M.Tech. - Renewable Energy

Course Duration:

2 Years– 4 Semesters

Eligibility Criteria:

- ✓ B.E. / B.Tech. with minimum of 55% marks or CGPA of 5.5 on a 10 point scale in the qualifying examination(50% marks or CGPA of 5.0 on a 10 point scale for SC/ST candidates) from UGC / AICTE recognized Institute / University.

The selection will be as per Gandhigram Rural Institute Norms.

Category A

Based on GATE Score.

Category B

Based on the Written Examination Conducted by Gandhigram Rural Institute – Deemed to be University if GATE qualified candidates is not available.

The evaluation is as follows:

The marks obtained by the qualifying examination		
from I semester to Pre Final Semester	-	50% Weightage
(for the benefit of Result Awaiting Students)		
Entrance Examination	-	50% Weightage

Maximum number of Seats:20

Programme Educational Objectives (PEOs):

To prepare the students to be successful professional in the field of Renewable Energy

1. To strengthen their knowledge and analytical skill to improve the Renewable Energy System Performance
2. To make the students understand, analyze, design, and create products / process to solve the renewable energy related issues.
3. To prepare the students to pursue research in latest technologies in Renewable Energy
4. To train the students to use Renewable Energy technologies for sustainable rural development
5. To inculcate professional ethics, effective communication skills, sprit of teamwork and ability to conduct energy analysis of various systems.

Programme Outcome

1. Demonstrate knowledge of mathematics, science and engineering in the field of Renewable Energy
2. Acquire knowledge in re-engineering of Renewable energy system for enhancing the efficiency
3. Enhance the skill to troubleshoot the renewable energy gadgets and analyze their performance
4. Quantify the Carbon emission reduction process through energy auditing and renewable energy integration
5. Apply modern software tools and techniques to optimize the performance of renewable energy systems
6. Observe and analyze energy related issues in rural areas for arriving sustainable solution considering Energy, Efficiency, Environment and Economics aspects including Governmental Polices
7. Appreciate the impact of renewable energy solution for societal improvement
8. Will develop confidence for self-education, community living and ability for life-long learning
9. Design a Product / Process on Renewable Energy / Energy Efficiency and Prepare a Comprehensive report

Programme Specific Outcome

1. Apply the knowledge of Renewable Energy in solving energy related problems being faced in society / industry
2. Solve the complex problems in the field of Renewable Energy with an understanding of Societal, legal and environmental impact of the solution
3. Design and Development of Cost Effective Renewable Energy Technologies
4. Apply the knowledge to develop Detailed Project Report for Rural Energy Planning
5. Demonstrate and Disseminate the knowledge in Renewable Energy for integrating energy efficiency and enhancement

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	2	3	3	3	2	3	3	3	3	1	3
2	3	3	-	2	3	2	2	1	3	3	3	3	3	2
3	2	3	3	3	3	3	2	-	3	3	3	3	3	3
4	3	3	2	2	3	3	3	-	3	3	3	2	3	3
5	1	3	3	3	3	3	3	2	3	3	2	2	3	3
6	1	3	3	3	2	3	3	3	3	3	3	3	3	2

M.Tech RENEWABLE ENERGY

Type	Course Code	Course Title	No. of Credits	L	T	P	Max. Marks		
							CFA	ESE	Total
Semester I									
Core I	21REEP0101	Solar Energy Utilization	4	4	0	0	40	60	100
Core II	21REEP0102	Wind, Small Hydro and New Renewable Energy Technologies	4	4	0	0	40	60	100
Elective I	21REEP01DX	Electives- Discipline Centric-1	3	4	0	0	40	60	100
Elective II	21REEP01DY	Electives- Discipline Centric-2	3	4	0	0	40	60	100
Core	21REEP0103	Solar Energy Laboratory	3	0	0	4	60	40	100
Core	21REEP0104	Wind Energy Laboratory	3	0	0	4	60	40	100
Core	21REEP0105	Research Methodology and IPR	4	4	0	0	40	60	100
Audit Course I	21GTPP0001	Gandhi in Every Day Life	2	2	0	0	50	0	50
		Total	**26**	**22**	**0**	**8**	**370**	**380**	**750**
Semester II									
Core III	21REEP0206	Power Systems Engineering	4	4	0	0	40	60	100
Core IV	21REEP0207	Waste to Energy	4	4	0	0	40	60	100
Elective III	21REEP02DX	Electives- Discipline Centric-3	3	4	0	0	40	60	100
Open Elective		Electives- Generic	3	4	0	0	40	60	100
Core	21REEP0208	Waste to Energy Laboratory	3	0	0	4	60	40	100
Core	21REEP0209	Energy Auditing of MSMEs (Field Visit)	2	0	0	4	30	20	50
Core	21REEP0210	Mini Project	3	0	0	4	0	50	50
Core	21REEP0211	Universal Human Value and Professional Ethics	2	0	0	4	50	0	50
Audit Course II	21ENGP00C1	Communication & Soft Skills	2	2	0	0	50	0	50
		Total	**26**	**20**	**0**	**12**	**350**	**350**	**700**
Semester III									
Core	21REEP0312	Summer Internship	2	0	0	0	0	50	50
Elective IV	21REEP03DX	Elective- Discipline Centric	3	4	0	0	40	60	100
Elective V	21REEP03DY	MOOC 1	2	2	0	0	50	0	50
Elective VI	21REEP03DZ	MOOC 2	2	2	0	0	50	0	50
Core	21REEP0313	Rural Energy Planning (Field Visit)	3	2	0	4	60	40	100
Modular Course	21REEP03MX	Modular Course	2	2	0	0	50	0	50
Dissertation	21REEP0314	Dissertation I	8	0	0	20	150	50	200

Extension	21EXNP03V1	Village Placement Programme	2	0	0	0	50	0	50
		Total	24	**10**	**0**	**24**	**400**	**200**	**600**
Semester IV									
Dissertation	21REEP0415	Dissertation II	**14**	**0**	**0**	**32**	**150**	**50**	**200**
			14						
		Total	**90**						

Courses for 21REEP01DX

21REEP01D1 Energy Auditing and Conservation
21REEP01D2 Optimum Utilization of Heat and Power
21REEP01 D3 Thermodynamic Analysis of Energy Systems
21REEP01 D4 Instrumentation for Energy Systems

Courses for 21REEP01DY

21REEP01D5 Advanced Numerical Analysis
21REEP01D6 Big Data Analysis for Renewable Energy System
21REEP01D7 Computational Fluid Dynamics
21REEP01 D8 Artificial Intelligence in Renewable Energy Technologies

Courses for 21REEP02DX

21REEP02D1 Energy Economics and Renewable Energy Policies
21REEP02 D2 Energy Forecasting and Project Management
21REEP02D3 Modeling and Analysis of Energy Systems
21REEP02D4 Environmental Impact Assessment

Courses for21REEP03DX

21REEP03D1 Rural Electrification: Technologies and Economics
21REEP03D2 Smart Grid
21REEP03D3 Energy Efficient Buildings
21REEP03D4 Electrical Vehicles and Energy Storage

Courses for21REEP03MX

21REEP02 M1 Rooftop Solar Photovoltaic Entrepreneurship
21REEP02 M2 Solar Thermal Systems for Industrial Process Heat
21REEP02 M3 Site Survey of Wind Power Plants
21REEP02 M4 Waste Management

21REEP0101 SOLAR ENERGY UTILIZATION

Course Objectives:

CO1 : Describe the fundamentals of Solar Physics
CO2 : Design and analysis of the solar thermal devices
CO3 : Design and analysis of the solar Photo Voltaic System
CO4 : Understand the government schemes and policies on Solar Energy
CO5 : Study the application of Solar Energy for Societal needs

Cognitive Level

K1 : Identify various terminologies of Solar Systems
K2 : Evaluate the Solar Energy Potential
K3 : Calculate the optical and heat transfer efficiency of solar thermal / PV systems
K4 : Design the Solar Thermal Collectors & PV Systems
K5 : Performance Evaluation and Cost benefit analysis of Solar Systems

Unit I

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

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

SOLAR POWER PLANTS (PV): Schematic arrangement of PV plant, Off-grid and On-grid systems, Merits and limitations - Net metering, Estimation of Energy bill saving and carbon foot print, System Design, MPPT, DC/DC converters, DC/AC converters, Life cycle costing (LCC), Approach and Methodology to develop large Roof Top Plants, Business Models for large capacity roof top PV plants, New solar technologies

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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	2	-	2	1	-	-	2	3	3	3	3	-	2
2	3	2	3	2	3	2	2	1	3	3	3	3	-	2
3	3	2	3	2	3	2	2	1	3	3	3	3	-	2
4	-	1	1	3	-	3	3	3	3	3	3	2	3	3
5	-	3	-	3	-	2	3	3	3	3	3	2	3	3

21REEP0102 WIND, SMALL HYDRO AND NEW RENEWABLE ENERGY TECHNOLOGIES

Course Objectives:

CO1 : Describe the fundamentals and main characteristics of wind energy conversion Techniques
CO2 : Analyze the potential of small hydro power generation
CO3 : Explore the possibility of usage of biofuel
CO4 : Study the fundamentals of new renewable energy technologies like fuel cell, Geothermal energy, Ocean energy etc.
CO5 : Study the application of New Renewable Energy for Societal needs

Cognitive Level

K1 : Identify various terminologies of Wind, Small hydro and new renewable energy Systems
K2 : Evaluate the New Renewable Energy Potential
K3 : Calculate the input / output relationship of wind, small hydro, OTEC & Fuel Cell
K4 : Design the Wind Turbine blades, Small Hydro Turbines and Fuel Cells
K5 : Performance Evaluation and Cost benefit analysis of New Renewable Energy System

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 –Fluid Mechanics – equations of motion -Euler's equation along a streamline – Bernoulli's equation -Laminar flow between parallel plates – flow through circular pipe – friction factor – smooth and rough pipes – Moody diagram

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 Characterization of biodiesel – Biodiesel engine development – modification – Environmental and health effects of biodiesel – R&D in biodiesel –disposal of cake – value addition of byproducts– Blending – Concept of Alternative Bio-CNG: Bio CNG production and Bottling for commercial value addition.

