COURSE STRUCTURE FOR MINOR

IN

SUSTAINABLE TECHNOLOGY AND CLIMATE CHANGE

Sl. No.	Code	Subject	Hours per week			Credit	Semester
			L	T	P		
1	EE 2S1	Climate Change Science and Environmental Impact	3	0	0	3	3rd
2	EE 2S2	Energy Conversion Technologies	3	0	0	3	4th
3	EE 3S1	Sustainable Energy Sources	3	0	0	3	5th
4	EE 3S2	Sustainable Energy Materials	3	0	0	3	6th
5	EE 4S1	Energy Audit and Conservation Policies	3	0	0	3	7th
6	EE 4S2	Project	0	0	3	3	8th
Total Credit						18	

EE 2S1	Climate Change Science and Environmental Impact	L	T	P	C
		3	0	0	3

Module 1: Scope and Importance of Climate

Definition; multidisciplinary nature of environmental science, scope and importance; global environmental problems; components of environment: biotic, abiotic (Lithosphere, Hydrosphere and Atmosphere). Ecosystem definition, structure and function; energy flow, food chain and food web; ecological pyramids Biogeochemical cycles (Carbon, Nitrogen and Phosphorus); Hydrological cycle; ecosystem types: ponds, ocean, river, cropland, wetland, desert, forests and grassland; ecological succession; primary, secondary and tertiary producers.

Module 2: Environmental resources

Water – supply, demand ; soil – structure, formation, erosion, conservation; land use; plant and animal resources; resource management; conservation; forest management, multipurpose dams, sustainable agriculture, mineral resources, conventional and non-conventional energy resources, food resources.

Module 3: Environmental Pollution

Definition of pollution and pollutants; types of pollution; causes of pollution, major pollution- air, water, soil, noise, thermal, nuclear; effects of pollution and control measures; liquid and solid waste management. Case study of cook-stove pollution.

Module 4: Environmental Management and Legislation

Environmental Impact Assessment (EIA) : Objectives, Principles of Process, screening of projects, methodologies, checklist and documentation, prediction methodologies, public participation, limitation of EIA ; Environmental Protection Acts in India : air, water, biodiversity, wildlife, forest; Lake and River action programmes; coastal zone management; pollution control boards, Management plans using Geographic Information System (GIS) and Remote Sensing (RS) tools.

Module 5: Environmental Organizations and Agencies

International Organizations : United Nations Environment Programme (UNEP), International Union for Conservation of Nature and Natural Resources (IUCN), International

Panel on Climate Change (IPCC), International Panel on Oceans (IPO), Earth Summit, Convention on Biological Diversity (CBD), World Wildlife fund (WWF), National Organizations: Man and Biosphere Programme (MAB), Ministry of Environment and Forests (MoEF), Ministry of Earth Sciences (MoES), Role of NGOs.

Module 6: Global Climate Change

Introduction – Measurement of Climate Change , Earth's Natural Greenhouse Effect – The Greenhouse Gases – CO_2 Emissions – The Earth's Carbon Reservoirs – Carbon Cycling: Examples – Climate and Weather – Global Wind Systems – Clouds, Storms and Climates – Global Ocean Circulation – Climate through the last 1000 years – Determining Past Climates – Causes of Millennial Scale change – Climate and CO_2 in the Atmosphere – Recent Global Warming – Climate Change in the Political Realm – The Link to the Ozone Problem – Disease and society – Designing Policy Responses. Understand the Sustainable Development Goals (SDGs)

Module 7: Waste-Water Treatment

Overview of water and wastewater systems - Urban and Industrial waste-water system, Treatment, Waste water treatment - Primary sedimentation, Biological treatment, Disinfection / Disinfectant removal, Other treatment process, Control of Biochemical Oxygen demand, Ammonium Ion, Nitrogen, Phosphorus

Course Outcomes: At the end of the course, students will be able to:

1. To understand different science of climate, their cycles and the resources
2. To understand different natural resources, pollutions and their impact on climate change
3. To know different acts of environment management and agencies working for it
4. To analyse the cause of Global climate change.
5. To analyse the necessity of water-treatment and control of key parameter in the urban and Industrial waste-water systems.

Reference Books

1. A text book of Environment, Agarwal, K. M., Sikdar, P.K. and Deb, S.C., (2202), Mac Millan Indian Ltd, Kolkata.

2. Fundamental and Environmental Ecology, III Edition, (1971) Odum, E.P., Prentice

Hall.

