
- (2004) *Trusteeship*, Navajivan Publishing House, Ahmadabad.
- (2001) *India of my Dreams*, Navajivan Publishing House, Ahmadabad.K.S.Bharathi (1995) Thought of Gandhi and Vinoba, *Shanti Sena*, Sarva Seva Sangh Prakashan,

Varanasi.V.P.Varma, (1999)*Political Philosophy of Mahatma Gandhi and Sarvodaya*, Lakshmi Narain Agarwal, Agra.
- Louis Fisher (2010) *Gandhi: His Life and Message*.
- B.R. Nanda. (2011)*Mahatma Gandhi: A Biography*, Allied Publishers Private Ltd., New Delhi.
- N.K. Bose. (2008) *Studies in Gandhism*, Navajivan Publishing House, Ahmadabad.
- Gopinath Dhawan, (2006)*The Political Philosophy of Mahatma Gandhi*, Navajivan Publishing House, Ahmadabad.
- N.Radhakrishnan, (2006) *Gandhi's Constructive Programmes: An Antidote to Globalized Economic Planning?,* Gandhigram Rural Institute, 2006.

**Films.**

- Richard Attenborough, Gandhi.
- Syam Benegal, The Making of Mahatma.
- Anupam P. Kher, Mine Gandhi Ko Nahin Mara.
- Peter Ackerman and Jack Duvall, A Force More Powerful

**Course Outcomes:**

To enable students to:

- To study in-depth the life and message of Gandhi.
- To understand the Gandhian way of Management.
- To practice the Gandhian model of conflict reduction.
- To lead a humane life on Gandhian lines.
- To become a Gandhian constructive worker.

## 18REEP0206 POWER SYSTEMS FOR RENEWABLE ENERGY SOURCES

**Course Objectives:**

- ✓ To get familiarized with the power quality management issues in Renewable Energy Sector
- ✓ To study the smart grid application for Rural Development
- ✓ To familiarize various IEEE/ IEC/BIS standards

**Unit I**

Concept of mini, micro and smart grids. Basics of Voltage stability issues in Power system. Synchronous Machines: basic principles, construction, speed and frequency, synchronous reactance, regulation, induced EMF, basic vector diagram, parallel operation. Elementary problems on synchronous machines, Permanent magnet synchronous generator (PMSG), Power Factor issues, and economics of power Factor, reactive power, apparent power and active power

**Unit II**

Introduction to Induction Machines: principle of operation, construction, classification,expression for induced EMF, Torque/slip characteristics, Vector diagram, losses and efficiency of the machine, related problems. Induction Generator: Grid connected, self-excited, Doubly Fed induction generator, estimation of capacitance requirements for self-excited IGs, problems on IGs

**Unit III**

Solar photovoltaic(PV) modules: series parallel connection of cells, Batteries for PV system, photovoltaic system design and applications, rating of PV systems, sizing of wires in PV system illustrative examples, maximum power point tracking (MPPT), charge controllers, DC to DC converters, DC to AC converters, hybrid PV systems ,issues with hybrid systems, grid connected PV systems, Lifecycle costing(LCC)

**Unit IV**

Issues of Embedded generation, common attributes of embedded generation, basic power conversion of wind turbine system, scenario of power conversion structure of wind turbine system, wind to electric conversion alternatives: choice of Electrical output. Grid requirements of PV and Wind Turbine System

**Unit V**

Power Quality: basic terminologies, impact of power quality on power factor, true RMS value of current, voltage and power factor(PF), elementary problems, impact of power quality on power system, design of transformers & cables in an harmonic environment with illustrations, point of common coupling(PCC),linear and non-linear load, sequence components of harmonics, impact of harmonics on neutral sizing, power quality audit, power quality analyzers, power quality issues of solar and wind power integration with grid , power quality standards. Power Quality Mitigation

**Text Book**


1. Chetan Singh Solanki: Solar Photovoltaics fundamentals, Technologies and Applications, PHI Learning Private Limited- Eastern Economy Edition
2. Nick Jenkin,Ron Allan,Peter Crossley,DanielKrischen and Goran Strbac: Embedded Generation, IET power and Energy series-31


**References**


1. Remus Teodorescu,Marco Liserre and Pedro Rodriguez: Grid Converters for Photovoltaic and Wind Power Systems, Wiley and sons Ltd
2. Janaka Ekanayake,Kithsiri Liyanage,Jianzhong Wu,Akihiko Yokoyama,Nick Jenkin: Smart Grid Technology and Applications, A John Wiley & Sons Ltd
3. C.Sankaran: Power Quality, CRC Press
4. Roger C.Dugan, Mark F. McGranaghan,Surya Santoso& H.Wayne Beaty: Electrical Power Systems Quality, Tata McGraw-Hill
5. Dr.P.S.Bimbhra: Electrical Machinery, Khanna Publishers


**Course Outcomes**

At the end of the course Learner will be able to

- ✓ Understand the Power system components for Renewable Energy grid integration
- ✓ Describe the application of Power electronic devices in Renewable Energy System
- ✓ Assess the Role of Power System in Wind Power integration and PV power integration
- ✓ Power Quality issues in Power System
- ✓ Recommended IEEE/IEC/BIS standards in Power System

## 18REEP0207 WASTE TO ENERGY CONVERSION TECHNOLOGIES

**Course Objectives:**

- ✓ To characterize the solid / liquid waste
- ✓ To Evaluate the performance bio chemical conversion technologies
- ✓ To Elucidate the thermo chemical conversion technologies