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 – Technology 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	-	2	2	-	-	2	3	3	3	3	-	2
2	3	3	-	2	2	-	-	2	3	3	3	3	-	2
3	2	3	-	3	2	3	3	3	3	3	3	3	2	2
4	2	2	1	3	1	3	3	3	3	3	3	2	2	3
5	-	3	-	3	-	2	3	3	3	3	3	2	3	3

21REEP01D1 ENERGY AUDITING AND CONSERVATION

Course Objectives:

CO1 : Familiarize with energy management
CO2 : Carryout energy analysis of thermal system
CO3 : Study the energy conversion in electrical utilities
CO4 : Increase the rational use of energy in process / product industries.
CO5 : Analyze the impact on energy efficiency on environment

Cognitive Level:

K1 : Identify various key factors for performance evaluation of thermal & electrical Systems
K2 : Describe the direct and indirect methodologies used for the performance Evaluation of thermal and electrical utilities
K3 : Calculate the efficiency of various utilities and suggest methods for energy Conservation.
K4 : Conduct energy audit, analyze the data using software techniques and suggest Economic measures for energy conservation.
K5 : Apply energy management systems and use management matrix as a tool to Prepare an action plan for improving theperformance of any organization / Industry.

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 auditinstruments

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:

Modern Energy Systems - Thermal energy content of fuels and calculations of energy efficiency. Advanced Heat Transfer Concepts - Modern Thermal Systems: Inclusion of waste heat recovery and combined heat and power (CHP) systems. Thermodynamic Principles in Energy Systems, Energy Transfer in Modern Systems, Smart Thermodynamics: Digital tools and simulations for better energy management. Green technology standards and energy conversion tools

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.

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

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. Inverter technology for variable speed control in compressors

Vapor absorption refrigeration system**:** Working principle, Types and comparison with vapor compression system, saving potential. Low Global Warming Potential (GWP) refrigerants, natural refrigerants; variable refrigerant flow (VRF) systems and enhanced heat exchanger designs; demand-controlled ventilation (DCV) and heat recovery systems

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, and Soft starters with energy saver, Variable speed drives, and Energy efficient transformers

Text Book:

1. CB Smith, *Energy Management Principles*, Pergamon Press, New York, 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	2	2	3	3	3	2	-	3	3	3	3	-	3
2	3	2	1	3	3	3	2	-	3	3	3	2	-	3
3	3	2	1	3	3	3	2	-	3	3	3	2	-	3
4	3	2	1	3	3	3	2	-	3	3	3	2	-	3
5	3	3	2	3	3	3	2	2	3	3	3	3	2	3

21REEP01D2OPTIMUM UTILIZATION OF HEAT AND POWER

Course Objectives:

CO1	:	Impart importance of optimum utilization of heat and power in process and product industry
CO2	:	Study the impact of CHP on environment
CO3	:	Optimize the CHP usage
CO4	:	Design of CHP
CO5	:	Integrate CHP with RE system

Cognitive Level:

K1	:	Identify various key factors in CHP System
K2	:	Performance evaluation of CHP System
K3	:	Calculate the efficiency of various process and integration of CHP
K4	:	Data analysis using software techniques and suggest economic measures
K5	:	Design a new CHP technique for process industry

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

Unit II

Pinch Technology–significance– Selection of pinch temperature difference – Stream splitting – Process retrofit – Installation of heat pumps, heat engines - Grand composite curve. Energy storage systems and combined heat and power (CHP) plants, dynamic and batch process pinch analysis; Organic Rankine Cycle (ORC) and thermal energy storage

Unit III

Insulation – Recuperative heat exchanger – Run –around coil systems – Regenerative heat exchangers – Heat pumps – Heat pipes –. Waste Heat Recovery -Cogeneration Technology. Aerogels, reflective insulation and phase change materials (PCMs), microchannel heat exchangers for compact, lightweight designs and enhanced heat transfer efficiency.

Unit IV

Sources of waste heat, Cogeneration - Principles of Thermodynamics - Combined Cycles- Topping -Bottoming - Organic Rankine Cycles- Advantages of Cogeneration Technology. Micro-CHP systems for residential or small-scale applications. Industrial-scale CHP for factories, refineries, and district heating systems.

Unit V

Application & techno economics of Cogeneration- Cogeneration - Performance calculations, Part load characteristics- financial considerations - Operating and Investments. Smart monitoring systems with AI for real-time optimization of CHP units and heat recovery systems, improving overall performance and reducing emissions.

Text Book:

1. Eastop, T.D. & Croft D.R, “Energy efficiency for engineers and Technologists”, 2ndedition, 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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	3	3	2	1	1	3	3	3	3	1	3
2	3	3	1	3	3	3	2	1	3	3	3	2	1	3
3	3	3	1	3	3	3	2	1	3	3	3	2	1	3
4	3	3	2	3	3	3	2	1	3	3	3	3	2	3

21REEP01D3 THERMODYNAMIC ANALYSIS OF ENERGY SYSTEMS

Course Objectives:

CO1 : Understand and apply the concept of availability,
CO2 : Calculate the behavior of real gases
CO3 : Predict the condition of systems and analyze them by the criteria of equilibrium
CO4 : Apply the concepts of advanced thermodynamics to combustion systems
CO5 : Analyze the thermal performance of RE Devices

Cognitive Level:

K1 : Various Definition of Thermodynamics
K2 : Performance evaluation of Thermal System
K3 : Calculate the efficiency of various thermodynamics process
K4 : Data analysis using software techniques and suggest economic measures
K5 : Design and optimize the performance thermal process in an industry

Unit I

Reversible work - availability – irreversibility. Second law efficiency for a closed system andsteady – 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 forthermodynamic 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 – Keslergeneralized three parameter tables. Fundamental property relations for systems of variablecomposition. Partial molar properties. Ideal and real gas mixtures. Equilibrium in multi-phasesystems

Unit III

First and second law analysis of reacting systems - Adiabatic flame temperature – Factors Affecting Adiabatic Flame Temperature; Entropy change of reacting systems, Entropy change calculation systems. Criterion for reaction equilibrium. Equilibrium constant for gaseous mixtures and evaluation of equilibrium composition. Exergy Analysis of Reacting Systems.

Unit IV

Combustion of Hydrocarbon Fuels. Chemical Kinetics of Hydrocarbon combustion, Kinetic modelling, large eddy simulations (LES) and Reynolds-averaged Navier-Stokes (RANS) models Heat of reaction, combustion and formation. Stoichiometric,fuel rich and oxygen rich reactions. Heating value of fuels. Application of energy equation tothe combustion process. Explosion limits, flames and flammability limits. Diffusion and premixedflames.

Unit V

Combustion in IC Engines and Gas turbines. Knocking and Detonation and control. Designprinciples of combustion chambers for IC Engines and Gas turbine. Arrangements of gas turbinecombustion chambers for power and comparative analysis. Advances in Fuel Injection Technology for Gas Turbines: Fuel Atomization and Spray Patterns, Low-NOx Combustors

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, Anuragam2014.
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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	1	3	3	3	1	1	3	3	3	3	2	3
2	3	3	1	2	2	2	2	1	3	3	3	2	2	3
3	3	3	2	3	3	3	2	1	3	3	3	2	2	3

21REEP01D4 INSTRUMENTATION FOR ENERGY SYSTEMS

Course Objectives:

CO1 : To impart knowledge about characteristics of measurement system and statistical analysis of measured data.

CO2 : To make students conversant with the electrical measurements and signal Conditioning circuits.

CO3 : To provide insight into the digital measuring techniques of physical quantities and Solar instruments.

CO4 : To make the students get acquainted with the measurement of thermo-physical Properties and air pollutants.

CO5 : To inculcate skills in the design and development of measurement and control Systems.

Cognitive Level:

K1 : Various Definition of measurement

K2 : Error analysis

K3 : Measurement of different properties

K4 : Datarecording and analysis

K5 : Design and optimize the control systems for renewable energy sources

UNIT – I

Introduction to measurement system, Errors in Measurement, Static and Dynamic characteristics of transducers, Statistical analysis of experimental data – Uncertainty analysis, Regression analysis, Design of experiments – Full and Half factorial design.

UNIT – II

Voltage, Current, Power, Energy, Time and Frequency measurement, Frequency Counter, Signal conditioning Circuits: Wheatstone bridge – Differential Amplifier – V to I Converter, I to V Converter, Integrator, Differentiator, Instrumentation Amplifier, Attenuators and Filters, DAC, ADC, PID Controller.

UNIT – III

Digital measuring techniques of Displacement, Temperature, Pressure, Force, Torque, Vibration, Acceleration, Velocity, Level, Flow, Thermal and Nuclear Radiation. Solar instruments:Pyrheliometers – Pyranometers– Pyrheliometers – Albedometers – Pyrradiometers – Pyrgeometers – Net Pyrradiometers – Sunphotometers.

UNIT – IV

Measurement of Thermal Conductivity – Solids, Liquids and Gas, Viscosity, Gas Diffusion. Calorimetry – Bomb Calorimeter – Continuous flow Calorimeter. Measurement of Heat Transfer, Humidity, Heat flux, pH, Air pollution Sampling and Measurement – Particulate Sampling techniques – Measurement of Sulphur Dioxide, Combustion products, Opacity and Odour.