3. Environmental Chemistry, De A.K. Wiley Eastern Ltd.
4. Environmental Science Sytems & Soultions, McKinney, M.I. & Schock, R.M. 1996. Web enhances edition..
5. Environmental Science, Miller, T.G.Jr., Wadsorth Publ.Co. (TB).
6. Waste Water treatment, Rao M.N. and Datta, A.K. 1987. Oxford & IBH Publ. CO. Pvt. Ltd.
7. Down to Earth, Centre for science and Environment (R).
8. Environmental Science, (Principles and Practice). Das, R.C., and Behera, D.K. (2008) Prentice- Hall of India, Pvt. Ltd.
9. Essentials of Environmental studies, Kurian Joseph., and Nagendran, R., (2004). Pearson Education (Singapore) Pte, Ltd.
10. Environmental Studies, V. Balu, Sri Venkateswara Publications, Chennai 2007.
11. Environmental Biology, P.D. Sharma, Rastogi Publications, Meerut 2003.
12. Ecology, Environment and Resource Conservation, J. S. Singh., S.P. Singh and S.R. Gupta, Anamaya Publications, New Delhi.
13. An Advanced Testbook on Biodiversity – Principles and Practice, Krishnamurthy, K.V. (2003). Oxford and IBH Publishing, New Delhi.
14. Principles of Environmental Science 2007: Inquiry and Applications by Cunningham and Cunningham, 2nd Edition.

Energy Conversion Technologies	L	T	P	C
EE 2S2	3	0	0	3

Course Assessment methods (both continuous and semester end assessment): It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid semester examination, surprise tests, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Topics Covered:

Module 1: Non-Conventional Energy Sources & Principles of Energy Conversion

Energy sources and their availability, Qualitative study of different types of dispatchable and non-dispatchable energy resources; Solar energy conversion: Solar thermal and Photovoltaic, wind energy conversion; principles of fuels and combustion; fuel cells; comparison of energy conversion processes, carbon footprint; greenhouse gas; energy audit.

Module 2: Fundamentals of Solar & Wind Energy Conversion

Solar thermal energy conversion devices; Solar energy storage and applications; Solar cell fundamentals; Solar cell technologies and PV systems; Solar energy assisted heating and cooling.

Basic principles of wind energy conversion, Betz limit, aerodynamics principle, Drag and lift force, components of a Wind Energy Conversion System (WECS)

Module: Battery and Fuel cell

Energy Storage Parameters; Lead–Acid Batteries, Nickel-Cadmium, Zinc Manganese dioxide batteries. Modern batteries as Zinc-Air, Nickel Hydride, Lithium Battery. Flow Batteries; Fuel cells for direct energy conversion, physical interpretation of the Carnot efficiency factor, electrochemical energy converters.

Module 4: Converter Interface for Solar and Wind Energy Conversion

Buck, boost and Fly back dc –dc converters, 1-ϕ and 3-ϕ inverters, Control schemes: unipolar, bipolar; Need for storage, different types of batteries suitable for SPV systems, characteristics and parameters, charging schemes of battery; Offgrid and grid connected SPV system, Single and double stage control for SPV system, Power processing.

Standalone and grid connected WEC Systems and its basic control approach, PLL and synchronization, Grid interconnection issues.

Text Books:

1. Ned Mohan, Tore. M. Undeland and William. P Robbins, “Power Electronics: Converters, Applications and Design”, John Wiley and Sons.
2. Daniel W. Hart. Power Electronics. TMH
3. Chetan Singh Solanki. Solar Photovoltaics: fundamentals, Technologies, and Applications. Prentice Hall of India.
4. S. N. Bhadra, D. Kastha& S. Banerjee. Wind Electrical Systems. Oxford university press.

Reference Books:

1. William Shepherd and Li Zhang Power, "Power Converter Circuits", Marcel Dekker Inc.
2. Robert W. Erickson, "Fundamentals of Power Electronics", Kluwer Academic Publishers.
3. Marian K. Kazimierczuk, "Pulse-width Modulated DC–DC Power Converters", John Wiley & Sons.
4. Remus Teodorescu, Marco Liserre, Pedro Rodriguez. Grid Converters for Photovoltaic and Wind Power Systems. Wiley Publications.
5. Mukund R. Patel. Wind and Solar Power Systems: Design, Analysis, and Operation. CRC Taylor & Francis.
6. Marcelo Godoy Simoes and Felix A. Farret. Renewable Energy Systems: Design and Analysis with Induction Generators. CRC Press.
7. Ion Boldea. Variable speed generators. CRC press.