**Unit I**

Solid Waste -Definitions: Sources, types, compositions; Properties of Solid Waste; Municipal Solid Waste: Physical, chemical and biological property; Collection, transfer stations; Waste minimization and recycling of municipal waste

Landfill method of solid waste disposal; Landfill classification; Types, methods & siting consideration; Layout & preliminary design of landfills: Composition, characteristics, generation; Design of Sanitary Land fill - Movement and control of landfill leachate &gases; Environmental monitoring system for landfill gases.- Gas Recovery – Applications

**Unit II**

Waste Treatment & Disposal Size Reduction: incineration; Furnace type & design; Types of Incinerators – Fuel Economy - Medical /Pharmaceutical waste / Hazardous waste / Nuclear Waste incineration .; Environmental impacts; Measures of mitigate environmental effects due to incineration;

**Unit III**

Energy Generation From Waste Types: Biochemical Conversion: Sources of energy generation, Industrial waste, agro residues; Anaerobic Digestion: Biogas production; Determination of BOD, DO, COD, TOC, & Organic loading, Aerobic & Anaerobic treatments – types of digester – factors affecting bio digestion - Activated sludge process. Methods of treatment and recovery from the in industrial waste water – Case Studies in sugar, distillery, dairy, pulp and paper mill, fertilizer, tanning, steel industry, textile, petroleum refining, chemical and power plant.

**Unit IV**

Rural applications of biomass –Combustion - Chulas - improved Chulas- Biomass – Physical - Chemical composition – properties of biomass –TGA – DSC characterization – Ash Characterization - Preparation of biomass – Size reduction – Briquetting of loose biomass- Briquetting machine - Co combustion – Fluidized bed combustion Perfect, complete and incomplete combustion - stoichiometric air requirement for bio fuels - equivalence ratio

**Unit V**

Thermo chemical Conversion -Basic aspects of biomass combustion - heat of combustion - different types of grates -Gasification - Fixed and Fluidized bed gasifier – Factors affecting Gasification - dual fuelling in IC engines – 100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning systems -Gasification technologies for the selected waste like Rice Husk, Coir pith, Bagasse, Poultry litter etc., - Pyrolysis – Char Characteristics Classification - process governing parameters – Typical yield rates. Carbonization Techniques – merits of carbonized fuels

**Text Book**

1. Parker, Colin, & Roberts, *Energy from Waste - An Evaluation of ConversionTechnologies*, Elsevier Applied Science, London, 1985
2. Shah, Kanti L., *Basics of Solid & Hazardous Waste Management Technology*, Prentice Hall, 2000

**References:**

1. Manoj Datta, *Waste Disposal in Engineered Landfills*, Narosa Publishing House, 1997
2. Rich, Gerald et.al., *Hazardous Waste Management Technology*, Podvan Publishers, 1987
3. Bhide AD., Sundaresan BB, Solid *Waste Management in Developing Countries*, INSDOC, New Delhi,1983.

**Course Outcomes**

At the end of the course learner will be able to

- ✓ Predict the best suited method for solid waste disposal.
- ✓ Select and assess various waste treatment processes.
- ✓ Develop ideas in the context of generating energy from various wastes.
- ✓ Characterize the biomass and its application in rural area for fulfilling energy demands.
- ✓ Analyze the Gasification process for various biomass wastes.

## 18REEP02E1 ENERGY ECONOMICS AND POLICIES

**Course Objectives**

- ✓ to understand the basics of energy economics so as to address to energy problems
- ✓ to study the policies of reneable energy for sustainable development

### UNIT I: INTRODUCTION TO ENERGY ECONOMICS

Natural Resources – Classification – Importance – Role of Natural Resources in Economic Development – Energy Resources – Classification – Properties and Forms of Energy –Energy Economics – origin, Scope and Nature.

### UNIT II: ENERGY AND DEVELOPMENT

Role of Energy in Economic Development – Energy Indicators - Energy Intensity and Energy Elasticity – National and International Comparison – Role of International Institutions – OPEC, OAPEC, IEA, and World Bank.

### UNIT III: ENERGY AND ENVIRONMENT NEXUS

Energy Environment Nexus Crisis – Causes and Consequences – Remedial Measures – Impact of Energy Consumption and Production on Environment with illustrations – Role of Energy Economists in solving Energy Crises.

### UNIT IV: ENERGY PLANNING AND MANAGEMENT

Energy Planning and Energy Conservation – Meaning, Objectives and Importance – Energy Management – Meaning, Objectives and Importance – Recent Developments: Energy Auditing – Energy Accounting – Energy conservation - Energy Pricing and Taxes – Role of Economists in Sustainable Energy Management.

### UNIT V: INDIA'S ENERGY PROFILE

Indian Energy Sector – Organizational Structure – Energy Supply sources and trends in production – Energy Demand on sectoral consumption trend – Renewable Energy Sources and Technologies - Renewable Energy Programmes in India

.

**Text Book**


1. Agarwal, M.C. and Monga, J.R. (1992): **Economic and Commercial Geography**, National Publishing House, New Delhi.
2. Agarwal, S.K. (1985): **Environment and Natural Resources Economics**, Scott Foresman & Co., London


**References**


1. Common, M. (1985): **Environmental and Resource Economics**, Longman, London.

2. David Pearct et al., (1990): **Sustainable Development – Economics and Environment in the Third World**, Earths Can Publications, London.
3. Karpagam, M. (1991): **Environmental Economics**, Sterling, New Delhi.
4. Kneese. A.V and Sweeny, J.L, 1993): **Handbook of Natural Resource and Energy Economics**, North Holland.
5. Munasinghe, M and Meier, P (1993): **Energy Policy and Modeling**, Cambridge University Press, UK.
6. Richard Eden (1981): **Energy Economics – Growth, Resources and Policies**, Cambridge University Press, London.
7. TERI (2015): **Teri Energy Data Directory and Year Book 2014-15**, The Energy Research Institute, New Delhi.