UNIT – V

Introduction to Arduino and Raspberry Pi – Interfacing with I/O devices of system: Sensors, Display devices, Stepper and Servo motors. Measurement by Data Acquisition System. Introduction to Internet of Things (IoT) – Application of IoT with Raspberry Pi for Process

monitoring and control – Energy management. Application of PID controller in PV and Energy systems. Application of Smart Sensors and Intelligent instrumentation and Control.

Text Book:

1. Barney G.C., "Intelligent instrumentation: microprocessor applications in measurement and control", Prentice Hall, 1988.
2. Bell C., "Beginning Sensor Networks with Arduino and Raspberry Pi", Apress, 2013.

REFERENCES:

1. Doebelin E. and ManikD.N., "Doebelin's Measurement Systems", Tata McGraw Hill, 2011.
2. George, B., Roy, J.K., Kumar, V.J., Mukhopadhyay, S.C., "Advanced Interfacing Techniques for Sensors", Springer, 2017.
3. Holman J.P., "Experimental methods for Engineers", Tata McGraw Hill, 2007.

Course Outcomes:

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

- ✓ Analyze and evaluate the uncertainties in measurement data.
- ✓ Identify appropriate sensors for measuring electrical quantities and signal conditioning circuits
- ✓ Explain the digital measurement techniques of physical quantities.
- ✓ Implement the measurement of thermo-physical properties and air pollutants.
- ✓ Design and develop the appropriate measurement and control system for an application.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	1	3	3	3	1	1	3	3	3	3	2	3
2	3	3	1	2	2	2	2	1	3	3	3	2	2	3
3	3	3	2	3	3	3	2	1	3	3	3	2	2	3
4	3	3	2	3	2	3	2	1	3	3	3	2	2	2
5	3	3	3	3	2	3	2	2	3	3	3	2	2	2

21REEP01D5 ADVANCED NUMERICAL ANALYSIS

Course Objectives:

CO1 : Solving of Simultaneous Equation
CO2 : Curve Fitting
CO3 : Numerical Solution of Differential Equation
CO4 : Develop of theory and practice in the use of advanced numerical methods for Efficient solution of differential equation in renewable energy engineering.
CO5 : Formulate the renewable energy device performance in the form of numerical Equations

Cognitive Level:

K1 : Understanding various terminologies in Numerical Analysis
K2 : Performance of simple iterations
K3 : Calculate the numerical solution using differentiation and integration
K4 : Renewable Data analysis using Numerical Methods
K5 : Design and optimize the performance of Renewable Energy system using Numerical Technique

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 functions 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, 5th 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	2	2	2	1	1	1	1	3	3	2	2	2
2	3	3	2	2	2	1	1	1	1	3	3	2	2	2
3	3	3	2	2	2	1	1	1	1	3	3	2	2	2
4	3	3	3	3	3	2	2	1	3	3	3	3	1	3
5	3	3	3	3	3	2	2	1	3	3	3	3	1	3

21REEP01D6 BIG DATA ANALYSIS FOR RENEWABLE ENERGY SYSTEM

Course Objectives:

To understand the basics of business analytics and its life cycle.
To gain knowledge about fundamental business analytics.
To learn modeling for uncertainty and statistical inference.
To understand analytics using Hadoop and Map Reduce frameworks.
To acquire insight on other analytical frameworks.

Cognitive Level:

K1 : Understanding various terminologies data analysis
K2 : Performance of uncertainty analysis
K3 : Calculate the statistical parameters
K4 : Renewable Data analysis using Numerical Methods
K5 : Design and optimize the performance of Renewable Energy system using Numerical Technique

UNIT I

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

UNIT II

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

UNIT III

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

UNIT IV

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to Map Reduce – Features of Map Reduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to Map Reduce.

UNIT V

Overview of Application development Languages for Hadoop – Pig Latin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Text Books:

1. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.

REFERENCES:

1. Anand Rajaraman, Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
2. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, "Essentials of Business Analytics", Cengage Learning, second Edition, 2016. 5. U. Dinesh Kumar, "Business Analytics: The Science of Data-Driven Decision Making", Wiley, 2017.
3. A. Ohri, "R for Business Analytics", Springer, 2012
4. Rui Miguel Forte, "Mastering Predictive Analytics with R", Packt Publication, 2015.

Course Outcomes:

On completion of the course, the student will be able to:

- ✓ Identify the real world business problems and model with analytical solutions.
- ✓ Solve analytical problem with relevant mathematics background knowledge.
- ✓ Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- ✓ Write and Demonstrate simple applications involving analytics using Hadoop and Map Reduce
- ✓ Use open source frameworks for modelling and storing data
- ✓ Apply suitable visualization technique using R for visualizing voluminous data.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	2	2	2	1	1	1	1	3	3	2	2	2
2	3	3	2	2	2	1	1	1	1	3	3	2	2	2
3	3	3	2	2	2	1	1	1	1	3	3	2	2	2
4	3	3	3	3	3	2	2	1	3	3	3	3	1	3
5	3	3	3	3	3	2	2	1	3	3	3	3	1	3

21REEP01D7 COMPUTATIONAL FLUID DYNAMICS

Course Objectives:

CO1 : Provide Computational Fluid Dynamics analysis of Renewable Energy application
CO2 : Formulation of CFD problems with different boundary conditions
CO3 : Able to mesh Different Geometry
CO4 : Understand the solver of fluid mechanics and heat transfer related problems.
CO5 : Simulation of Renewable energy device performance

Cognitive Level:

K1 : Understanding various terminologies in CFD
K2 : Governing Equation analysis
K3 : Calculate the meshing quality
K4 : Renewable Data analysis using CFD
K5 : Design and optimize the performance of Renewable Energy system using CFD

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. Introduction to CFD Software Packages and Tools- ANSYS Fluent, OpenFOAM, COMSOL Multiphysics, CFX

Unit II

Review of Governing Equations - Navier-Stokes Equations, Continuity Equation, Energy Equation. 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 modelling
- ✓ Generate and optimize the numerical mesh
- ✓ Simulate simple CFD models and analyse its results.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	2	2	3	3	1	-	3	3	3	3	-	3
2	3	3	2	-	3	2	2	-	3	3	3	3	-	3
3	3	3	2	1	2	3	2	-	3	3	3	3	-	3
4	3	3	3	2	2	2	2	-	3	3	3	3	-	3

21REEP01D8 ARTIFICIAL INTELLIGENCE IN RENEWABLE ENERGY TECHNOLOGIES

Course Objectives:

CO1 : Differentiate between Algorithmic based methods and knowledge based methods
CO2 : Use the soft computing techniques for renewable power system problems
CO3 : Use appropriate AI framework for solving renewable power system problems
CO4 : Application of AI techniques in solar, wind and bio systems
CO5 : Application ofFuzzy Logic Controller to Renewable power system

Cognitive Level:

K1 : Understanding the various Artificial intelligence techniques in Renewable systems
K2 : Application of AI Principles in renewable power generation
K3 : AI based optimization of renewable power system
K4 : Fuzzy logic Controller design and installation in renewable energy systems
K5 : Design of Fuzzy logic based Applications in renewable energy systems

UNIT-I: INTRODUCTION:

Artificial Neural Networks (ANN) – definition and fundamental concepts – Biological neural networks – Artificial neuron – activation functions – setting of weights – typical architectures – biases and thresholds – learning/training laws and algorithms. Perceptron – architectures, ADALINE and MADLINE – linear separability- XOR function. Application of ANN in Renewable Energy Systems.

UNIT-II: FUNDAMENTALS OF SOFT COMPUTING TECHNIQUES:

Definition-Classification of optimization problems- Unconstrained and Constrained optimization Optimality conditions- Introduction to intelligent systems- Soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques - Single solution based and population based algorithms in renewable energy systems– Exploitation and exploration in population based algorithms - Application in Renewable Energy Systems.

UNIT-III: CLASSICAL AND FUZZY SETS:

Introduction to classical sets- properties, Operations and relations; Fuzzy sets, Membership, Operations, Properties, Fuzzy relations, Cardinalities, Membership functions in the renewable energy system.

UNIT-IV: FUZZY LOGIC CONTROLLER (FLC):

Fuzzy logic system components in solar, wind, Bio energy conversion system: Fuzzification, Inference engine (development of rule base and decision making system), De-fuzzification to crisp sets- De-fuzzification methods in renewable energy systems.

UNIT-V: APPLICATIONS OF ANN AND FLC:

Applications of ANN- Solar energy forecasting- Wind energy power generation – Biogas generation prediction, Load flow, Economic load dispatch, Load forecasting, PWM solar charge controllers, selected harmonic elimination in renewable power penetration- Applications of FLC- Load frequency control of renewable grid- Speed control of solar water pumping.

Text Books

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and pai – PHI Publication.
2. Fuzzy logic with Fuzzy Applications – T.J Ross – Mc Graw Hill Inc, 1997.

References

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Zimmermann, H.J., „Fuzzy set theory and its applications", Allied publishers limited, Madras, 2001
3. Yegnanarayana B, "Artificial Neural Networks", Prentice hall of India Private Ltd., New Delhi, 1999.
4. Zurada, J.M., „Introduction to Artificial Neural Systems", Jaico publishing house, Bombay, 1992.
5. David Goldberg, „Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 2007.
6. N P Padhy, „Artificial Intelligence and Intelligent Systems", Oxford University Press, 2005.

