

Post Graduate Programme (Renewable Energy Engineering), CTAE, Udaipur

Semester-wise Scheme for Post Graduate Program in Renewable Energy Engineering, 2011-12

Course Title	Course No.	Credit	Semester			
			I	II	III	IV
Core Courses Total 12 credits, two courses in first semester and one course in second and third semester to be evaluated externally for Master students and total 6 credits in each semester) for doctoral students						
Solar Energy Utilisation	RES 511	3(2+1)	3	-	-	-
Bio-energy Conversion & Processing of Wastes	RES 512	3(2+1)	3	-	-	-
Biogas Technology & Mechanism	RES 521	3(2+1)	-	3	-	-
Renewable Sources of Energy	RES 531	3(2+1)	-	-	3	-
Renewable Energy for Industrial Application	RES 611	3(2+1)	3	-	-	-
Solar Energy Utilization for Heating & Cooling	RES 621	3(3+0)	-	3	-	-
Major Courses- 2 courses in first & second semester each and one course in third semester for ME and two courses each in first and second semester for Ph.D. (Total 15 credits hours in 3 semesters to be decided by the advisory committee for Master students and total 12 credit hours in two semesters fro Doctoral student)						
Energy Conservation & Management	RES 513	3(2+1)	3	-	-	-
Waste Recycling and Resources Recovery Systems	RES 514	3(2+1)	3	-	-	-
Agro-Energy Audit and Management	RES 515	3(2+1)	3	-	-	-
Wind Energy Utilisation	RES 516	3(3+0)	3	-	-	-
Design and Analysis of Renewable Energy Conversion Systems	RES 522	3(3+0)	-	3	-	-
Energy Management in Food Processing Industries	RES 523	3(3+0)	-	3	-	-
Alternate Fuels & Applications	RES 524	3(3+0)	-	3	-	-
Energy, Ecology & Environment	RES 525	3(3+0)	-	3	-	-
Direct Energy Conversion Technologies	RES 535	3(2+1)	-	-	3	-
Energy Lab	RES 536	3(0+3)	-	-	3	-
Energy Management in Agriculture	RES 537	3(3+0)	-	-	3	-
Power System Analysis	RES 612	3(3+0)	3	-	-	-
Thermochemical Conversion of Biomass	RES 613	3(2+1)	3	-	-	-
Environmental Pollution & Control	RES 614	3(3+0)	3	-	-	-
Management & Utilization of Natural Resources	RES 622	3(3+0)	-	3	-	-
Gender & Energy	RES 623	3(3+0)	-	3	-	-
Renewable Energy Techniques	RES 624	3(2+1)	-	3	-	-
Wind & Human Environment	RES 625	3(3+0)	-	3	-	-
Supporting Courses (Total 3 Courses of 9 credits hours for Master students and Doctoral students to be decided by the advisory committee, one in each semester)						
Statistical Methods	AST 510	3(2+1)	3	-	-	-
Advance Programme with C ⁺⁺	CSE 511	3(1+2)	3	-	-	-
Engineering Properties of Food Materials	PFE 512	3(2+1)	3	-	-	-
Applied Instrumentation in Farm Machinery & Stress Analysis	FMPE 513	3(2+1)	3	-	-	-
Farm Power and Machinery Management	FMPE 514	3(2+1)	3	-	-	-
Higher Mathematics	BS 515	3(3+0)	3	-	-	-
Drying and Dehydration of Foods	PFE 516	3(2+1)	3	-	-	-
CAD/CAM	MED 518	3(1+2)	3	-	-	-
Methods of Numerical Analysis	BS 521	3(2+1)	-	3	-	-
GIS and Remote Sensing for Land and Water Resource Management	SWC 522	3(2+1)	-	3	-	-
Post Harvest Processing of Grains	PFE 535	3(2+1)	-	-	3	-
Finite Element Analysis	MED 612	3(3+0)	3	-	-	-
Advances in Drying of Food Materials	PFE 612	3(2+1)	3	-	-	-
Agricultural Waste and By-Products Utilization	PFE 625	3(2+1)	-	3	-	-
System Engineering and Productivity	SWCE 526	3(2+1)	-	3	-	-
Others						
Non Credit Courses	-	NC	1	1	-	-
Seminar (0+1)/ (0+2)	RES 532/632	1*/2**	-	-	1*/2**	-
Comprehensive Examination* / Preliminary Examination**	RES 533/633	NC	-	-	NC	-
Thesis	RES 534/634	20*/45**	-	-	-	20*/45**
Total credits to be offered (for Master Programme)		57	15	12	10	20
Total credits to be offered (for Doctoral Programme)		74	15	12	2	45

*For Master programme, Thesis minimum duration 2 semester

**For Doctoral programme, Thesis minimum duration 4 semester

RENEWABLE ENERGY ENGINEERING

Course Contents

SOLAR ENERGY UTILISATION

RES 511

Credit 3(2+1)

Solar Radiation: The sun and its characteristics, Structure of the Sun, Extraterrestrial solar radiation, the solar constant. Solar radiation at earth's surface, beam and scattered radiation and air mass, variation in extraterrestrial radiation, diffuse radiation, attenuation of beam and diffused radiation at the ground, Basic Sun Earth Angles, solar time and the equation of time, Day length.