**Course Outcomes**

- ✓ The students would have understood the importance of energy in economic development and need for energy conservation.
- ✓ They also be able to take up research in energy economics.

## 18REEP02E2 ENERGY MODELING AND PROJECT MANAGEMENT

**Course Objectives:**

- ✓ To be able to use relevant tools and model for energy engineering in view of proposing the most efficient energy systems mix
- ✓ To model different types of renewable energy mix for optimum usage

**Unit I**

Macroeconomic Concepts - Measurement of National Output - Investment Planning and Pricing - Economics of Energy Sources - Reserves and Cost Estimation. Energy Markets: Monopoly, oligopoly and competitive markets, behavior of markets with price change of energy, balance payment problems.

**Unit II**

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Basic Pricing: Basic Pricing Principles, Growing Demands and Dynamic effects, Short Run versus Long Run Marginal Cost Pricing, Peak load and seasonal pricing, Pricing of Nonrenewable energy resources. Subsidized Prices and life line rates

**Unit III**

Energy Demand Modeling - Overview of Econometric Methods. Methodology of Energy Demand Analysis - Methodology for Energy Technology Forecasting -Methodology for Energy Forecasting - Sectoral Energy Demand Forecasting.

**Unit IV**

Solar Energy - Biomass Energy - Wind Energy and other Renewable Sources of Energy - Economics of Waste - Heat Recovery and Cogeneration - Energy Conservation Economics.

**Unit V**

Cost Analysis - Budgetary Control - Financial Management - Techniques for Project Evaluation. Definition and scope of project, Technical Design, Financing, Contracting, Implementation and Performance Monitoring, Implementation Plan for top management, Planning Budget, Procurement procedures, Construction, Measurement and Verification. Investment needs Appraisal and Criteria, Financial Methods of Projects evaluations, Case Studies

**Text Book**


1. M.Munasinghe and P.Meier *Energy Policy Analysis and Modeling,*CambridgeUniversity Press 1993
2. W.A.Donnelly *The Econometrics of Energy Demand: A Survey of Applications*, New York.1987
3. S.Pindyck and Daniel L.Rubinfeld *Econometrics Models and Economic Forecasts, 3rd edition* MC Graw -Hill, New York 1990

**References:**


1. UN-ESCAP *Sectoral Energy Demand Studies: Application of the END-USE Approach to Asian Countries,* New York 1991
2. UN-ESCAP *Guide Book on Energy -Environment Planning in Developing Countries:Methodological Guide on Economic Sustainability and Environmental Betterment Through Energy Savings and Fuel Switching in Developing Countries*, New York1996
3. S.Makridakis , *Forecasting Methods and Applications.*Wiley 1983


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Identify and select the effective energy modelling with interpreting the economics and investment planning.
- ✓ Calculate the energy demand and customize the best suited methods /option.
- ✓ Interpret the data and compare the various renewable energy options along with energy conservation technologies.
- ✓ Select appropriate project evaluation technique and plan the methodology of evaluation.

## 18REEP02E3 ENVIRONMENTAL IMPACT ASSESSMENT

**Course Objectives:**

- ✓ To Critically understand the use, strengths, and limitations of EIA
- ✓ To develop working familiarity with EIA methods and analytic techniques.

**Unit I**

Basic concept of EIA : Initial environmental Examination, Elements of EIA, - factors affecting E-I-A Impact evaluation and analysis, preparation of Environmental Base map, Classification of environmental parameters.

E I A Methodologies: introduction, Criteria for the selection of EIA Methodology, E I A methods, Ad-hoc methods, matrix methods, Network method Environmental Media Quality Index method, overlay methods, cost/benefit Analysis.

**Unit II**

Impact of Developmental Activities and Land use: Introduction and Methodology for the assessment of soil and ground water, Delineation of study area, Identification of actives.

Procurement of relevant soil quality, Impact prediction, Assessment of Impact significance, Identification and Incorporation of mitigation measures.

**Unit III**

E I A in surface water, Air and Biological environment: Methodology for the assessment of Impacts on surface water environment, Air pollution sources, Generalized approach for assessment of Air pollution Impact.

Assessment of Impact of development Activities on Vegetation and wildlife, environmental Impact of Deforestation – Causes and effects of deforestation.

**Unit IV**

Environmental Audit & Environmental legislation , objectives of Environmental Audit, Types of environmental Audit, Audit protocol, stages of Environmental Audit, onsite activities, evaluation of Audit data and preparation of Audit report.

**Unit V**

Post Audit activities, The Environmental pollution Act, The Water Act, The Air (Prevention & Control of pollution Act.), Mota Act, Wild life Act. Case studies and preparation of Environmental Impact assessment statement for various Industries.