Course Outcomes

At the end of the course learner will be able to

- ✓ Establish AI Techniques in Renewable Energy Systems
- ✓ Describe the various AI based control for renewable power generation technologies
- ✓ Evaluate the Fuzzy logic based renewable energy projects
- ✓ Identify and analysis the fuzzy logic controller for renewable energy applications.
- ✓ Gain knowledge about ANN and FLC

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	2	3	3	3	3	2	3
2	2	2	2	3	3	3	3	3	3	3	3	3	2	3
3	2	2	2	3	3	3	3	3	3	3	3	3	2	3
4	2	2	2	3	3	3	3	3	3	3	3	3	2	3
5	2	2	2	3	3	3	3	3	3	3	3	3	2	3

21REEP0103 SOLAR ENERGY LAB

Course Objectives:

CO1 : Carryout the performance evaluation of solar thermal system
CO2 : Optimize the performance of solar thermal devices
CO3 : Carryout the performance evaluation of Solar PV system
CO2 : Optimize the performance of solar photovoltaic conversion devices
CO3 : Simulate the system using tools

Cognitive Level:

K3 : Calculate the efficiency of solar thermal and electrical system
K4 : Performance analysis of solar devices
K5 : Design and optimize the performance of Solar Thermal & Electrical System

1. Study on greenhouse 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. Performance analysis of solar photo voltaic panel in series and parallel combination
11. Performance analysis of charging characteristics of a lead acid battery using solar photo voltaic panel.
12. Performance analysis of String inverter
13. Performance analysis of Micro inverter
14. Performance analysis of Power optimizer

Course Outcomes

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

- ✓ Solar thermal system
- ✓ Solar PV system

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	3	2	3	3	3	3	3	3	3	3	-	3
2	2	3	3	2	3	3	3	2	3	3	3	3	-	3

21REEP0104 WIND ENERGY LAB

Course Objectives:

CO1 : Analyze wind potential mapping
CO2 **:** Carryout the performance evaluation of wind electrical System
CO3 : Carry out the performance analysis of wind mechanical system
CO4 : Study the grid integration of Wind system
CO5 : Simulate and carryout the performance testing of Renewable Energy Devices Using software tools

Cognitive Level:

K3 : Calculate the efficiency of wind energy conversion systems
K4 : Performance analysis of wind electric generators
K5 : Design and optimize the performance of wind water pumping system

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. Performance analysis of Hybrid inverter
12. Simulation using Open Source Software (Spoken Tutorials, IIT, Bombay)
13. Study of Wind Rose Diagram
14. Study of the impact of turbine height on energy generation

Course Outcomes

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

- ✓ Wind Electric
- ✓ Wind Pumping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	2	3	3	3	3	3	3	3	3	2	3
2	**2**	3	3	2	3	3	3	2	3	3	3	3	-	3

Course Code & Title	RESEARCH METHODOLOGY AND IPR (21REEP0105)
Cognitive Level	**K-1** Understanding various terminologies in Research Methods
	K-2 Analysis of Statistical Data
	K-3 Calculate the Probability
Course Objectives	**The Course aims 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

UNIT	Content	No. of Hours
I	Scientific Research – methods of acquiring knowledge - Inductive and Deductive Reasoning, scientific method and its applications. New Developments in IPR: Administration of Patent System - Traditional Knowledge Case Studies. Plagiarism. Research Process: Selection of Research problem, Review of literature, Formulation of Hypothesis, Nature and Types of Variable.	**12**
II	Research Design: Purpose, preparation and Types of research design – Historical, Descriptive, and Experimental. Field survey and evaluation research. Qualitative and Quantitative Studies – Mixed Methods. Multi-disciplinary, Interdisciplinary and Transdisciplinary Research.	**13**
III	Tools and techniques of data collection – Observation, interview, Inquiry Forms, Psychological tests, Projective techniques, rating scales, Likert and Thurstone, Guttman type scales, Focus Group discussion, and PRA. Validity and reliability. Structure and qualities of a Research Report; Dissemination of research findings, Evaluation of Research Report.	**13**
IV	Data Analysis: Data Bases. Categorization, Presentation of data - Diagrams and Frequency distributions – Central measures – Arithmetic mean, Median, Mode. Dispersion measures – Range, Quartile Deviation,	**13**

	Mean Deviation, Standard Deviation and Coefficient of variation – Skewness – Normal distribution – Kurtosis. Correlation – Rank Correlation. Regression analysis.	
V	Sampling: Probability and non-probability sampling techniques, sampling and non-sampling errors. Testing of Hypothesis: Basic concepts and steps; Statistical Tests – z test, t-test, Chi-square test, ANOVA. Factor analysis and Discriminate analysis. Introduction to Structural Equation Modeling (SEM).	**13**
References	• Gupta.S.C, *Fundamentals of Statistics*, Mumbai: Himalaya Publishing House, 2018. • Kothari.C.R, *Research Methodology*, New Delhi: Wishva Prakashan, 2019. • Panneer Selvam, Research Methodology, New Delhi: PHI Learning Private Ltd, 2014. • Tony Greenfield and Sue Greener, Research Methods for Post Graduates, John Wiley and Sons Ltd, 2016. • W.G.Cochran, Sampling Techniques, Wiley Eastern Ltd, New Delhi, 1985.	
Text Books	• Cauvery.R. and Girija. M, Research Methodology, New Delhi: S.Chand and Company Ltd, 2010. • Gupta, S.P, Statistical Methods, New Delhi; Sultan Chand and Sons, 2012. • Nicholas Walliman, Research Methods: The basics. London; New York: Routledge, 2011. • Venkatachalapathy, S.G., Premraj, H., Statistical Methods, Chennai: Margham publications, 2015. • Vijayalakshmi.G. and Sivapragasam.C, *Research Methods: Tips and Techniques*, Chennai: MJP Publishers, 2009.	
Websites	• https://www.ggu.edu/courses/syllabus.do?id=29059 • https://www.ncrm.ac.uk/ • https://www.scribbr.com/category/methodology/ • https://online-learning.harvard.edu/subject/statistics • http://www.ddegjust.ac.in/studymaterial/mcom/mc-106.pdf • https://www.statisticssolutions.com/spss-statistics-help	
Course Outcomes	On completion of the course, students should be able to do	

	CO1: Develop expertise and skills to undertake independent research inthe renewable energy area CO2: Development research questionnaire CO3: Understand IPR related issues CO4: Apply of statistical tools for the renewable energy system performance CO5: Write research article and prepare project report

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	2	1	3	3	3	3	3	2	3	3	2	3	3
2	3	3	2	3	3	3	3	3	2	3	3	2	3	3
3	1	3	1	3	3	3	3	2	3	3	3	3	2	3
4	2	3	1	3	3	2	3	2	3	3	3	3	2	3
5	2	3	1	3	3	3	3	2	3	3	3	3	3	3

21GTPP0001 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.

21REEP0206 POWER SYSTEMS ENGINEERING

Course Objectives:

CO1 : Get familiarized with the power quality management issues in Renewable Energy Sector
CO2 : Study the smart grid application for Rural Development
CO3 : To familiarize various IEEE/ IEC/BIS standards
CO4 : Design of Control system for Renewable Energy System integration
CO5 : Design of Micro Controller for Rural Energization

Cognitive Level:

K1 : Understanding various Standards IEEE/ IEC/BIS
K2 : Analysis of Power profile of Conventional / Renewable energy systems
K3 : Calculate the Capacity of Solar / Wind & Hybrid Systems
K4 : Power Quality analysis using various tools
K5 : Design of smart grid for decentralized power generation

Unit I

Introduction: Structure of Power System, Basic aspects of AC power transmission, stability issues in power system, EHV transmission, HVDC transmission, Tariff System, Economics of Power Factor, Classification of substation, Components of Substation, Nature and causes of faults

Unit II

Power System Grounding: Ungrounded System, Purpose of Grounding, Various types of neutral grounding, Methods of non-effective Grounding, Equipment grounding, Grounding at Substations, Grounding of line structures, Concept of step voltage and touch voltage, Typical Grounding arrangement for small distribution station, Reference National standard for grounding

Unit III

Economics of Power Generation: Cost of Electrical Energy, Expressions for cost of Electrical Energy, Methods of determining Depreciation, Terms commonly used in system operation, Factors affecting the cost of generation, Curves useful in system operation, Base load and Peak load on Power station, Selection of generating units, Interconnection of stations

Unit IV

Performance Of Transmission Lines: Classifications of Overhead Transmission lines, Important terms, Merits of high transmission voltage, Performance of short transmission lines, Effect of load power factor on regulation and efficiency, Three phase unbalanced loads, Economic choice of transmission voltage, Economic choice of conductor size, Requirements of satisfactory Electric supply

Unit V

Power Quality Issues: Basic terminologies, impact of power quality on power system, Harmonic issues, Point of common coupling (PCC), linear and non-linear loads, power quality audit, power quality analyzers, Power Quality Mitigation. Reference standards. Smart Grid: Benefits & Technologies of Smart Grid

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
6. A.ChaKrabarti, M.L.Soni, P.V.Gupta, U.S.Bhatnagar: Power System Engineering, Dhanpat Rai & Co

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	3	3	2	3	3	2	1	2	3	3	3	1	3
2	2	3	3	3	3	3	3	1	3	3	3	3	3	3
3	3	3	2	2	2	3	1	-	2	3	2	3	2	3
4	3	3	2	3	3	3	3	1	3	3	3	3	3	3
5	3	3	2	3	3	3	3	2	3	3	3	3	3	3

21REEP0207 WASTE TO ENERGY

Course Objectives:

CO1 : Characterize the solid / liquid waste
CO2 : Evaluate the performance bio chemical conversion technologies
CO3 : Elucidate the thermo-chemical conversion technologies
CO4 : Design of Small Scale Waste to Energy System
CO5 : Apply waste to energy conversion techniques for sustainable development

Cognitive Level:

K1 : Understanding various terminologies in bio and thermo-chemical conversion
K2 : Analysis of Waste Treatment techniques
K3 : Sizing of Biogas plants and Gasifiers
K4 : Analysis of Supply Chain issues in Waste Management
K5 : Design of Waste Management Strategy for Smart Cities

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. Transesterification of non-edible oil Vs Used edible oil, challenges in biochemical conversion