Course Outcomes: At the end of this subject, students will be able to:

1. Understand the principles of energy conversion of various non-conventional energy sources
2. Analyze the various batteries/fuel cells for sustainable energy interface.
3. Examine the characteristics of solar PV systems.
4. Analyze converters for Solar PV system in off grid and grid connected modes.
5. Understand the performance of fixed speed and variable speed and different converters for wind energy conversion systems.

EE 3S1	Sustainable Energy Sources	L	T	P	C
		3	0	0	3

Module 1: Energy

The role of energy in our lives, various sources of energy that we use, the energy consumption of the world, comparison among countries and between continents, the relationship between Human Development Index (HDI) and energy consumption; Indian energy scenario: India's energy consumption from all resources, consumption of oil, coal, gas, import of fossil resources, foreign exchange requirements, energy security, and import dependency. Sustainable energy: characteristics of resources, advantages, and disadvantages. Energy units: units of energy, small and large units of energy, and units for energy consumption of individuals, institutions, and countries.

Module 2: Hydro energy

Hydrology and selection of site, power generation capability, Schematic arrangement of elements of hydropower plants: surge tank, Governor, Penstock, spillway, Tail Race; Types of turbines: Pelton turbine, Francis turbine, Kaplan turbine; Classification according to water flow, type of load and head; Environmental impact of Hydro power plants; Hydro potential in India.

Module 3: Solar and Wind Energy Sources

Sun as source of energy, solar energy reaching the Earth's surface, solar spectrum; solar irradiation and insolation: extra-terrestrial solar radiation, global, direct, and diffuse solar radiation and measuring instruments; Quantifying solar energy resources and solar radiation data; solar radiation and collectors; solar electric power generation: solar cells and PV power plant, solar thermal power plants. Wind Energy: Origin of Winds, Characteristics of Winds, Wind Energy Conversion Systems (WECS): Wind Turbine Aerodynamics, Types of wind turbine, types of generators.

Module 4: Waste to Energy

Photosynthesis Process, Usable Forms of Biomass, their Composition and Fuel Properties, Biomass Resources, Biomass Conversion Technologies, Urban Waste to Energy Conversion, Biomass Gasification, Biomass Liquefaction, Biomass to Ethanol Production, Waste to Energy programme of India.

Module 5: Geothermal, Ocean Energy and Fuel cells

Geothermal: Origin and Distribution of Geothermal Energy, Types of Geothermal Resources, utilization of Geothermal Resources; types of geothermal power plants, Economics related to Geothermal Resources ; Effects on environment; Geothermal Resources in India; Ocean: tidal, wave and ocean thermal energy; Potential of Ocean energy in India; Fuel cells: Types and applications.

Course outcomes: At the end of the course, students will be able to:

1. Understand the basics of various sustainable energy sources.
2. Analyse the principle and elements of Hydro energy generation.
3. Analyse the energy conversion principles of Solar and Wind energy generation.
4. Outline Waste to Energy conversion technologies
5. Understand the basics of Geothermal, Ocean and Fuel cells.

Reference books:

1. Ch. Pavan Kalyan and M. Pavan Das, Future Energy Scenario: A Better Planet with Renewable Energy, 2020
2. S. P. Sukhatme and J. K. Nayak, Solar Energy – Principles of Thermal Collection and Storage, Tata McGraw Hill, 2008
3. C. S. Solanki, Solar Photovoltaics – Fundamentals, Technologies and Applications, 3rd Ed. Prentice Hall of India, 2016
4. D.P. Kothari, "Renewable energy resources and emerging technologies", Prentice Hall of India Pvt.Ltd, 2006.
5. Ankur Mathur, Non-Conventional Sources of Energy, Laxmi Publications Pvt. Ltd., 2015
6. John Twidell, Tony Weir, Renewable Energy Resources, Taylor & Francis, 2005
7. Andrew L. Simon, Energy Resources, Elsevier Science, 2013

EE 3S2 Sustainable Energy Materials

L	T	P	C
3	0	0	3

Course Assessment methods (both continuous and semester end assessment):

It may be class tests, assignments, attendance, quiz, poster/seminar presentation on different topics including contemporary issues, mid semester examination, surprise tests, self-learning, grand viva, group discussion, mini projects, end semester examination, etc.

Module 1: Introduction to Materials and Testing

Review of different materials in power electronics, various relevant high voltage tests, tools available, basics of material fabrication and design, insulation properties and related measurements, thermal properties, microscopic characterization, dielectric spectroscopy, relevant test standards.