**Text Book**


1. Y. Anjaneyulu, *Environmental Impact Assessment Methodologies,* B.S. Publication, Sultan Bazar, Hyderabad. 2002
2. J. Glynn and Gary W. Hein Ke *Environmental Science and Engineering*, Prentice Hall Publishers 2000

**References:**


1. Suresh K. Dhaneja – S.K., *Environmental Science and Engineering,* Katania & Sons Publication., New Delhi.1998
2. Dr H.S. Bhatia *Environmental Pollution and Control,* Galgotia Publication (P) Ltd, Delhi, 1996


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Understand the process of environmental impact assessment (EIA).
- ✓ Discuss current trends in EIA.
- ✓ Predict the environmental consequences (positive or negative) of a plan, policy, program, or project prior the implementation decision.
- ✓ Investigate new technological solution based on the Environmental Audit.

## 18REEP0208 WASTE TO ENRGY LAB

**Course Objectives:**

- ✓ Performance evaluation of bio chemical conversion process
- ✓ Elucidate the thermo chemical energy conversion devices performance

1. Proximate analysis of solid wastes
2. Calorific value of solid wastes
3. Combustion characteristics of solid wastes
4. Study of Composting of solid wastes
5. Estimation of energy recovery potential of solid wastes
6. Study of refuse derived fuel (RDF)
7. Estimation of BOD, DO level in effluent
8. Estimation of COD level in effluent
9. Evaluation of Fixed Dome biogas plant
10. Evaluation of Floating Drum biogas plant
11. Performance analysis of gasifier
12. Performance analysis various wood stoves
13. Estimation of Calorific Value of Gaseous fuels
14. Characteristics of Fuel Cell
15. Analysis of Non Edible oil as alternate energy source

**Course Outcomes**

At the end of this course learner will be able to,
Evaluate the performance of

- ✓ Biochemical Conversion technologies
- ✓ Thermochemical conversion technologies
- ✓ Alternate Energy Sources

## 18REEP0209 ENERGY AUDITING OF MSMEs (FIELD VISIT)

**Course Objectives:**

- ✓ To carryout the energy analysis of MSMEs
- ✓ To explore the energy conervation steps in MSMEs

**CFA:**

- ✓ Energy Auditing, Energy Conservation Potential Identification - 30 marks
- ✓ Energy Audit Report Preparation - 30 marks

**ESE:**

Seminar Presentation - 20 marks
Viva-Voce - 20 marks

**Course Outcomes**

At the end of the course learner will be able to
Get exposure in

- ✓ MSMEs Operation
- ✓ Energy Auditing of MSMEs
- ✓ Energy Conservation Potential

## 18REEP0210 MINI PROJECT

**Course Objectives:**

- ✓ To Design and Development of Renewable Energy Gadgets
- ✓ To analyzer the performance of the system

A group of 3 to 4 Students should develop a cost effective renewable energy gadget / Evaluation of bottlenecks of existing devices / Evaluation of Renewable Energy Plants / Market Potential Analysis of Renewable Energy Devices etc,

Evaluation is based on the product, report and *viva voce*.

**ESE:**

| | | |
|---|---|---|
| Product & Report | - | 25 marks |
| Seminar & Viva Voce | - | 25 marks |

**Course Outcomes**

At the end of the course learner will be able to
Get exposure in

- ✓ Desigining of product / process
- ✓ Fabrication / optimization techniques

# 18REEP02M1 ROOFTOP SOLAR PHOTOVOLTAIC ENTREPRENEUR

**Course Objectives:**

- ✓ Training candidates for the job of a "Rooftop Solar Photovoltaic Entrepreneur" as per NSQF

**Unit I**

Select the right quality of solar module by identifying the key technical parameters in data specification sheets - select the right quality of inverter by identifying the key technical parameters in data specification sheets- select the right quality of mounting structure by identifying the key technical parameters in data specification sheets - select the right quality of battery by identifying the key technical parameters in data specification sheets - select the balance of system by identifying the key technical parameters -Identify market price of different components of solar PV system - prepare a cost estimate for a solar project - prepare a cost benefit analysis for a rooftop solar PV plant including LCOE, Payback, IRR etc. - identify the policy, regulations and procedures for solar rooftop sector in the local market - identify and select the appropriate business models in solar rooftop sector

**Unit II**

Identify optimum location of installations - Assess the site level pre-requisites for solar panel installation - Decide on the type of mounting to be constru cted and place of mounting as per client requirement - Check for any shading obstacles - Prepare a site map of the location where installation has to be carried out - Assess the load to be run on solar PV power plant and prepare a load profile - Estimate the capacity of solar PV power plant - Decide on battery backup as per grid availability, loads and client expectation - Assess or obtain the site specific major parameters of solar resource data like GHI, DNI, Temperature and Wind

**Unit III**

Perform shading analysis -Estimate the energy generated from the rooftop solar PV power plant using solar design softwares - Identify the risks associated with the specific solar project- Prepare a site Feasibility Study Report using specialized software

Read and interpret the single line diagram, civil / mechanical drawings and electrical drawings - Read and interpret the bill of material - Calculate the lifecycle cost of a rooftop solar project- Identify and mitigate various risks associated with the project - Ensure the solar PV system and structure meets the local government and regulatory requirements - Prepare action plan and coordinate the implementation of rooftop solar project - Identify the maintenance activity required for a rooftop solar PV power plant components -Prepare a preventive maintenance schedule - Ensure proper cleaning of solar panels periodically - Ensure regular inspection of the solar PV system to identify and rectify the faults

**Unit IV**

Describe the process for setting up a new venture - Identify the key ingredients of a business plan