Solar Radiation Measurement and Estimation: Solar energy measuring instruments, pyranometer, pyrliometer, sunshine recorder, Estimation of average solar radiation, ratio of beam and total radiation on tilted surface of that on horizontal surface.

Solar Collectors: Flat plate collector, Materials for flat plate collector and their properties, Thermal Analysis of Flat-plate Collector and Useful Heat Gained by the fluid, fin efficiency, collector efficiency factor, Heat Removal Factor. Focusing collectors, types and applications of focusing collectors

Solar Energy Applications: Introduction and principle of operation of solar cooker, solar air heater, solar water heater, solar distillation, solar pond, solar thermal power generation, Greenhouse, Solar PV system.

Storage of Solar Energy: Types of Energy Storage, Thermal Storage, Electrical Storage, Chemical Storage, Hydro-storage.

Practical:

1. Study of flat plate collector
2. Study of a box type solar cooker and calculation of its thermal efficiency.
3. Study of a solar distillation system.
4. Study of natural convection type solar water heater
5. Study of natural convection type solar Dryer
6. Study of forced convection type solar Dryer
7. Study of Solar Pond
8. Study of solar animal feed cooker
9. Study of Solar Greenhouse
10. Study of Solar Tunnel Dryer

Suggested Readings

1. Meinel, A.B and Meinel, M.P.; Applied Solar Energy, Addison Wesley Publishing Company, New York
2. Duffie, J.A., and Beakman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York.
3. Sayigh, A. A. M., Solar Energy Engineering Academic Press, New York.
4. Rai, G.D., Solar Energy Utilization, Khanna Publishers, Delhi.
5. Garg, H.P., Treatise on Solar Energy, Jhon Willey & Sons.
6. Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co.

BIO-ENERGY CONVERSION AND PROCESSING OF WASTES

RES 512

Credit 3(2+1)

Biomass Production: Introduction, Wastelands, classification and their use through energy plantation, selection of species, methods of field preparation and transplanting. Harvesting of biomass and coppicing characteristics.

Biomass Characterizations: Physio-chemical characteristics of biomass, calorific values of solid, liquid and Gaseous fuels.

Biomass Conversion: Different routes of conversion of biomass such as

Physical: cutting, sizing, drying and storage of wood, twigs and other biomass.

Biochemical: Conversion of biomass, sugar, starch and cellulose into alcohol, biodiesel.

Thermo chemical: Direct combustion, Improved cookstoves, Briquetting of biomass, pyrolysis, gasification.

Practical:

1. Identification of different plant species for energy plantation.
2. Determination of biomass properties such as bulk density, moisture content, volatile solids, ash content, calorific value.
3. Measurement of calorific value of solid, liquid and gaseous fuels.
4. Study of biomass cutter.
5. Study of briquetting machines.
6. Performance evaluation of improved cookstoves.
7. Study on alcohol production from sugar, starch and cellulose.

Suggested Readings

1. Vimal, O.P. Energy from Biomass, Agricole Publishing Academy, New Delhi
2. Vimal, O. P. and Bhatt, M.S., Wood Energy System, Agricole, Pub. New Delhi.
3. Rathore N. S., Panwar N. L, Kothari S., Biomass Production and Utilization Technology. Himanshu Production, 2007

ENERGY CONSERVATION AND MANAGEMENT

RES 513

Credit 3(2+1)

Energy Conservation: Status and significance with respect to developing and developed countries, concept and thermo dynamics and energy conservation, second law of thermo dynamics and efficiency analysis of system, thermal insulation.

Energy Audit: Type of energy auditing, walk through, minimum and maximum- (a) Energy accounting and analysis; input, output and impact variance, (b) Energy auditing of different sectors; Industrial tools, agriculture fields and electrical auditing.

Fuel and Process modification, Control and Instruments in Energy Conservation: Energy conservation in water pumping and other agricultural operations/machinery, food process industries and domestic appliances.

Co-generation: Waste heat recovery, co-generation with alternate energy system, Dual cycle, steam economy.

Practical:

1. Study of different energy audit techniques.
2. Study of instrumentation required for energy audit.

3. Energy audit of selected industry.
4. Scope of renewable energy techniques in industries.

Suggested Readings

- 1 Vogt, F; Energy Conservation and use of Renewable Energies in the Bio-Industries.
- 2 Pratap Singh et. al Sustainable Development through Renewable Energy Sources Yash Publications, Bikaner, 2004
- 3 Shinkey, F.J. Energy Conservation through control.

WASTE RECYCLING AND RESOURCES RECOVERY SYSTEMS

RES 514

Credit 3(2+1)

Introduction: Sources of different wastes, their nature and characteristics; quantum of industrial, agricultural, municipal, bio-medical and other organic wastes/by products and its management needs.

Waste to Energy Conversion Technologies: viz. biomethanation, gasification, alcoholic fermentation, hydrogen reduction, agrochemical fuel extraction, etc. suitable for organic by products & wastes, their management approach, application and acceptability.