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 fueling 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	1	3	2	3	3	2	2	3	3	2	2	2
2	2	3	2	3	2	3	3	2	3	3	3	3	3	3
3	2	3	2	3	2	3	3	2	3	3	3	3	3	3
4	3	3	3	3	2	3	3	3	3	3	3	3	3	3
5	2	3	3	3	1	3	3	1	3	3	3	3	3	3

21REEP02D1 ENERGY ECONOMICSAND RENEWABLE ENERGY POLICIES

Course Objectives

CO1 : Understand the basics of energy economics so as to address to energy problems
CO2 : Able to correlate the energy intensity and GDP
CO3 : Analyze different economic methods and carbon payback analysis
CO4 : Estimate Payback period of Renewable Energy Projects
CO5 : Study the policies of renewable energy for sustainable development

Cognitive Level:

K1 : Understanding various terminologies in economics
K2 : Analysis of Energy Intensity and GDP
K3 : Policies of Government of India on Renewable Energy
K4 : Analysis of Environment Nexus
K5 : Design of Cost Economics with Payback of Renewable Energy Projects

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

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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, and 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	1	3	2	3	3	3	3	2	3	2	3	3
2	3	3	1	3	3	3	3	2	3	3	3	3	3	3

21REEP02D2 ENERGY FORECASTING AND PROJECT MANAGEMENT

Course Objectives:

CO1 : To understand about National energy scenario.
CO2 : To predict the energy demand using various forecasting models.
CO3 : To develop an optimization model for the effective utilization of energy sources.
CO4: To know the procedure to the write the project proposal.
CO5: To know the energy policies in the country.

UNIT – I

Role of energy in economic development and social transformation: Energy & GDP, GNP and itsdynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumptionin various sectors and its changing pattern -Status of Nuclear and Renewable Energy: PresentStatus and future promise.

UNIT – II

Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental
Smoothing - Triple Exponential Smoothing – ARIMA model- Validation techniques – Qualitativeforecasting – Delphi technique - Concept of Neural Net Works.

UNIT – III

Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective Optimization – Mathematical Optimization Software – Development of Energy OptimizationModel - Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.

UNIT – IV

Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-costbenefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – FinancialEvaluation.

UNIT – V

National & State Level Energy Issues - National & State Energy Policy - Energy Security - National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)-Costing.

Course Outcomes:

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

- ✓ Have knowledge in the National energy scenario.
- ✓ Do Energy prediction using various forecasting techniques.
- ✓ Develop optimization model for energy planning.
- ✓ Capable of writing project proposals.
- ✓ Understand the National and state energy policies.

Text Book:

1. Armstrong J.Scott (ed.), Principles of forecasting: a hand book for researchers and Practitioners, Norwell, Massachusetts: Kluwer Academic Publishers.2001.
2. DhandapaniAlagiri, Energy Security in India Current Scenario, The ICFAI University Press, 2006.

References:

1. Fred Luthans, Brett C. Luthan, Kyle W. Luthans, Organisational Behaviour: An Evidence-Based Approach, Information Age Publishing; 13 edition, 2015
2. Spyros G. Makridakis, Steven C. Wheelwright, Rob J. Hyndman, Forecasting: Methods and Applications, 4th Edition, ISBN: 978-0-471-53233-0, 2003
3. Yang X.S., Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, Int. Science Publishing, 2008

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	3	3	3	2	1	3	3	3	3	2	3
2	3	3	2	3	3	3	2	1	3	3	3	3	2	3
3	3	2	2	3	2	3	3	2	3	3	3	3	2	3
4	3	3	2	3	2	3	3	2	3	3	3	3	3	3
5	3	3	2	3	3	3	3	2	3	3	3	3	3	3

21REEP02D3 MODELING AND ANALYSIS OF ENERGY SYSTEMS

Course Objectives:

CO1 : Able to use relevant tools and model for energy engineering in view of Proposing the most efficient energy systems mix
CO2 : Model different types of renewable energy mix for optimum usage
CO3 : Analyze Demand Forecasting and Modeling of Energy System
CO4 : Understand role of renewable in demand increase
CO5 : Study the financing model of RE Projects

Cognitive Level:

K1 : Understanding various terminologies of Energy Modeling and Management
K2 : Analysis of Energy Demand Modeling
K3 : Interpret Energy modeling with RE integration
K4 : Analysis of forecasting techniques
K5 : Design and Cost Economics analysis of RE project management system

Unit I

Overview of technologies and conventional methods of energy conversion, Workable and optimum systems, Steps in arriving at a workable system, Creativity in concept selection

Unit II

Mathematical modeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping Power

Unit III

Classes of simulation, flow diagrams, Sequential and simultaneous calculations, Newton-Raphson method- Optimization procedure, mathematical statement of the problem

Unit IV

The Lagrange multiplier equations, Sensitivity coefficients- Single variable – Exhaustive, Dichotomous and Fibonacci, Multivariable unconstrained - Lattice, Univariable and Steepestascent

Unit V

Dynamic Programming-Geometric Programming-Linear Programming- Linear regression analysis, Internal energy and enthalpy, Pressure temperature relationship at saturated conditions

Text Book

1. W.F. Stoecker: “Design of Thermal Systems”, 3rd Ed., McGraw Hill, 1989.
2. B.K.Hodge: “Analysis and Design of Thermal Systems”, Prentice Hall Inc., 1990.
3. M.Munasinghe and P.Meier *Energy Policy Analysis and Modeling*,CambridgeUniversity Press 1993
4. W.A.Donnelly *The Econometrics of Energy Demand: A Survey of Applications*, New York.1987
5. 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	3	3	3	2	1	3	3	3	3	2	3
2	3	3	2	3	3	3	2	1	3	3	3	3	2	3
3	3	2	2	3	2	3	3	2	3	3	3	3	2	3
4	3	3	2	3	2	3	3	2	3	3	3	3	3	3

21REEP02D4 ENVIRONMENTAL IMPACT ASSESSMENT

Course Objectives:

CO1 : Understand the use, strengths, and limitations of EIA
CO2 : Develop working familiarity with EIA methods and analytic techniques.
CO3 : Prepare the plan of Land use
CO4 : Understand EIA studies on RE Projects
CO5 : Able to prepare the EIA report for RE Projects

Cognitive Level:

K1 : Understanding various terminologies of EIA
K2 : Analysis of Environmental Data
K3 : Interpret EIA data for various systems
K4 : Analysis of RE impact of Environment
K5 : Environmental Auditing

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. Risk Assessment in EIA, Public Participation, Data Quality and Uncertainty Analysis & Regulatory Frameworks

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. Impact of Urbanization, Long-Term Monitoring, Ecosystem Services Evaluation, Land Degradation Indicators.

Unit III

E I A in surface water, Air and Biological environment: Methodology for the assessment of Impacts on surface water environment, Airpollution 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. Climate Change Impacts, Cumulative Impact Assessment, Water Quality Standards, Impact of Noise Pollution.

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. Corporate Environmental Responsibility, Environmental Management Systems (EMS), Third-Party Audits, Best Practices and Benchmarks.

Unit V

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

various Industries. Case Study Analysis: In-depth analysis of specific industry case studies to illustrate the application of environmental legislation and audit findings and Environmental Impact Mitigation Plans.

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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	3	3	3	3	2	2	3
2	2	2	2	3	3	3	2	1	3	3	3	2	2	3
3	3	2	2	3	3	2	2	2	2	3	3	3	2	3
4	3	3	3	3	3	2	3	2	2	3	3	3	3	3

21REEP0208 WASTE TO ENRGY LAB

Course Objectives:

CO1 : Study the characteristics of wastes
CO2 : Understand supply chain issues in Waste Management
CO3 : Performance evaluation of bio chemical conversion process
CO4 : Elucidate the thermo chemical energy conversion devices performance
CO5 : Explore the biodiesel potential

Cognitive Level:

K3 : Calculate the efficiency of bio chemical and thermo chemical conversion system
K4 : Performance analysis of bio energy gadgets
K5 : Design and optimize the performance of biogas and gasifiers

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	3	2	3	3	3	3	3	3	3	3	-	3
2	2	3	3	2	3	3	3	2	3	3	3	3	-	3
3	3	3	3	3	3	3	3	2	3	3	3	3	-	3
4	3	3	3	3	3	3	3	2	3	3	3	3	-	3
5	2	2	2	3	3	3	3	2	3	3	3	3	2	3

21REEP0209 ENERGY AUDITING OF MSMEs (FIELD VISIT)

Course Objectives:

CO1 : Study the energy consumption pattern of MSMEs
CO2 : Carryout the energy analysis of MSMEs
CO3 : Analyze the data on thermal and electrical utilities of MSME
CO4 : Explore the energy conservation steps in MSMEs
CO5 : Prepare the Energy Auditing report

Cognitive Level:

K3 : Calculate the efficiency of thermal and electrical utilities of MSME
K4 : Performance analysis of MSME
K5 : Energy Auditing Report Preparation of MSME

CFA:

- ✓ Energy Auditing, Energy Conservation Potential Identification - 15 marks
- ✓ Energy Audit Report Preparation - 15 marks

ESE:

Seminar Presentation - 10 marks
Viva-Voce - 120 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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	3	3	3	3	3	3	3	3	3	1	3
2	3	3	3	3	3	3	3	3	3	3	3	3	1	3
3	2	2	2	3	3	3	3	3	3	3	3	3	1	3

21REEP0210 MINI PROJECT

Course Objectives:

CO1 : Design and Development of Renewable Energy Gadgets
CO2 : Analyzer the performance of the system

Cognitive Level:

K3 : Calculate the efficiency of existing RE devices
K4 : Performance analysis of RE System
K5 : Develop a cost effective RE device

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

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	3	3	3	3	3	3	3

21REEP0211 UNIVERSAL HUMAN VALUE AND PROFESSIONAL ETHICS

Course Objective:

CO1 : Development of a holistic perspective based on self-exploration about themselves (Human being), family, society and nature/existence.