- Distinguish between fixed and working capital requirements -Describe the components of a loan application for fund raising -Demonstrate good Etiquettes and manners while communicating with the client - Demonstrate the importance of time management - Demonstrate leadership skills and effective resource management techniques - Demonstrate the use of MS word and MS excel for preparing a proposal - Prepare a workable presentation for marketing and business development -Choose the right buyer in a given situation of market parameters - Identify the challenges and risks for new entrepreneurs and the possible mitigation measures

**Unit V**

Dentify the requirements for safe work area; -Administer first aid; - Identify the personal protective equipment used for the specific purpose; - Identify the hazards associated with photovoltaic installations; - Identify work safety procedures and instructions for working at height; - Understand Occupational health & Safety standards and regulations for installation of Solar PV system

**Text Book**

1. Semiconductor Devices, Basic Principles, Jasprit Singh, Wiley,(2001)
2. The Physics of Solar Cells, Jenny Nelson, Imperial College Press ((2003)
3. Skill Council for Green Job, SGJ/Q0104, V1.0

**References:**

1. Solar Cell Device Physics (2nd edition), Stephen J. Fonash ,Academic Press (2010)
2. Handbook of Photovoltaic Science & Engineering,A. Luque and S. Hegedus (Ed), Wiley (2003)

**Course Outcomes**

At the end of the course learner will be able to

- ✓ Carry out market research and prepare a cost estimate for a Rooftop Solar Photovoltaic plant
- ✓ Prepare site feasibility report
- ✓ Manage Solar PV project lifecycle
- ✓ Entrepreneurship skills
- ✓ Maintain Personal Health & Safety at project site

# 18REEP02M2 SOLAR PROPOSAL EVALUATION

**Course Objectives:**

- ✓ Training candidates for the job of a "Solar Proposal Evaluation Specialist" as per NSQF

**Unit I**

Identify particulars of land or rooftop, whether free hold, lease, rent etc. - Assess suitability of foundations & structures of ground mount Solar PV power plant based on soil testing report including wind sustainability. - Assess suitability of foundations & structures of ground mount solar PV power Plant based on structural stability report including wind sustainability. -Assess the availability and capacity of the local grid and substation.

**Unit II**

Identify required permits and clearances from local authority for proposed project. - Assess the solar resource availability for the site and its potential variability - Identify whether the selected technology is proven - Assess the viability of the certificates and specification datasheets of the solar PV power plant components for quality and adherence to standards. - Assess the warranty conditions and check the basis safety parameters of the components in terms of lifespan and quality.

**Unit III**

Read and Interpret the software simulation report of any solar modelling software for performance ratio, Annual Energy Yield, Loss analysis , ROI, Payback Period, cash flow, etc wit the help of software - Evaluate the performance of the Solar PV Power Plant. - Determine the financial viability of Solar PV power plant - Identify and asses the replacement cost of the Solar components - Identify and asses the operation and maintenance cost - Identify the government policy and procedures as well as benefits available, if any Assess a reasonable gestation period for erection and commissioning of a Solar PV power plant.

**Unit IV**

Calculate the levelized cost of Electricity (LCOE) from a solar PV power plant. - Read and interpret the power purchase agreement and other contractual agreements - Assess the various risks involved in a solar project and identify the possible risk mitigation measures - Assess the financial viability of Solar PV plant based on Return on investment (ROI), payback period, Net present Value(NPV), IRR, Debt service coverage ratio (DSCR) , etc. - Describe the Process for setting up a new venture - Identify the key ingredients of a business plan

**Unit V**

Distinguish between fixed and working capital requirements - Describe the components of a loan application for fund raising- Demonstrate good Etiquettes and manners while communicating with the client - Demonstrate the importance of time management - Demonstrate leadership skills and effective resource management techniques -Demonstrate the use of MS word and MS

excel for preparing a proposal - Prepare a workable presentation for marketing and business development - Choose the right buyer in a given situation of market parameters - Identify the challenges and risks for new entrepreneurs and the possible mitigation measures

**Text Book**

1. Semiconductor Devices, Basic Principles, Jasprit Singh, Wiley,(2001)
2. The Physics of Solar Cells, Jenny Nelson, Imperial College Press ((2003)
3. Skill Council for Green Job, SGJ/Q0105, V1.0

**References:**

1. Solar Cell Device Physics (2nd edition),Stephen J. Fonash ,Academic Press (2010)
2. Handbook of Photovoltaic Science & Engineering,A. Luque and S. Hegedus (Ed), Wiley (2003)

**Course Outcomes**

At the end of the course learner will be able to

- ✓ Check the site feasibility of Solar PV Power Plant.
- ✓ Assess the technology feasibility of Solar PV Power Plant.
- ✓ Determine the financial viability of Solar PV Power Plant.

## 18REEP02M3 ENERGY AUDITING INSTRUMENTATION

**Course Objective**

- ✓ To Train candidates for the use of "Energy Auditing Instrument
- ✓ To assertain the Calibration and error analysis of the instrument

**Unit I**

Instrument classification, Characteristics of Instruments - Static and dynamic, experimental error analysis, systematic and random errors, Statistical analysis, Uncentainity, Experimental planning and selection of measuring instruments, Reliability of instruments.

**Unit II**

Data logging and acquisition, use of intelligent instruments for error reduction, element of micro-computer interfacing, intelligent instruments in use.

**Unit III**

Measurement of thermo-physical properties, instruments for measuring temperature, pressure and flow, use of intelligent instruments for the physical variables.
Electrical measurement – Power analyzer – harmonic analyzer – power factors

**Unit IV**

Techniques, shadow graph, Schlieren, interferometer, Laser Doppler anemometer, heat flux measurement, Telemetry in engines.