Economics of Waste disposal to energy conversion, advantages & disadvantages,

Design of a suitable waste disposal plant based on local needs/village case study.

Practical:

1. Identification of industrial, bio-medical and agricultural wastes/by-products under local conditions causing environmental hazards.
2. Study of existing practices for waste disposal
3. Study of advanced organic/carbonic waste management technologies.
4. Development of a suitable waste management process for an identified organic waste / by-product suitable under local conditions.
5. To evaluate economics of waste disposal/handling process via advanced technique vis-à-vis conventional method.

Suggested Readings

1. Pratap Singh et. al., Sustainable Development through Renewable Energy Sources, Yash Publications, Bikaner, 2004
2. Rathore N.S., Kurchania A.K. Biomethanation Technology, Apex Publications, Udaipur, 2006

AGRO-ENERGY AUDIT AND MANAGEMENT

RES 515

Credit 3(2+1)

Objective

To acquaint and equip about the sources of energy, conservation of energy and its management. Energy use scenario in agricultural production system, agro-based industry. Study of energy efficiency, energy planning, forecasting and energy economics.

Theory

Energy resources on the farm: conventional and non-conventional forms of energy and their use. Heat equivalents and energy coefficients for different agricultural inputs and products. Pattern of energy consumption and their constraints in production of agriculture. Direct and indirect energy. Energy audit of production agriculture, and rural living and scope of conservation. Identification of energy efficient machinery systems, energy losses and their management. Energy analysis techniques and methods: energy balance, output and input ratio, resource utilization, conservation of energy sources. Energy conservation planning and practices. Energy forecasting, Energy economics, Energy pricing and incentives for energy conservation, factors effecting energy economics.

Practical:

1. Study of energy audit techniques.
2. Study of energy use pattern and management strategies in various Agro-industries.
3. Assessment of overall energy consumption, production and its cost in selected agro industries.
4. Visit to related Agro-industry.

Suggested Readings

1. Kennedy WJ Jr. & Wayne C Turner.1984. Energy Management. Prentice Hall.
2. Pimental D. 1980. Handbook of Energy Utilization in Agriculture. CRC
3. Fluck RC & Baird CD.1984. Agricultural Energetics. AVI Publ.
4. Rai GD. 1998. Non-conventional Sources of Energy. Khanna Publ.
5. Twindal JW & Anthony D Wier 1986. Renewable Energy Sources. E & F.N. Spon Ltd.
6. Verma SR, Mittal JP & Surendra Singh 1994. Energy Management and Conservation in Agricultural Production and Food Processing. USG Publ. & Distr., Ludhiana.

WIND ENERGY UTILIZATION

RES 516

Credit 3(3+0)

Wind Energy- Introduction, history of development, applications of wind energy, wind velocity, wind mapping minimum, maximum and averaging.

Wind Power- Power produced due to wind current, effect of height, obstacle and valley- Criterion for selection of site for wind power harnessing. Wind power equipment such as pumps, generator storage of wind energy, wind power plant and supply of wind power to consumer/grid.

Wind Measuring Instruments and Controls-Different systems of measuring and recording wind velocity, wind tower, controls used in wind machines.

Wind Machines- Types of wind mills, systems of wind machine, different parts such as rotor, structure, plunger, rod and their design, Different power transmission systems and design, Wind blade and its configurations, forces on wind blade, drag and lift, load matching, speed range selection, Selection of material for different parts.

Suggested Readings

1. More and Maheshwari; Wind Energy Utilization in India
2. Lysen, E.H. Introduction to Wind Energy
3. Dunn, P.D. Renewable Energy Sources, Conversion and Application
4. Veziroglue, Najat, T., Alternate Energy Sources, Vol. IV Indirect Solar Energy.

BIOGAS TECHNOLOGY AND MECHANISM

RES 521

Credit 3(2+1)

Biogas Technology: Introduction, historical background, digestion process, factors enhancing/ inhibiting biogas production.

Bio-chemical and Microbial Aspects: Biogas mechanism, enhancing the biogas production and its purification.

Biogas Plant: Systems, Types of biogas plants, classification, design of a biogas plant (cow dung and organic waste), and structural strength, selection of site and size, construction technique material requirement, high rate digesters, night soil linked biogas plant.

Biogas Distribution and Utilization: Properties of biogas, different uses, design of biogas distribution system, pressure and flow measuring devices, safety devices, biogas fittings, principles of dual fuel biogas engines, its limitations, biogas appliances including thermal and cooking efficiency test.

Effluent: Handling of effluent of biogas plant (cow dung based, sanitary latrine attached and agro industrial wastes), effluent treatment and management effect of slurry on crop and fish production. Integrated recycling of organic wastes.

Alternate Feed Material: Study of biogas plant for distillery and sugar mills effluent, willow dust, agro-wastes, agro and processing industry wastes.

Repair and Maintenance: Repair and maintenance of biogas plants.