CO2 : Understanding (or developing clarity) of the harmony in the human being, Family, society and nature/existence

CO3 : Strengthening of self-reflection.

CO4 : Development of commitment and courage to act.

Unit I

Course Introduction - Need, Basic Guidelines, Content and Process for ValueEducation. Purpose and motivation for the course, recapitulation from Universal HumanValues. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance'and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basicrequirements for fulfilment of aspirations of every human being with their correctPriority Understanding Happiness and Prosperity correctly- A critical appraisal of thecurrent scenario Method to fulfil the above human aspirations: understanding and living inharmony at various levels.Include practice sessions to discuss natural acceptance in human being as theinnate acceptance for living with responsibility (living in relationship, harmonyand co-existence) rather than as arbitrariness in choice based on liking-disliking

Unit II:

Understanding Harmony in the Human Being - Harmony in Myself! Understanding human being as a co-existence of the sentient 'I' and thematerial 'Body'Understanding the needs of Self ('I') and 'Body' - happiness and physical facility Understanding the Body as an instrument of 'I' (I being the doer, seer andenjoyer). Understanding the characteristics and activities of 'I' and harmony in 'I'. Understanding the harmony of I with the Body: Sanyam and Health; correct Appraisal of Physical needs, meaning of Prosperity in detail. Programs to ensure Sanyam and Health.Include practice sessions to discuss the role others have played in makingmaterial goods available to me. Identifying from one's own life. Differentiatebetween prosperity and accumulation. Discuss program for ensuring health vsdealing with disease

Unit III:

Understanding Harmony in the Family and Society- Harmony in Human Relationship Understanding values in human-human relationship; meaning of Justice (nineuniversal values in relationships) and program for its fulfilment to ensure mutualhappiness; Trust and Respect as the foundational values of relationshipUnderstanding the meaning of Trust; Difference between intention andCompetence Understanding the meaning of Respect, Difference between respect anddifferentiation; the other salient values in relationship Understanding the harmony in the society (society being an extension offamily): Resolution, Prosperity, fearlessness (trust) and co-existence ascomprehensive Human Goals Visualizing a universal harmonious order in society- Undivided Society,Universal Order- from family to world family.Include practice sessions to reflect on relationships in family, hostel and instituteas extended family, real life examples, teacher-student relationship, goal ofeducation etc. Gratitude as a universal value in relationships. Discuss withscenarios. Elicit examples from students' lives

Unit IV

Understanding Harmony in the Nature and Existence - Whole existence asCoexistence18. Understanding the harmony in the NatureInterconnectedness and mutual fulfilment among the four orders of nature recyclability and self-regulation in natureUnderstanding Existence as Co-existence of mutually interacting units in all-pervasivespaceHolistic perception of harmony at all levels of existence.Include practice sessions to discuss human being as cause of imbalance innature (film "Home" can be used), pollution, depletion of resources and role oftechnology etc.

Unit V: Implications of the above Holistic Understanding of Harmony onProfessional EthicsNatural acceptance of human values Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and HumanisticUniversal Order Competence in professional ethics: a. Ability to utilize the professionalcompetence for augmenting universal human order b. Ability to identify the scopeand characteristics of people friendly and eco-friendly production systems, c.Ability to identify and develop appropriate technologies and managementpatterns for above production systems.Case studies of typical holistic technologies, management models andproduction systemsStrategy for transition from the present state to Universal Human Order: a. Atthe level of individual: as socially and ecologically responsible engineers,technologists and managers b. At the level of society: as mutually enrichinginstitutions and organizations

Text Book

1. Human Values and Professional Ethics by R Gaur, R Sangal, G P Bagaria,Excel Books,New Delhi, 2010

References

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak,1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - PanditSunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	-	-	-	-	-	-	2	1	-	-	-	-
CO2	-	-	-	-	-	-	1	1	-	-	-	-
CO3	-	-	-	-	-	-	2	1	-	-	-	-
CO4	-	-	-	-	-	-	1	1	-	-	-	-
CO5	-	-	-	-	-	-	3	1	-	-	-	-

21ENGP00C1 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.

21REEP0312 SUMMER INTERNSHIP

Course Objective

CO1 : 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

Cognitive Level:

K3 : Data / Survey questionnaire preparation
K4 : Data Analysis
K5 : Interpretation of data and report preparation

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

CO/PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3
CO1	2	1	1	-	2	1	2	1	1	3	2	1
CO2	1	2	2	2	1	2	2	1	1	2	3	1
CO3	-	-	-	-	-	1	3	-	1	1	2	1

21REEP03D1 SUSTAINABILITY AND RURAL ELECTRIFICATION

Course Objectives:

CO1 : Inculcate the Sustainability in Rural Electrification
CO2 : Understand the Schemes and Policies of Govt. of India
CO3 : Know the different technologies option for Rural Electrification
CO4 : Analyze the financial viability and cost benefit analysis
CO5 : Able to prepare the techno-commercial report on Rural Electrification

Cognitive Level:

K1 : Understanding the various basics of Sustainability
K2 : Application of sustainability in renewable and rural electrification process
K3 : Interpret various economics models sustainably
K4 : Comparative analysis of technologies of Rural Electrification
K5 : Comparison of various technologies and economics for Rural Electrification

Unit-I:

Introduction, Need and concept of sustainability, social environmental and economic sustainability concepts. Sustainable development, nexus between technology and challenged for sustainable development – multilateral environmental agreement and protocol –Environmental legislations in India – Electricity Act, Water Act, Air Act

Unit-II:

The Concept of Sustainable Development - Definition of Sustainable Development as an Ambiguous Compromise- evolution, approaches, interpretations - Triple P- An Introduction to Economic Growth - Questions about Sustainable Development- Timeline for Sustainable Development - Sustainable Production and Consumption.

Unit-III:

Green Engineering –Conventional and Non-Conventional Energy sources- Sustainable Urbanization- sustainable industrialization - United Nations Framework Convention on Climate Change (UNFCC)-Kyoto Protocol- Conference of Parties (COP) - Clean Development Mechanism (CDM), Prototype Carbon Fund (PCF)

Unit IV

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 V

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- 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

Text Book

1. Allen. D. T. and Shonnard, D.R ., Sustainability Engineering: Concepts, Design and case studies, Prentice Hall
2. Peter P. Rogers, Kazi F. Jalal, John A. Boyd ., An Introduction to Sustainable Development., Routledge, Business & Economics, 2008
3. H. Lee Willis and W.G. Scott: Distributed Power Generation: Planning and Evaluation, Marcel Dekker, 2000.
4. 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

- ✓ Establish Sustainability in Rural Energy planning
- ✓ 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	2	3	3	3	3	2	3
2	2	2	2	3	3	3	3	3	3	3	3	3	2	3
3	2	2	2	3	3	3	3	3	3	3	3	3	2	3
4	2	2	2	3	3	3	3	3	3	3	3	3	2	3
5	2	2	2	3	3	3	3	3	3	3	3	3	2	3

21REEP03D2 SMART GRID

Course Objectives:

CO1 : Understand the main issues of smart grid development
CO2 : Know the recent technologies that underpinfor the smart grid development
CO3 : Able to analyze the economic analysis of Smart Grid
CO4 : Understand grid integration issues on smart grid
CO5 : Compare AC/ DC micro girds

Cognitive Level:

K1 : Understanding various terminologies on smart grid
K2 : Analysis of IEC / IEEE Standards
K3 : Interpret various economics models
K4 : Comparative analysis of Distribution Management system
K5 : Design and Analysis of AC/ DC Smart Grids

Unit I

Introduction to Smart Grid: Evolution of Smart Grid. Need and Benefits of Smart Grid. Divers for Smart grid, functions, opportunities and challenges. Difference between conventional and Smart Grid. Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid

Unit II

Smart Grid Technologies: Smart Grid Technology Drivers, Renewable energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

Unit III

Advanced Metering Infrastructure: Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols and standards, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices(IED) & their applications.

Power Quality Management In Smart Grid : Power Quality in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Unit IV

Smart Grid Communications: Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Wireless Sensor Networks (WSNs) Cyber Security for Smart Grid.

Data Analytics In Smart Grids: Data Analytics, Foundations, Big Data Management, Analytical Models in Utility, Predictive Analysis and Prescriptive Analysis, Operational Analytics. etc. Applications in Energy Forecasting, Demand response and Energy Analytics, case study in Python and R.

Unit V

Challenges faced by the Transmission System Developing technology and systems that will enable smarter transmission of bulk energy. Developing technology and systems that will enable smarter distribution networks (DC – MVDC, Fault Current Limiters, Others (AC/DC TXs etc)) Smart Grid Applications: Demand Side Management, Load Management, State Estimation, Energy Management and Conservation, Smart Grid Analytics, Data Mining and Clustering.

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 or deregulated 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 various issues 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	2	3	3	3	3	2	3
2	2	2	2	3	3	3	3	3	3	3	3	3	2	3
3	2	2	2	3	3	3	3	3	3	3	3	3	2	3
4	2	2	2	3	3	3	3	3	3	3	3	3	3	3
5	2	2	2	3	3	3	3	3	3	3	3	3	3	3

21REEP03D3 ENERGY EFFICIENT BUILDINGS

Course Objectives:

CO1 : Ascertain the need, opportunities and demand of green buildings
CO2 : Explore the possibility of energy efficiency on buildings
CO3 : Comparative study of green buildings on different climatic zone
CO4 : Understand cost economics and payback calculation of energy efficient buildings
CO5 : Able to compare different rating techniques of buildings

Cognitive Level:

K1 : Understanding various terminologies on green building
K2 : Analysis of ISHRA / GRIHA/ GBC Standards
K3 : Interpret various design of green buildings
K4 : Comparative analysis of conventional Vs energy efficient buildings
K5 : Design and Analysis of Solar Passive Buildings

Unit I:

Introduction to architecture; Study of Building Loads. 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; Concept of Microclimate – factors affecting microclimate.