**Unit V**

Chemical, thermal, magnetic and optical gas analysers, measurement of smoke, dust and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques.

**Text Book**


1. Holman, J.P., *Experimental methods for engineers*, McGraw-Hill, 1988.
2. Barney, *Intelligent Instrumentation*, Prentice Hall of India, 1988.


**References:**


1. Prebrashensky, V., *Measurements and Instrumentation in Heat Engineering,* Vol.1 and 2, MIR Publishers,1980.
2. Raman, C.S., Sharma, G.R., Mani, V.S.V., *Instrumentation Devices and systems,* Tata McGraw Hill, New Delhi, 1983.
3. Doeblin, *Measurements System Application and Design*, McGraw Hill, 1978.
4. Morris. A.S, *Principles of Measurements and Instrumentation,* Prentice Hall of India, 1998.


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Operate and record the various energy paramters
- ✓ Test and accuracy level of instruments
- ✓ Interuptation of results

## 18ENGP00C1 COMMUNICATION & SOFT SKILLS

**Course Objectives:**

- ✓ To impart effective communication
- ✓ To inculcate the soft skill

**UNIT I**

- Basics of Communication
- Barriers to Communication

**UNIT II**

- Communication and Language Skills
- Communicating in a Global Language

**UNIT III**

- Resumes and Cover Letters
- Group Discussions

**UNIT IV**

- Business communication
- Intercultural Communication

**UNIT V**

- Professional Communication
- Interviews

**Textbook:**

Krishnaswamy, Dhariwal and Krishnaswamy. *Mastering Communication Skills and Soft Skills*. Blomsbury, 2015.

**Course Outcomes**

i). To develop inter personal skills and be an effective goal oriented team player.
ii). To develop professionals with idealistic, practical and moral values.
iii). To develop communication and problem solving skills.
Iv). To re-engineer attitude and understand its influence on behavior.

## 18REEP0311 SUMMER INTERNSHIP

**Course Objective**

- ✓ To sensitize students to the nuances of a work place by assigning time-bound projects in a company / R&D organization or NGO working on Renewable Energy

Student should undergo an inplant training in a process / product industry / NGO in energy related area or should undergo an energy auditing in any rural industries and submit a report along with certificate (details of the training undergone) from the industry where he / she undergone the training for a period of 30 calendar days. Student should present a seminar about the energy saving potential / case study of the industry or energy planning. Evaluation is based on the report, Seminar Performance and *viva voce*.

**ESE:**

Report - 25 marks
Seminar & Viva-Voce- 25 marks

**Course Outcomes**

At the end of the course learner will be able to
Get exposure in

- ✓ Renewable Energy Industrial Exposure
- ✓ Rural Industries Energy Auditing
- ✓ Role of NGO's in Energy planning

## 18REEP03E1 RURAL ELECTRIFICATION: TECHNOLOGIES AND ECONOMICS

**Course Objectives:**

- ✓ To inculcate the rural energy related issues and technological options
- ✓ To analyze the financial viability and cost benefit analysis

**Unit I**

Role of Electricity in Rural Development - Village Electrification in India - Current Status- Rural Electrification – Indian Perspective - Genesis of India's RE Programme- Major RE Programmes - Pradhan Mantri Gramodaya Yojana (PMGY) - Accelerated Rural Electrification Programme (AREP) – Recent Policy And Frame Work Of Re Programme - Characteristics of RE Programme - Rural Electrification Models

**Unit II**

Potential electrification models- Decentralized generation technologies; Costs and choice of technology, Demand and benefits forecasting and program development, Principles of cost-benefit calculations

Economic and financial analysis of stand-alone electrification projects, Decentralized versus central station generation, Traditional power systems, Load curves and load curve analysis

**Unit III**

Financial Analysis – Fixed and Variable Cost – Interest Rate – Simple Payback - Discounted Cash Flow Methods - Net Present Value Method - Internal rate of return method- Profitability index - Factors Affecting Analysis Real value

Project Management - Project Definition and Scope - Technical Design – Financing – Contracting - Implementation -Performance Monitoring

**Unit IV**

Rural Energy Planning and Management – Objectives – Village Level Study – Population - Hamlet Basic Data – Land Area Classification - Live Stock – Village Energy Scenario – Domestic Vs Public – Fuels used – Energy Requirement for Thermal – Electrical – Irrigation – Transportation – Energy Consumption Source wise – Per capita Energy Consumption – Renewable Energy Availability – Renewable Energy Utilization Scenario – Forecasting – Energy Requirement – Energy Analysis by the intervention of RE Devices - Payback analysis

**Unit V**

The power grid; DG-Grid interconnection issues, Mini and Micro Grids – Economics – Environmental Factors – Transmission and Regulations – Recent Trends

**Text Book**

1. H. Lee Willis and W.G. Scott: *Distributed Power Generation: Planning and Evaluation*, Marcel Dekker, 2000.

2. J. J. Burke: *Power Distribution Engineering, Fundamentals and Applications*, Marcel Dekker, 1994.

**References:**

1. T. Gonen: *Electric Power Distribution System Engineering*, McGraw-Hill 1986.
2. M Mohan: *Rural electrification for development: policy analysis and applications.*Boulder : Westview Press, 1987
3. G. Saunier: *Rural electrification guidebook for Asia and the Pacific,* Asian Institute of Technology, 1992.