Practical:

1. Study on production of biogas from different models of biogas plants.
2. Determination of N, P and K contents of the fresh and digested slurry by chemical analysis.
3. Study of constructional details of willow dust based biogas plants.
4. Testing of biogas burner for heat transfer, thermal and cooking efficiency.
5. Testing of biogas lamp
6. Determination of BOD/COD
7. Determination of calorific value of biogas.
8. Analysis of biogas to determine its constituents
9. Visit to industrial biogas plants.
10. BIS code for efficiency testing of biogas appliances.

Suggested Readings

1. Khandelwal, K.C. and S.S Mahdi.; Biogas Technology: A Practical Hand Book, Tata McGraw Hill Pvt. Co.
2. Chawla, O.P., Advances in Biogas Technology, I.C.A.R., New Delhi
3. Rathore N.S., Kurchania A.K., Biomethanation Technology, Apex Publications, Udaipur, 2006
4. Mathur, A.N. and N.S Rathore; Biogas production management and utilization- Himanshu Publication.

DESIGN AND ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS

RES 522

Credit 3(3+0)

Objective

To acquaint and equip with the conventional and non-conventional energy sources. Energy from biomass, conversion of energy from biomass. Development of biogas and biofuels.

Theory

Energy cycle of the earth; water flow and storage; ocean currents and tides. Energy heat flow and energy storage; photosynthesis and biomass; renewable energy sources.

Thermodynamics of energy conversion; conversion of solar energy, wind energy, water flows, heat, biomass, etc.; other conversion processes.

Development and use of biogas, alcohols and plant oils, plant oil esters in I.C. engines. Study of various parameters for measuring the performance of the output.

Design of bio-fuel production units: design of gasifiers, gas flow rates, biogas plants. Establishment of esterification plant, fuel blending.

Suggested Readings

1. Boyle Godfrey. 1996. Renewable Energy: Power for Sustainable Future. Oxford Univ. Press.
2. Culp AW. 1991. Principles of Energy Conservation. Tata McGraw Hill. Duffle JA & Beckman WA. 1991. Solar Engineering of Thermal Processes. John Wiley.
3. Garg HP & Prakash J. 1997. Solar Energy - Fundamental and Application.
4. Tata McGraw Hill.
5. Grewal NS, Ahluwalia S, Singh S & Singh G. 1997. Hand Book of Biogas Technology. Solar Energy Fundamentals and Applications. TMH New Delhi.
6. Mittal KM. 1985. Biomass Systems: Principles & Applications. New Age International.
7. Odum HT & Odum EC. 1976. Energy Basis for Man and Nature. Tata McGraw Hill.
8. Rao SS & Parulekar BB. 1999. Non-conventional, Renewable and Conventional . Khanna Publ.
9. Sukhatme SP. 1997. Solar Energy - Principles of Thermal Collection and Storage. 2nd Ed. Tata McGraw Hill.

ENERGY MANAGEMENT IN FOOD PROCESSING INDUSTRIES

RES 523

Credit 3(3+0)

Objective

To acquaint and equip the students with different energy management techniques including energy auditing of food industries.

Theory

Energy forms and units, energy perspective, norms and scenario; energy auditing, data collection and analysis for energy conservation in food processing industries.

Sources of energy, its audit and management in various operational units of the agro-processing units; passive heating, passive cooling, sun drying and use of solar energy, biomass energy and other non-conventional energy sources in agro-processing industries. Reuse and calculation of used steam, hot water, chimney gases and

cascading of energy sources. Energy accounting methods, measurement of energy, economics of energy use.

Suggested Readings

1. Pimental D. 1980. Handbook of Energy Utilization in Agriculture. CRC Press.
2. Rai GD. 1998. Non-conventional Sources of Energy. Khanna Publ.
3. Twindal JW & Anthony D Wier 1986. Renewable Energy Sources. E & F.N. Spon Ltd.
4. Verma SR, Mittal JP & Surendra Singh. 1994. Energy Management and Conservation in Agricultural Production and Food Processing. USG Publ. & Distr., Ludhiana.

ALTERNATE FUELS AND APPLICATIONS

RES 524

Credit 3(3+0)

Introduction to alternate fuels, synthetic fuels, production, composition and properties, combustion characteristics, bio-fuels (alcohol, methanol, ethanol, biogas, producer gas hydrogen) and fuel cell.

Composition and properties of alternate fuels, comparison with conventional fuels, potential, possibilities and problems.

Production of biogas, producer gas, ethanol, methanol, alcohol and hydrogen.

Utilization: Thermal and mechanical applications, utilization in SI and CI engines, modifications needed to convert existing SI and CI engines to run on alternate fuels, utilization for miscellaneous applications.

Environmental aspects of alternate fuels: Environmental impact and safety factors, efficiency of different alternate fuels.

Economics and commercial considerations.

Suggested Readings

1. Edger J. D.; Biogas Fuel of Future
2. Robertson E.; Gaseous Fuels
3. Das R. S. et al; Biogas as a Replacement Fuel to Diesel
4. Ratnakar G. L.; Utilization of Biogas in IC Engines
5. Mathur H. B.; Synthetic Fuels

ENERGY, ECOLOGY AND ENVIRONMENT

RES 525

Credit 3(3+0)

Origin of the earth, Earth's temperature and atmosphere, Sun as a source of energy, biological processes, photosynthesis, food chain, energy, fuel and power.