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; Solar heat Gain Factor, ASHRAE Tables. Heat transfer due to ventilation/infiltration, internal heat transfer; Solar temperature; Decrement factor; Phase lag. Design of daylighting – Sky lights, Roof Windows, light shelves, reflectors, Solar tubes, Day light pipes.

Unit IV:

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. Passive Solar heating & Cooling techniques – Trombe walls, Water walls, evaporative cooling, desiccant-based cooling, solarium, wind towers.

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.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	2	3	3	3	3	2	3
2	2	2	2	3	3	3	3	3	3	3	3	3	2	3
3	2	2	2	3	3	3	3	3	3	3	3	3	2	3
4	3	3	2	3	3	3	3	2	3	3	3	3	3	3
5	3	3	2	3	3	3	3	2	3	3	3	3	3	3

21REEP03D4 ELECTRICAL VEHICLES AND ENERGY STORAGE

Course Objectives:

CO1 : Describe the fundamentals of Electric Vehicle
CO2 : Design and analysis of the Electric Vehicle
CO3 : Design and analysis of the Hybrid Electric Vehicle
CO4 : Understand the concepts of Nano grid, energy storage and management
CO5 : Study on power quality issues on Nano Grid Technologies

Cognitive Level

K1 : Identify and analyze the various classification of Electric Vehicle
K2 : Evaluate the Performance of Electric Vehicle
K3 : Calculate drive system efficiency of Electric Vehicle
K4 : Design of V2G energy systems
K5 : Performance Evaluation of Nano Grid in terms of Power Quality

UNIT-1

Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. Social and environmental importance of hybrid and electric vehicles

UNIT-2

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives - Induction Motor drives - Permanent Magnet Motor drives - Switch Reluctance Motor drives, drive system efficiency. Electric traction – various topologies-Power flow-Case Study - Design of a Hybrid Electric Vehicle (HEV)

UNIT-3:

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery - Fuel Cell - Super Capacitor- Flywheel based energy storage system - Introduction to energy management strategies - classifications, comparison of different energy management strategies, implementation issues of energy management strategies.

UNIT-4

Introduction to vehicle to Grid technologies-Embedded generation-Issues of Embedded generation-Vehicle to Grid technologies, common attributes of embedded generation, basic power conversion of solar PV system, wind electric conversion systems-Grid requirements of PV and Wind Turbine System

UNIT-5

Definition of Power Quality-Effect of Harmonics on Power System Devices-Guidelines for Harmonic Voltage and Current Limitation-Power Quality Measurement Devices- Number of

Test Locations-Test Duration-Instrument Setup-Instrument Setup Guidelines-Harmonic Current Mitigation-Equipment Design-Harmonic Current Cancellation-Harmonic Filters

TEXT BOOKS:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Roger C.Dugan, Mark F. McGranaghan,Surya Santoso& H.Wayne Beaty: Electrical Power Systems Quality, Tata McGraw-Hill

REFERENCES

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. Related MOOC Courses
4. C. Sankaran : Power Quality CRC Press,2002

Course Outcomes

At the end of the course learner will be able to

- ✓ Understand the concepts of Electric vehicles
- ✓ Design the Electric Vehicle
- ✓ Evaluate the performance of Electric vehicles
- ✓ Optimize the various energy sources in Nano grid technologies (V2G)
- ✓ understating the various International Power quality standards and mitigation techniques

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	2	-	2	1	-	-	2	3	3	3	3	-	2
2	3	2	3	2	3	2	2	1	3	3	3	3	-	2
3	3	2	3	2	3	2	2	1	3	3	3	3	-	2
4	-	1	1	3	-	3	3	3	3	3	3	2	3	3
5	-	3	-	3	-	2	3	3	3	3	3	2	3	3

18REEP03DY MOOC1

18REEP03DZ MOOC2

21REEP0313 RURAL ENERGY PLANNING

Course Objectives:

CO1 : Learn about the Rural Energy related issues
CO2 : Collect and analyze the village level data
CO3 : Prepare the Detailed Project Report incorporating Govt. Schemes and Policies

Cognitive Level:

K3 : Data / Survey questionnaire preparation
K4 : Data Analysis
K5 : Interpretation of data and report preparation

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 thefuture 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 village which will enable to create a '*Model Energy Village'.*

CFA:

Seminar Presentation 1 - 10
Seminar Presentation 2 - 10
DPR Preparation - 40

ESE:

Report and Seminar Presentation - 20 marks
Viva-Voce - 20 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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	1	1	3	3	3	3	3	3	3	3	3	3	3
2	3	2	2	3	3	3	3	3	3	3	3	3	3	3
3	3	2	2	3	3	3	3	3	3	3	3	3	3	3

21REEP02M1 ROOFTOP SOLAR PHOTOVOLTAIC ENTREPRENEUR

Course Objectives:

CO1 : Training candidates for the job of a "Rooftop Solar Photovoltaic Entrepreneur" as per NSQF

Cognitive Level:

K3 : Calculate the capacity of Roof top solar system
K4 : Enhance Entrepreneur skill on Roof top solar system
K5 : Design a Project Report of Roof top solar system with Economic analysis

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 constructed 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 software - 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

Identify 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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	2	3	3	3	3	2	3
2	2	2	2	3	3	3	3	3	3	3	3	3	2	3
3	2	2	2	3	3	3	3	3	3	3	3	3	2	3
4	3	3	2	3	3	3	3	2	3	3	3	3	3	3
5	3	3	2	3	3	3	3	2	3	3	3	3	3	3

21REEP02M2 SOLAR THERMAL SYSTEMS FOR INDUSTRIAL PROCESS HEAT

Course Objectives:

CO1 : To understand the installation of solar thermal system for industrial process heating from the point of renewable energy technology and management of skill council of green jobs (SCGJ)

Cognitive Level:

K3 : Understanding the basics of solar thermal system

K4 : Design of solar thermal based Industrial process heating

K5 : Detailed Installation and commissioning of concentrating collector, solar water heat with industrial safety Regulations

UNIT-I:

Basic concepts – System, temperature, pressure – Energy, work, heat – Conduction, convection, radiation – Laws of thermodynamics - Principle of conversion of solar radiation to heat – Effect of earth atmosphere – measurement – anti reflective coating – Selective coating-suitable material

UNIT-II:

Analyze the client requirements: visit the client site to understand the details of their manufacturing process - identify the heat requirement for various process, temperature and quantity - collect data on the present source of heat and its utilization - compute the shadow free open area available on the ground or rooftop for installation of solar thermal system - obtain and analyze solar radiation data for the project site - describe the benefits of using solar thermal technologies to the client - **Select and design solar thermal technology (i.e.,) for supply of process heat:** analyze and recommend the relevant solar thermal technologies (i.e. air collectors, FPC/ETC water heater, scheffler disc, , parabolic trough collector and linear Fresnel reflector collector) as per client requirements and suitability - suggest capacity of solar thermal system with estimated heat output at designed temperature and solar radiation levels - design relevant solar thermal technology solution catering to the client's requirement - Identify necessary changes to existing process for integration of solar thermal system - integrate the solar thermal system with the existing process heat supply system - Quality of water and need for treatment plant and thermal storage, if required

UNIT-III:

Site Preparation : analyze designs and drawings of solar thermal system - ensure proper marking of site as per design and drawings **Installation as per design drawings :** ensure installation of concentrating collectors and receiver mounting structures - ensure installation and orientation of reflectors/ collector - ensure installation of tracking system - ensure installation of piping network including pumping system - ensure installation of temperature sensors, vent and pressure release valves as per the design - ensure the proper integration with auxiliary heating systems - **Testing and Commissioning:** ensure testing of pressure sensors, temperature sensors and vents/ pressure valves and replace accordingly if any defects found measure and compare pressure in different tubes as per design values - carry out testing of the piping network for any leakages and rectify accordingly if any defects found - ensure proper working of tracking system commission the solar thermal system prepare as- built drawing and document design changes, if any

UNIT-IV:

Analyze the design and drawings of the solar water heating system to be installed - identify the type of footing required as per the roof structure - arrange for relevant tools and consumables required for civil/mechanical installation - construct the foundations as per the design specifications - install mounting posts, roof attachments, anchors and any other structural attachments - install collector mounting structure and apply corrosion protection paints - apply weather proofing on mounting structures to avoid any seepage and penetrations - unpack the collectors and inspect them for physical damage

conduct performance test on each collector,heat exchanger for leakage - install the cold water make up tank as per the design - install the air vents as per the design - test for prevention of air interlocking - install the fluid circulation pumps and controls systems - pre-test the fluid circulation in the system for any leakages in pipelines - interconnect the collectors and other components of the solar water heater with pipes of material and specifications given in the drawing - ensure that the slope of the pipes for feeding water is aligned to the collectors as per design - pre-test the solar water heating system to adhere to the performance specifications - test the system for leakage by pressurizing the water at designed pressure and plug any leakages to ensure proper insulation of the hot water pipeline as per design - commission the solar water heating system

UNIT-V:

identify corporate policies required for workplace safety - identify requirements for safe work area and create a safe work environment - identify contact person when workplace safety policies are violated - provide information about incident/violation - identify the location of first aid materials and administer first aid - identify the personal protection equipment required for specific locations on-site - identify expiry dates and wear & tear issues of specified equipment - demonstrate safe and accepted practices for personal protection - identify environmental hazards associated with the project site - identify heat and mechanical hazards - identify personal safety hazards or work site hazards and mitigate hazards - select tools, equipment and testing devices needed to carry out the work demonstrate safe and proper use of required tools and equipment - check access from ground to work area to ensure it is safe and in accordance with requirements - re-assess risk control measures, as required, in accordance with changed work practices and/or site conditions and undertake alterations - inspect/install fall protection and perimeter protection equipment ensuring adequacy for work and conformance to regulatory requirements - identify approved methods of moving tools and equipment to work area and minimize potential hazards associated with tools at heights - select and install appropriate signs and barricades - place tools and materials to eliminate or minimize the risk of items being knocked down dismantle plant safely in accordance with sequence and remove from worksite to clear work area.