Module- : Solar Cell Design and Materials

Introduction to the basic concepts of photovoltaic solar energy conversion, including; operating principles and theoretical limits of photovoltaic devices; device fabrication, architecture, and primary challenges and practical limitations for the major technologies and materials used for photovoltaic devices

Module 3: Power Electronic Devices and Apparatus

Basics of power electronic modules, limitations of presently used materials, fabrication of new materials: epoxy resin micro, nano, and hybrid composites; Basics of solid state transformers (SST) and medium frequency transformer, review of applications in different areas, design of SST and MFT, various insulation and core materials used in SSTs and MFTs.

Module 4: Energy Storage Devices:

Types of batteries (Lead-acid, Ni/Cd, Ni/metal hybrid), Lithium batteries, chemistry and physics of lithium batteries, anode and cathode materials, applications, Introduction to fuel cells, materials for electrodes, electrolytes and other components, similarities and differences between supercapacitors and batteries, challenges and opportunities in the presently used materials.

Module 5: High Voltage Cables and Accessories:

Design requirements of the high voltage cable, materials for high voltage cable, new cable design, failure of high voltage cables, condition monitoring of high voltage cables, superconducting cables.

Course Outcomes: At the end of this course, students will be able to:

1. Identify the characterization and measurement tools for material testing
2. Design the insulation for solar cells, batteries and supercapacitors
3. Analyze the role of material design in the power electronics
4. Design different materials for high voltage cables.

Reference Books:

1. Advanced Nanodielectrics: Fundamentals and Applications, Tanaka, Toshikatsu and Takahiro Imai, CRC press, 2017.
2. Advanced Materials for Thermal Management of Electronic Packaging, Tong, X. C., Vol. 30, Springer Science & Business Media, 2011.
3. Mazzanti G, Marzinotto M. Extruded cables for high-voltage direct-current transmission: advances in research and development, IEEE Press, 2013.
4. Battery Technology Handbook by H. A. Kiehne , Marcel Dekker, Inc. , New York, Basel
5. High voltage engineering fundamentals, Kuffel, John, and Peter Kuffel, Elsevier, 2000.

EE 4S1	Energy Audit and Conservation Policies	L	T	P	C
		3	0	0	3

Module 1: General Aspects of Energy Management and Audit

Energy Scenario, Energy Conservation Act 2001 and related policies, Energy Management and Audit, Energy Action Planning, Energy Monitoring and Targeting, and Energy Efficiency and Climate Change.

Module 2: Energy Efficiency in Thermal Utilities

Fuel and combustion, Boilers, Steam systems, Insulation, Co-generation, Waste Heat Recovery, Heat Exchanges.

Module 3: Energy Efficiency in Electrical Utilities

Electrical systems, Lighting systems, compressed air systems, HVAC, Refrigeration systems, pumps and pumping systems, cooling systems, and Energy Conservation in Buildings.

Module 4: Energy Performance Assessment for Equipment and Utility Systems

Financial analysis and Assessment of energy performance in steel, cement, textile, paper, and fertilizer industries

Module 5: Industrial Energy Conservation

Energy conservation in electrical systems: transformers, motors, HT and LT supply, illumination, Cable sizing, power factor improvement, harmonics, Energy billing.

Course outcomes: At the end of the course, students will be able to:

1. Outline energy scenario, audit, and management.
2. Analyze and audit thermal systems for energy efficiency.
3. Analyze and audit electrical systems for energy efficiency.
4. Evaluate energy economics.
5. Apply energy conservation policy and regulations in industrial practices.
6. Identify opportunities for rational use of energy.

Reference Books

1. BEE Guidebook for General Aspects of Energy Management and Energy Audit
2. BEE Guidebook for Energy Efficiency in Thermal Utilities
3. BEE Guidebook for Energy Efficiency in Electrical Utilities
4. BEE Guidebook for Energy Performance Assessment for Equipment and Utility Systems
5. A. Thumann, T. Niehus, and W. J. Younger, Handbook of Energy Audits, 9th ed. CRC Press, 2013.
6. S. Doty and W. C. Turner, Energy Management Handbook, 6th ed. Fairmont Press, 2007.
7. M. H. Chiogioj, Industrial Energy Conservation, Marcel Dekker, 1979. 4. W. F. Kenney, Energy Conservation in the Process Industries, Academic Press, 1984.
8. Z. K. Morvay and D. D. Gvozdenac, Applied Industrial Energy and Environmental Management, Wiley, 2008.