Energy sources, quality and concentration of energy sources, characteristics, temperature, classification of energy sources, renewable energy and non-renewable energy sources, scientific principles of renewable energy, technical and social implications.

Scope and history of ecology, nature of environmental responses, community ecology, eco-system, theory, population ecology, evolutionary and geographical ecology.

Environment and its relationship with earth, forest, dams, atmosphere, habitats, health, energy, living resources, agents of change. Environmental degradation, primary and secondary pollutants. Environmental Impact Assessment.

Micro climatic effects of pollution, pollution from stationary and mobile sources, ground water pollution, biological effect of radiation, heat and radio activity disposal, Pollution abatement methods, Greenhouse Effect.

Suggested Readings

1. Twidell John W. and A. D. Weir; Renewable Energy Sources
2. Dune, P. D.; Renewable Energies: Sources, Conversion and Applications
3. Hopes G. Puppy; Energy and Environment, Mankind and Energy Needs, Elsevir Pub. Co., New York
4. Rao C. S.; Environmental Pollution Control Engineering
5. Rathore N.S., Kurchania A.K., Climatic Changes & Their Remedial Measures, Shubhi Publications, Gurgaon, 2001
6. Mathur A. N., Rathore N. S. and V. K. Vijay; Environmental Awareness

RENEWABLE SOURCES OF ENERGY

RES 531

Credit 3(2+1)

Solar Energy: Sources, its advantages, availability. Heat transfer processes applicable to solar energy, solar radiation and its analysis, Instruments for measurement of solar energy (Pyranometer / pyrliometer), Introduction to basic flat plate and focusing collectors. Solar thermal energy technology application: Solar Cooker and Water Heater, Solar Dryers, Solar Green House, Active/passive Heating, Stills, Solar photovoltaic technology.

Biogas: its applications and importance, Biogas plant (types, size their features, merits and demerits) Utilization of biogas-spent slurry.

Biomass: Introduction to biomass as source of energy and its advantages, Biomass Classification, Characteristics of biomass (proximate analysis and ultimate analysis).

Harvesting of biomass (coppicing, pollarding, lopping, pruning, thinning)

Biomass conversion technologies (thermo-chemical, bio-chemical and agro-chemical) technology, Briquetting, Biomass gasification technology.

Improved Cookstoves: Fundamental & types, techno-economic analysis of renewable energy sources and comparison with conventional energy sources.

Wind Energy: Basic principles of wind energy conversion, site selection consideration, Basic components of wind energy conversion system, Type of wind machine.

Practical:

1. Study of a box type solar cooker,
2. Study of a solar distillation plant.
3. Study of biomass briquetting machine
4. Study of direct and indirect solar dryer
5. Study of a KVIC biogas plant.
6. Study of a Deenbandhu biogas plant.
7. Study of a biomass gasifier.
8. Study and testing of biogas appliances
9. Study and testing of improved cookstoves.
10. Study of Wind Energy Conversion Devices
11. Design of solar water heater.
12. Design of solar dryer.

Text Books/References:

1. Garg H.P. Advances in Solar Energy Technology. D. Publishing Company, Tokyo, 1990.
2. Alan L: Farredbruch & R.H. Buse. Fundamentals of solar Academic Press, London, 1983
3. Bansal N.K., Kleemann M. & Michael, Meliss, Rene, energy Sources & Conversion Technology. Tata Megras publishing Company, New Delhi, 1990.
4. Mathur, A.N.& Rathore N.S. ,Biogas Production Management & Utilization. Himanshu Publications, Udaipur. 1992.
5. Khandelwal, K.C. & Mandi, S.S. Practical hand boo Biogas Technology, 1990.
6. Rai, G.D. Non-Conventional Energy Sources, Kh Publishers, New Delhi.
7. Mathur A.N. & Rathore N.S. Renewable Energy Sources Bohra Ganesh Publications, Udaipur.

DIRECT ENERGY CONVERSION TECHNOLOGIES

RES 535

Credit 3(2+1)

Basic Science of Energy Conversion, Physics of semi-conductor junctions for photo-voltaic conversion of solar energy, solar cell, types of solar cell modules, components of SPV system, details of blocking diode, charge controller, inverter and batteries used, application of solar cell in photo-voltaic power generation system, power output and conversion efficiency, advantages and disadvantages of photo-voltaic solar energy conversion, design of photo-voltaic systems.

Technologies and physics of thermo-electric generators, thermo-electric materials and optimization studies.

Basic concepts and design consideration of MHD generators, cycle analysis of MHD system, thermo ionic power conversion and plasma, thermo-dynamics and performance of fuel cells and their applications.