TEXT BOOKS:

1. S P Sukhatme, Solar Energy, Tata McGraw Hill, 2008
2. Renewable Energy Technology and Management by skill council for green jobs
3. H.P.Garg., Prakash J., Solar Energy: Fundamentals & Applications, Tata McGraw Hill, New Delhi, 1997

REFERENCES:

1. P.K.Nag , "Engineering Thermodynamics", Tata McGraw-Hill Publishing Co., Ltd., 1994.
2. Alan L Fahrenbruch and Richard H Bube , Fundamentals of Solar Cells: PV Solar
3. 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. H S Rauschenbach, Solar Cell Array Design Handbook, Van Nostrand Reinfold Company, New York, 1980
6. Tiwari G.N., Suneja S., Solar Thermal Engineering System, Narosa Publishing House, New Delhi, 1997.
7. Moran, Shapiro, Munson and Dewitt, “Introduction to Thermal Systems Engineering: D Y Goswami, Frank Kreith and J F Kreider, Principles of Solar Engineering, Taylor & Francis, 1998
8. Richard H Bube, Photovoltaic Materials, Imperial College Press, 1998

Course Outcomes

At the end of the course learner will be able to

- ✓ Design of solar based industrial process heating
- ✓ Design and installation of solar concentrator based industrial heating system
- ✓ Design and installation of solar water based industrial heating system
- ✓ Maintain Personal Health & Safety at project site
- ✓ Entrepreneurship skills

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	2	2	3	3	2	3	2	3	3	2	3	2	2
2	2	2	2	3	3	3	1	3	3	2	1	3	2	3
3	2	2	3	3	3	3	3	1	3	3	1	3	2	2
4	3	3	2	3	1	3	3	2	3	3	3	3	3	3
5	3	3	2	3	1	3	3	2	3	3	1	3	3	3

21REEP02 M3 SITE SURVEY OF WIND POWER PLANT

Course Objectives:

CO1 : To understand the site survey methodology and feasibility study of wind power plants from the point of Renewable Energy Site Surveyor as per NSQF

Cognitive Level:

K3 : Estimation of Wind Resource Assessment
K4 : Enhance site survey skill on wind power conversion system
K5 : Detailed wind resource assessment of wind power plant and report writing

UNIT-I:

Analyse detailed site information - analyse the daily, monthly and annual wind resource data of site to evaluate the potential for wind energy generation -ensure the collection of data on local weather conditions such as temperature range, flooding (in case of onshore), wind speed, humidity, rainfall and assess its impact on wind energy generation. -Assess the ground water availability and quality, load bearing capacities, pH levels and seismic risk -analyse the pre-site selection baseline data for project execution suitability -identify location for Power Curve test -ensure installation of meteorological mast (met mast) at site - analyse wind data collected from met mast for wind potential

UNIT-II:

Prepare a detailed survey plan of the land proposed for installation of wind power plant with elevations and topography - calculate the exact land area of the proposed site where installation is to be commenced -prepare contour map of proposed wind plant site -conduct field surveys and give site ranking -identify position of WTG, substation, transmission line, transformers, etc.

UNIT-III:

Identify accessibility of the site i.e., its connectivity to various transport mechanisms including rail, road, connecting roads etc. -ensure conducting of route survey - identify soil type and its strength -identify state/central law of land leasing and purchase

UNIT-IV:

Analyse environmental and social impact of the plant and site risk analysis -Identify local support and hindrance factors and include in the report as a special section -Identify limitations and incentives according to relevant applicable policies, regulations and procedures

UNIT-V:

Validate collected wind data from site -verify the wind potential with other resources such as NREL/ATLAS -prepare detailed site survey report using GPS/DGPS and wind data analysis software.

TEXT BOOK:

1. David A. Spera, (Editor) Wind Turbine Technology: Fundamental Concepts of Wind Turbine Engineering, American Society of Mechanical Engineers; (1994)
2. Mukund R. Patel, Wind and Solar Power Systems , CRC Press; (1999)

REFERENCE BOOK:

1. G.L.Johnson. Wind Energy Systems, Prentice Hall Inc, New Jersey, 1985
2. Erich Hau,Wind Turbines: Fundamentals, Technologies, Application and Economics, Springer Verlag; (2000)
3. Paul Gipe , Karen Perez, Wind Energy Basics: A Guide to Small and Micro Wind Systems, Chelsea Green Publishing Company; (1999)
4. J. F. Manwell, J. G. McGowan, A. L. Rogers, Wind Energy Explained, John Wiley & Sons; 1st edition (2002)

Course Outcomes

At the end of the course learner will be able to

- ✓ Carry out the wind site resource assessment
- ✓ Prepare site feasibility report
- ✓ Manage Wind power project lifecycle
- ✓ Entrepreneurship skills
- ✓ Maintain Personal Health & Safety at project site

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	2	3	3	3	3	2	3
2	2	2	2	3	3	3	3	3	3	3	3	3	2	3
3	2	2	2	3	3	3	3	3	3	3	3	3	2	3
4	3	3	2	3	3	3	3	2	3	3	3	3	3	3
5	3	3	2	3	3	3	3	2	3	3	3	3	3	3

21REEP02 M4 WASTE MANAGEMENT

Course Objectives:

CO1 : To understand the waste management from the point of Manager- Waste a Management as per NSDC

Cognitive Level:

K3 : Estimation of Waste Resource or Source

K4 : Enhance the market survey and operational plan creation on Waste management

K5 : Operational Management of Biomass Depot, Compost yard and Dry Waste Center

UNIT-I:

Explain different types of waste and compost - Describe the role of Manager for Waste Management - Demonstrate processes for procurement, processing and onward supply of biomass for biomass depot - Explain production management and marketing of urban waste compost - Demonstrate collection and management of dry waste focusing on plastic, paper and other waste

UNIT-II:

Identify methods of determining existing market demands- Outline primary and secondary research to identify market determinants and customer's needs - Demonstrate project growth using statistical tool and develop profiles of resulting market segments - Identify competitors in the market and assess their respective sales strategies - Formulate an operational plan - Demonstrate methods to identify key resources, suppliers of different waste stream based on the market analysis conducted - Outline technical activities associated with business operations - Explain how to prepare a medium / long term sales forecast - Explain creation of an expense budget, long term cash flow statement indicating various fixed and variable costs likely to be encountered - Describe preparation of a cost – benefit analysis and develop a loan repayment plan

UNIT-III:

Demonstrate the structure and functioning of Biomass Depot - Identify key supplier for biomass procurement and supply - Demonstrate the method of sorting, densification and storage of biomass - Explain the mode of stakeholder engagement and identify challenges encountered in daily operations - Describe monitoring of financial performance of the business - Demonstrate resources and inventory management - Identify and demonstrate customer redressal system for solving customer problems

UNIT-IV:

Demonstrate the structure and functioning of Compost yard - Demonstrate method of evaluating material summary reports and identifying technical challenges in composting operations - Describe monitoring of financial performance of the business - Demonstrate method of identifying potential contingencies applicable to the business - Identify methods of managing key resources i.e. availability of machinery, manpower etc. required during operation - Demonstrate resources and inventory management - Evaluate compost industry best practices for enhance quality - Evaluate the effectiveness of marketing campaigns to identify avenues for enhancing market share and profitability.

UNIT-V:

Demonstrate the structure and functioning of Dry waste Collection Center - Explain various categories of plastic waste, paper waste and other waste - Demonstrate method of evaluating material summary reports and identifying technical challenges in waste collection operations - Describe monitoring of financial performance of the business - Demonstrate method of identifying potential contingencies applicable to the business - Identify methods of managing key resources i.e. availability of machinery, manpower etc. required during treatment / pre-processing of plastic waste, paper waste and other waste - Describe monitoring of non-financial activities of the business which include timely and accurate segregation of plastic waste into various identified categories - Demonstrate disposal / utilization of dry waste in a responsible manner

Text Book

1. Rai, G.D., "Non-Conventional Sources of Energy", Khanna Publishers, Delhi 1995
2. Parker., Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
3. 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 Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987
2. 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

- ✓ Carry out market analysis
- ✓ Identify key suppliers of waste
- ✓ Manage overall operations of biomass depot
- ✓ Manage overall operations of compost yard
- ✓ Manage overall operations of dry waste collection centre
- ✓ Entrepreneurship skills

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	2	2	2	3	3	3	3	2	3	3	3	3	2	3
2	2	2	2	3	3	3	3	3	3	3	3	3	2	3
3	2	2	2	3	3	3	3	3	3	3	3	3	2	3
4	3	3	2	3	3	3	3	2	3	3	3	3	3	3
5	3	3	2	3	3	3	3	2	3	3	3	3	3	3

21REEP0314 DISSERTATION- I

Course Objective:

CO1 : To design and develop and analyze the renewable energy system / process

Cognitive Level:

K3 : Data / Survey questionnaire preparation
K4 : Data Analysis
K5 : Interpretation of data and report preparation

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3

21EXNP03V1 VILLAGE PLACEMENT PROGRAMME

As per Gandhigram Rural Institute – Deemed to be University Norms.

21REEP0415 DISSERTATION II

Course Objective:

CO1 : To design and develop and analyze the renewable energy system / process

Cognitive Level:

K3 : Data / Survey questionnaire preparation
K4 : Data Analysis
K5 : Interpretation of data and report preparation

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 (In-depth 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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3