**Course Outcomes**

At the end of the course learner will be able to

- ✓ Describe the decentralized power generation technologies and can perform the cost benefit calculations.
- ✓ Evaluate the economic and financial analysis of stand-alone electrification projects.
- ✓ Identify and analysis the power generation from renewable energy sources.
- ✓ Gain knowledge about mini and micro girds that includes economics and environmental factors.

## 18REEP03E2 SMART GRID

**Course Objectives:**

- ✓ To understand the main issues of smart grid development
- ✓ To know the recent technologies that underpin for the smart grid development

**Unit I**

Introduction –driving the move towards Smart Grids globally and in India Smart Grid. Overview of how Indian power market is organized, operated and challenges being faced. Overview of how the Indian GENERATION, TRANSMISSION and DISTRIBUTION business is operated and controlled and some of the challenges being faced. How software can manage generation and optimize generator performance, Software to support integration of renewables, System planning & condition monitoring based maintenance, Forecasting & basic trading, Demand response, Performance management

**Unit II**

Overview of power sector communications, Generic model of communication network needed for Smart-grid, Introduction to different communication technologies available in the market (Latest standards. Emphasis on importance of inoperability and standardization of communication protocols), Matrix of different technologies against the smart-grid communication needs in a given utility environment, AMI, AMR & MDA: How it works and how it will help to; reduce peaks manage networks more efficiently and contribute towards smarter grids, Communication Standards IEC6150, Wide Area Situation Awareness (WASA), Network stability and Phasor Measurement Unit (PMU), 6Automation and Integration of Distributed Generation / Renewable Energy, Automation and Micro-grids

**Unit III**

Distribution Management Systems (DMS) and Meter Data Management (MDM) are improving energy efficiency and security of supply in Distribution Systems, Overview of Power Electronics in Electrical T&D Systems, Power Electronics in emerging Smart Grids, Transmission (DC Super Grids) , Distribution (PE facilitating the integration of, (Distributed Generation, Renewables, Microgrids, Virtual Power Plants (VPP), Storage, Fault Current Limitation, Power Electronics, Super Conducting and Magnetic types)

**Unit IV**

Developing technology and systems that will enable grids to work smarter in the future: Storage: Organic and Inorganic Salts & Synthetic Heat Storage, Developing technology and systems that will enable grids to work smarter in the future (Smart Meters, Recording consumption, Advanced payback options for load-management, Communication between the utility and customer's home (for home automation)), In-home controls, Demand Side Management (DSM).Power Trading & the India Energy Exchange : Encouraging Markets, Regulation enabling grids to work smarter in India, Project Financing: Financial Incentives to Enable Smart Grids in India, Smart Grid Economics: Making Smarter Grids Financially Viable, Planning for Smarter Grids

**Unit V**

Challenges faced by the Transmission System Developing technology and systems that will enable smarter transmission of bulk energy (Metering, Trading mechanisms, AC – FACTS (Statcom) DC – HVDC, Fault Current Limiters), Challenges faced by the Distribution Networks:( How to be more energy efficient, stable, reliable and environmentally friendly, Reducing losses, Integration of renewables Connecting/disconnecting micro-grids and virtual power plants, manage bi-directional energy flows), Developing technology and systems that will enable smarter distribution networks (DC – MVDC, Fault Current Limiters, Others (AC/DC TXs etc))

**Text Book**

1. Join Gridwise & Smartgrids groups in LinkedIn http://www.linkedin.com/
2. Sign up to Smart Grid News www.smartgridnews.com
3. US DoE Smart Grid Book
   http://www.oe.energy.gov/DocumentsandMedia/DOE_SG_Book_Single_Pages(1).pdf

**References:**

1. Technology enabling the transformation of India's power distribution
   http://www.infosys.com/newsroom/features/power-sector-report.pdf
2. Gridwise Alliance website http://www.gridwise.org/
3. European Union Smart Grids Technology Platform http://www.smartgrids.eu/

**Course Outcomes**

At the end of the course students will be able to

- ✓ Lead students towards a clear understanding and firm grasp of the basic principles of smart grid.
- ✓ Understand the structure of an electricity market in either regulated orderegulated market conditions.
- ✓ Understand how (wholesale) electricity is priced in a transmission network.
- ✓ Evaluate the trade-off between economics and reliability of an electric power system.
- ✓ Understand the impacts of renewable resources to the grid and the variousissues associated with integrating such resources to the grid.
- ✓ Evaluate various investment options (e.g. generation capacities,transmission, renewable, demand-side resources, etc) in electricity markets.
- ✓ Understand the concepts and principles of Smart Grid, technology enabling, and demand participation.

## 18REEP03E3 GREEN BUILDINGS

**Course Objectives:**

- ✓ To assert the need, opportunities and demand of green buildings
- ✓ To explore the possibility of energy efficiency on buildings

**Unit I:**

Introduction to architecture; Building science and its significance; Energy management concept in building - 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;

**Unit II:**

Calculation of solar radiation on buildings; building orientation; Introduction to design of shading devices; Overhangs; Factors that effects energy use in buildings; Ventilation and its significance; Air-conditioning systems; Energy conservation techniques in air-conditioning systems

Passive Cooling And Heating Concepts - Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces; 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.

**Unit III:**

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. Design of daylighting

**Unit IV:**

Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

Bioclimatic Classification - Bioclimatic classification of India; Passive concepts appropriate for the various climatic zones in India; Typical design of selected buildings in various climatic zones; Thumb rules for design of buildings and building codes.