Practical:

1. To study fabrication and evaluation methods of solar cells.
2. To study VI characteristics of solar PV system
3. Performance evaluation of solar PV pumps for lighting power.
4. To study MHD generation system details
5. To study thermo ionic power conversion systems
6. To study different batteries used in pv system

Suggested Readings

1. Meinel & Meinel, Applied Solar Energy -
2. Derrick, Francis and Bokalders, Solar Photo-voltaic Products
3. M. P. Agrawal, Solar Energy
4. R. H. Taylor Alternate Energy Sources
5. G. D. Rai, Non-conventional Energy Sources
6. Pratap Singh et al., Sustainable Development through Renewable Energy Sources, Yash Publications, Bikaner, 2004

ENERGY LAB

RES 536

Credit 3(0+3)

1. Study of Solar cell characteristic.
2. Study of Solar P. V. System
3. Study of Plank's constant by radiation law
4. Study of Solar Still and calculation of its efficiency
5. Study of agricultural wastes fired gasifier for power generation.
6. Study of Solar Powered Refrigeration system.
7. Study of Gas Chromatograph and determination of composition of biogas, producer gas and flue gases.
8. Development of solid and liquid fuel from biomass.
9. Study and testing of dual fuel engine running on biogas and diesel.
10. Development of biodiesel from Jatropha oil.
11. Study of Bomb Calorimeter and measurement of calorific value of different biomass.
12. Study of Proximate and Ultimate analysis of biomass.
13. Testing of portable type of Improved Cook stoves
14. Study the harnessing the power from wind.
15. Study of Integrated Energy System

Suggested Readings

1. Rathore N.S., Kurchania A.K., Panwar N.L., Renewable Energy: Theory & Practice, Himanshu Publications, 2006
2. Khandelwal, K.C. & Mahdi, S.S. Biogas Technology, 1990.
3. Rai, G.D. Non-Conventional Energy Sources, Kh Publishers, New Delhi.

ENERGY MANAGEMENT IN AGRICULTURE

RES 537

Credit3 (3+0)

General aspects of Energy, Energy Economics, Principles of Energy Conservation, Global Environmental Concerns, Measurement of Energy & Power, Power & Energy Measuring Devices, Rural Energy Action Planning, Rural Project Management, Rural Energy Modeling.

Energy efficiency in Thermal Utilities of Agro-industries/Processing Plants, Cogeneration, Power Production from Conventional & Non Conventional Energy Sources, Energy Efficiency in Electrical Utilities of Agro-industries/Processing Plants, Waste & Heat Recovery, Application of Non-conventional & Renewable Energy Sources, Waste Minimization & Resource Conservation, Energy Performance Assessment for Equipment & Utility Systems, Energy Conversion Act

Suggested Readings

1. Donald L. Klass & George M. Emert. 1985. Fuels from Biomass & Wastes. Ann Arbor Science Publishing Inc. Michigan.
2. Colin Parket & Tim Robers. 1983. Energy from Waste – An Evaluation of Conversion Technologies – Elsevier-Applied Science Publishers, London.
3. Murphy W.R. & Mc Kay G. 1982. Energy Management.

4. Rathore N.S., Mathur A.N & Solanki A.S. 1993. Integrated Rural Energy Planning.
5. Murgai M.P. & Ram Chandra. 1990. Progress in Energy Auditing & Conservation.
6. Victor B. Ottaviano.1993. Energy Management.
7. Craig B. Smith. 1081. Energy Management, Principles, Applications, Benefits and Savings.
8. Richard Porter & Tim Roberts. 1985. Energy Savings by Waste Recycling.
9. Szues. 1980. Similitude & Modeling.

RENEWABLE ENERGY FOR INDUSTRIAL APPLICATION

RES 611

Credit 3(2+1)

Solar: Solar Power Generation, Solar water heating, steam solar cooking system, Industrial solar dryer & solar process heat. Solar cooling system (refrigeration, air conditioning and solar architecture technology), solar furnace & solar green house technology for high-tech cultivation.

Bio Energy Sources: Power generation through biomethanation, gasification & dendro thermal power plant.

Wind Energy: aero generator of new era and national and international state of art in wind power generation.

Other renewable energy sources: Magneto Hydro Dynamics, solar photo- voltaic technology, Ocean thermal energy conversion technology, fuel cells technology & micro-hydro energy technology.

Practical:

1. Design of solar dryers.
2. Design of solar Photovoltaic system.
3. Design of gasifiers.
4. Design of combuster (gasifier stove).
5. Study of solar greenhouse.
6. Study of biogas engine generator set.
7. Field visit to NRSE power generation site.

Suggested Readings

1. Pratap Singh et al., Sustainable Development through Renewable Energy Sources, Yash Publications, Bikaner, 2004
2. Rathore N. S., Kurchania A. K., Panwar N. L., Non Conventional Energy Sources, Himanshu Publications, 2007
3. Duffie, J.A., and Beakman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York.
4. Sayigh, A. A. M., Solar Energy Engineering Academic Press, New York.

SOLAR ENERGY UTILIZATION FOR HEATING AND COOLING

RES 621

Credit 3(3+0)

Solar Architecture- Thermal comfort, building orientation and design, passive heating concept, passive cooling concepts, heat transfer in buildings, evaporative cooling, Tromb wall.

Solar Refrigeration and Air- conditioning- Potential and scope of solar cooling, types of solar cooling systems, solar collectors and storage system for solar refrigeration and air conditioning, solar operation of vapour absorption and compression, refrigeration cycle and their assessment, solar desiccant cooling systems; open cycle solar absorption/adsorption, solar cooling alternatives.
New Development on the area; some case studies.

Suggested Readings

1. Bansal, N.K., Solar Passive building, Science and Design.
2. Kaushik, S.L., Solar Refrigeration and Space conditioning.
3. Pratap Singh et al., Sustainable Development through Renewable Energy Sources, Yash Publications, Bikaner, 2004

POWER SYSTEM ANALYSIS

RES 612

Credit 3(3+0)

Load forecasting' load characteristics and probability of loss of load.
DLoad flow studies; Fault level analysis; Fundamentals of power system stability; Physical concepts; Synchronous machine power angle relations; swing equation; Stability of small and large disturbances; Numerical techniques for solution of swing equations; Digital computer solution of transient stability; Method of improving transient stability, Microprocessor applications in power systems.

Suggested Readings

1. Culp AW. 1991. Principles of Energy Conservation. Tata McGraw Hill. Duffle JA & Beckman WA. 1991. Solar Engineering of Thermal Processes. John Wiley.
2. Garg HP & Prakash J.1997. Solar Energy - Fundamental and Application. Tata McGraw Hill.
3. Rao SS & Parulekar BB.1999. Non-conventional, Renewable and Conventional . Khanna Publ.

THERMOCHEMICAL CONVERSION OF BIOMASS

RES 613

Credit 3(2+1)

Introduction – Thermochemical degradation. History of small gas producer Engine system. Chemistry of gasification. Gas producer – type, operating principle. Gasifier fuels, properties, preparation, conditioning of producer gas. Application, shaft power generation, thermal application, economics.
Combustors- construction, operation, wood burning stoves.
Pyrolysis – plant, operation, product recovery, incineration and plant lay out.
Co-generation plant – type, layout, energy recovery
Instruments related to thermochemical conversion.

Practical:

1. Study of producer gas generators such as open core, throat type for shaft power production and thermal application.
2. To study design and drawing of gasifier.
3. To study wood burning stoves.
4. Estimation of pollutant caused by gasification process.

5. Study of pyrolysis plant.
6. Study of charcoal making unit.
7. Study of incinerator and co-generators for power production.
8. Study of instrumentation required for thermal degradation.

Suggested Readings

1. Kauppa, A., 1984. Gasification of Rice hulls – Theory and Practice. Publication of GATE. GmbH, Germany.
2. Rathore, N. S., Panwar, N. L. and Kothari S. 2007, Biomass Production and Utilization Technology, Himanshu Publication, Udaipur
3. Vimal O. P. and Tyagi, P. D., 1985 Fuel wood from waste land. Agricole Publishing Academy, New Delhi

ENVIRONMENTAL POLLUTION AND CONTROL

RES 614

Credit 3(3+0)

Pollution – Sources of pollution, consequences of pollution growth, energy problems, air pollution, water pollution, ozone depletion.

Air Pollution – Definition, classification, sources of air pollution, effect of air pollution on health, vegetation, material, air pollution measurement, air pollution laws and standards.

Air pollution analysis – For sulphur dio-oxide, nitrogen oxide, carbon mono-oxide, oxidants and ozone, hydrocarbons, particulate matters

Water Pollution – Types of water pollution, effect on air temperature, effect on water temperature

Control – Air pollution control methods, source correction method, cleaning of gaseous effluents, particulate emission control, control of gaseous emission.

Water Treatment – Basic process of water treatment, primary treatment, secondary (biological) treatment, advanced waste water treatment, recovery of material from process effluents.

Suggested Readings

1. Jhadav, H & Bhosale, V. M.: Environmental Protection & Laws, Himalaya Pub. House, Delhi
2. Rao, M. N. and A. K. Datta, Waste Water Treatment. Oxford & IBH Publ. Co. Pvt. Ltd.
3. Rathore N.S, Kurchania A.K., Biomethanation Technology, Apex Publications, Udaipur, 2006
4. Sharma, B. K., Environmental Chemistry. Goel Publishing House, Meerut

MANAGEMENT AND UTILISATION OF NATURAL RESOURCES

RES 622

Credit 3(3+0)

Natural Resources and it's classification. Renewable and Non Renewable resources.

Water Resources, status of use and problems associated with over utilization. Surface and ground water potential and future scenario. Problems related to water resources i.e. floods, draughts, and disturbance in natural water cycle, water logging & salinity.

Energy resources, conventional and non-conventional energy sources, potential & state of art of technology of utilization. Use of Renewable Energy sources, case studies.
Mineral resources, use and exploitation, environmental effect of extracting & using Mineral. Open cast and underground mining, various mineral resources & potential.

Land resources- National status of land as a resource, land degradation, landslides, soil erosion, desertification & sand dunes.

Forest Resources – Natural scenario of forest, use & over exploitation, deforestation, effect of loss of forest on won and allied field.

Food sources, Growing energy need, modern agriculture techniques, world food problems

Air resource, its quality & pollution status, causes, effect & control measures of air pollution

Management and utilization of natural resources in equitable manner for sustainable development.