**Unit V:**

Energy Efficient Landscape Design -Modification of microclimatic through landscape element for energy conservation; Energy conservation through site selection, planning, and design; Siting and orientation – GRIHA – Certification of Green Buildings

**Text Book**


1. M.S.Sodha, N.K. Bansal, P.K. Bansal, A. Kumar and M.A.S. Malik, *Solar Passive Building, Science and Design,* Pergamon Press, 1986.
2. J.R. Williams, *Passive Solar Heating,* Ann Arbar Science, 1983.

3. R.W.Jones, J.D. Balcomb, C.E. Kosiewiez, G.S. Lazarus, R.D. McFarland and W.O. Wray, *Passive Solar Design Handbook, Vol. 3, Report of U.S. Department of Energy (DOE/CS-0127/3),* 1982.

**References:**


1. J Krieder and A Rabi *Heating and Cooling of Buildings : Design for Efficiency,* McGraw-Hill (1994)
2. R D Brwon, T J Gillespie, *Microclimatic Landscape Design,* John Wiley & Sons, New York, 1990.
3. D.S. Lal, Sharda Pustak Bhawan, *Climatology,*Allahabad, (2003)
4. Majumder Milli, *Energy Efficient Buildings,* TERI, New Delhi 2002
5. T A Markus, E N Morris*, Building, Climate and Energy,* Spottwoode Ballantype Ltd. London, 1980.
6. Sanjay Prakash (et al.), *Solar architecture and earth construction in the NorthWest Himalaya,*Vikas, New Delhi,1991
7. Energy Research Group, CD Rom Version 2 , LIOR Ireland, *Solar Bioclimatic Architecture,*1999


**Course Outcomes**

At the end of the course learner will be able to

- ✓ Classify different climatic zones and comfort environment.
- ✓ Incorporate and assess various passive solar techniques in building design.
- ✓ Modeling of heat distribution in the built environment.
- ✓ Design & assess the energy efficient landscape through modification of microclimate.

## 18REEP0312 RURAL ENERGY PLANNING

**Course Objectives:**

- ✓ To learn about the Rural Energy related issues
- ✓ To Collect and analyze the village level data
- ✓ To prepare the Detailed Project Report incorporating Govt. Schemes and Policies

Group of Students (Maximum of 5 to 6) will be provided to undergo a 100% Energy related survey in a selected village panchayat and analyze the present energy consumption and the future energy requirement. Based on the survey report the student must submit a Detailed Project Report (DPR) incorporating all the polices and schemes of the Govt. to be implemented in the selected villagewhich will enable to create a '*Model Energy Village'*.

**ESE:**

| | | |
|---|---|---|
| DPR | - | 25 marks |
| Viva-Voce | - | 25 marks |

**Course Outcomes**

At the end of the course learner will be able to

Get exposure in

- ✓ Rural Energy related issues to inconformity with the Constitutional Provisions
- ✓ Planning of present and future energy requirement of village
- ✓ Govt. Schemes and polices implemented or to be implemented
- ✓ Developing evaluation indicators for the Govt. Schemes
- ✓ Detailed Project Report (DPR) preparation

## 18REEP0313 DISSERTATION (PHASE I)

**Course Objective:**

- ✓ To design and develop the renewable energy system / process
- ✓ To analyze the data and optimize

Student should take up project related to renewable energy and work at GRI or they should obtain a permission to take up industry / institute related project where the external guide will be made available in the organization. However the evaluation is only based on the internal guide. No financial commitment will be given to the external guide. The evaluation of Dissertation is as follows:

**CFA:**

| | | |
|---|---|---|
| Seminar I (Identification of Problem & Literature Review) [Month of August] | - | 25 marks |
| Seminar II (Report on the progress of the project) [Month of October] | - | 25 marks |
| Seminar III (Findings and interpretation of results) [Month of November] | - | 25 marks |
| Report Evaluation by External Examiner | - | 75 marks |
| Total | - | 150 marks |

**ESE:**

| | | |
|---|---|---|
| Viva Voce [jointly conducted by internal examiner and external examiner] | - | 50 marks |
| Total | - | 200 marks |

**Course Outcomes**

- ✓ To evolve new device / methodology to evaluate the system performance

## 17EXNP03V1 VILLAGE PLACEMENT PROGRAMME

As per Gandhigram Rural Institute – Deemed University Norms.

## 18REEP0414 DISSERTATION (PHASE II)

**Course Objective:**

- ✓ To design and develop the renewable energy system / process
- ✓ To analyze the data and optimize

Student should take up project related to renewable energy and work at GRI or they should obtain a permission to take up industry / institute related project where the external guide will be made available in the organization. However the evaluation is only based on the internal guide. No financial commitment will be given to the external guide. The evaluation of Dissertation is as follows:

**CFA:**

| | | |
|---|---|---|
| Seminar I (Indepth study of Phase I – Gap to be addressed) [Month of December] | - | 25 marks |
| Seminar II (Report on the progress of the project) [Month of February] | - | 25 marks |
| Seminar III (Findings and interpretation of results) [Month of April] | - | 25 marks |
| Report Evaluation by External Examiner | - | 75 marks |
| Total | - | 150 marks |

**ESE:**

| | | |
|---|---|---|
| Viva Voce [jointly conducted by internal examiner and external examiner] | - | 50 marks |
| Total | - | 200 marks |

**Course Outcomes**

- ✓ To evolve new device / methodology to evaluate the system performance