Role of individuals in management of natural resources, future strategies for prevention of natural resources.

Suggested Readings

1. Colin Parket & Tim Robers. 1983. Energy from Waste – An Evaluation of Conversion Technologies – Elsevier-Applied Science Publishers, London.
2. Murphy W.R. & Mc Kay G. 1982. Energy Management.
3. Rathore N.S., Mathur A.N & Solanki A.S. 1993. Integrated Rural Energy Planning.
4. Murgai M.P. & Ram Chandra. 1990. Progress in Energy Auditing & Conservation.
5. Victor B. Ottaviano.1993. Energy Management.
6. Craig B. Smith. 1081. Energy Management, Principles, Applications, Benefits and Savings.

GENDER & ENERGY

RES 623

Credit 3 (3+0)

Gender concepts, overview of gender & energy planning, identifying gender needs & goals, framework for gender analytical tool, Engineering Energy Policy, Gender tools for energy projects, gender mainstreaming v/s the women-only approach, MDG goals & targets related to gender & energy. Case studies.

Suggested Readings

1. Murphy W.R. & Mc Kay G. 1982. Energy Management
2. Odum HT & Odum EC. 1976. Energy Basis for Man and Nature. Tata McGraw Hill.

RENEWABLE ENERGY TECHNIQUES

RES 624

Credit 3(2+1)

Energy in house Hold, Energy sources, Application & Present Energy Consumption Pattern, Energy and economical Development, Use of New & Renewable Energy Sources in House Hold

Biogas

Biogas Technology and Mechanism, Factors Affecting Biogas Production, Properties of Biogas, Uses, Types of Biogas Plants, Classification Selection of Site, Selection of Size Night Soil based Biogas Plants, Alternative feed material and slurry utilization Socio-Economic aspects, Role of women in Propagation Technology, Effect of Environment and Health User's Education / Motivation

Solar Energy

Solar Radiation and Measuring Instrument, Solar Collectors, Solar Cooking, Solar drying, Solar Distillation, Solar water Heating, Solar Photovoltaic Power Generation, Quality of Solar Processed Food/Grain

Improved Cook-Stove

Various Cooking Options, Traditional Cookstoves and their constraints, Wood combustion Techniques of Biomass, Improved Cook Stoves, , Materials for Construction of Improved Cook stoves

Practical:

1. Study of Solar Cooker.
2. Study of Solar Dryers.
3. Study of Deenbandhu Biogas Plant.
4. Study of Pragati Biogas Plant.
5. Construction of Fixed type Improved Cook Stoves
6. Testing of Fixed type Improved Cook Stoves.
7. Testing of Portable cook Stoves.

Suggested Readings

1. Rathore N. S., Kurchania A. K., Panwar N. L., Non Conventional Energy Sources, Himanshu Publications, 2007
2. Mathur, A.N. & Rathore N.S., Biogas Production Management & Utilization. Himanshu Publications, Udaipur. 1992.
3. Khandelwal, K.C. & Mandi, S.S. Biogas Technology, 1990.
4. Rai, G.D. Non-Conventional Energy Sources, Kh Publishers, New Delhi.
5. Rathore N. S., Kurchania A. K., Panwar N. L., Renewable Energy Sources: Theory and Practice, Himanshu Publication, 2007
6. Rathore N. S., Kurchania A. K., Panwar N. L., Non Conventional Energy Sources, Himanshu Publications, 2007

WIND AND HUMAN ENVIRONMENT

RES 625

Credit 3(3+0)

Wind Energy- Symbolism and Mythology' concept and historical progress in the wind energy harnessing techniques.

Wind and it's Effects- Origin of wind, atmospheric circulation, gradient wind geostrophic winds, Hurricanes, Tornado Ratings, tornadoes in various countries, measurements forward velocity, Tangential velocity, Horizontal component of Extricates on maximum pressure differential, rate of pressure change.

Aerodynamic wind forces- Wind loads, velocity pressure, static velocity pressure, wind forces, pressure coefficient, Aerodynamics, airflow Streamlines, Energy flow and

Dissipation, Wind loads on buildings. Wind loads on Rigid Frames, Wind load factors and Form response to wind.

Wind in the Natural Environment- Wind over land, Evaporation wind fire interaction, wind effect on climate, wind and nature of wind over water and shores.

Wind in the Urban and Regional Environment- Heat losses by wind, wind effect on sound propagation, wind as recreational resource.

Wind Power- History, Wind conversion (Theoretical values), Power Augmentation, Turbines, Design of Wind Rotor and other accessories, Wind Intermittence and storage systems and its design, wind machine design for maximum efficiency; Wind wave energy; ocean waves energy conversion techniques, present state of art for wind energy utilization; Future development.

Suggested Readings

1. Wind in Architectural and Environmental Design- Michele Melarango Publication, Van Nostrand Rinchold Company.
2. Rathore N.S., Kurchania A.K., Panwar N.L., Renewable Energy: Theory & Practice, Himanshu Publications, 2006
3. Man and the winds- De la Rue E.A., Philosophical Library.