Centre for Energy Studies **Annexure: 1**

Course Name: **Renewable Energy Resources**
Course Code: **EN-311**

Prerequisite: Nil	L	T	P	C
	3	0	0	3

Course Objectives :

- **CO1** To understand the different clean and sustainable energy sources.
- **CO2** To understand the basic principles and conversion technologies to achieve the United Nations Sustainable Development Goal: SDG 7
- **CO3** To identify and utilize the potential of locally available renewable energy resources.

Course Content:

Energy Scenario: World Energy Scenario, Indian Energy Scenario, Conventional Energy, Fossil Fuels, Environmental Impact of Fossil Fuels, India's Renewable Energy Programmes, Renewable Sources Potential.

Bio-Energy: Basics; India's Bio Energy Potential, Biogas, Biomass gasification, Waste-to-Energy,
Hydropower: Hydropower Power Plants, India's Small Hydro Potential Energy Conversion, Pumped Hydro System, Ocean Energy, Tidal Energy.
Geothermal Energy: Origin, Geo thermal Potential of India; Types of Geothermal Energy Sites, Site Selection, Geothermal Power Plants.

Solar Energy: Solar Radiation, Solar Thermal, Measurements and Estimation. Solar Thermal Collectors, Solar Heating of Buildings, Solar Passive Cooling. Solar Photovoltaic SPV- Principle of Photovoltaic Conversion of Solar Energy, Types of Solar Cells and Fabrication, Photovoltaic Applications, Battery Charging.

Wind Energy- Wind Energy Potential, Indian's Wind Energy Potential, Atmospheric Circulations, Classification, Factors Influencing Wind, Wind Energy Conversion Systems: Classification, Characteristics, Applications.
Electric vehicles (EV's), Fuel cells, Hydrogen and Biofuels.

Course Outcome:

Upon successful completion of the course, the students will be able to
CO1 Understand different clean and sustainable energy sources.
CO2 Understand the basic principles and conversion technologies.
CO3 Understand the concept of new and sustainable transformational fuels.

Text Books:

1. Kreith F, Kreider JF, Principles of Solar Engineering, McGraw-Hill 1978.
2. Sukhatme SP, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill 1984.
3. Tiwari GN, Solar Energy-Fundamentals, Design, Modelling & Applications , Narosa, 2009

Reference Books:

1. Twidell JW, Weir AD, Renewable Energy Resources, ELBS.
2. Garg HP, Prakash J, Solar Energy fundamentals & Applications , Tata Mcgraw Hill , 1997.
3. Sorensen B, Renewable Energy, (2nd Ed), Academic press, New York, 2000.

Centre for Energy Studies **Annexure: 2**

Course Name: **Energy & Environment**
Course Code: **EN-312**

Prerequisite: Nil	L	T	P	C
	3	0	0	3

Course Objectives :
CO1: To understand the overview of different energy sources, their environmental impact with respect to development.
CO2: To investigate, conceptualize and solve environmental problems due to energy use.
CO3: To evaluate a wide range of potential energy and environmental solutions after considering public health and safety.

Course Content:
Origin of the Earth; Earth's Temperature and Atmosphere; Biological Processes; Photosynthesis; Food Chains; Energy Sources: Classification of Different Energy Sources, Quality and Concentration of Energy Sources; Overview of World Energy Scenario; Fossil Fuel Reserves - Estimates, Duration, UN Sustainable Goals ; Overview of India's Energy Scenario, Energy and Development Linkage, Energy Poverty, Energy Access.

Ecosystems; Concepts,; Types of Ecosystems; Energy Flow in a Ecosystems; Carbon Cycle, Hydro Cycle ; Biodiversity; Impact of Development & Human Interaction; Impact of Different Industries on Eco System.

Environmental Effects of Energy Extraction, Conversion and Use; Fossil Fuels; Sources of Pollution; Primary and Secondary Pollutants; Consequence of Pollution; Air, Water, Soil, Radioactive, Industrial Pollution ; Cement Plant Noise Pollution- Cause and Effect; Causes of Global, Regional and Local Climate Change; Pollution Control Methods; Environmental Laws on Pollution Control. Environmental Effects of Renewable Energy Systems.

Green House Gas Emissions, Impacts, Mitigation; Sustainability; Externalities; Future Energy Systems; Clean Energy Technologies; United Nations Framework Convention on Climate Change (UNFCC); Sustainable Development; Kyoto Protocol; Conference of Parties (COP); Clean Development Mechanism (CDM); Prototype Carbon Fund (PCF). CO_2 Capture Process, Carbon Credits. Carbon Credit Marketing; Sustainable Development, Steps Towards Carbon Neutral Globe. Water Footprint Calculation,

Course Outcome:
Upon successful completion of the course, the students will be able to
CO1 Reflect and evaluate the environmental impact of energy production through renewable sources of energy.
CO2 Account for conventional energy technologies and the relationship between energy production, consumption and climate change.
CO3 Analyze the consequences of today's energy consumption.

Text Books:

1. Masters GM, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.
2. Boyle G, Everett B, Ramage J, Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University Press, 2012.
3. Wilson R, Jones WJ, Energy, Ecology and the Environment, Academic Press Inc.

Reference Books:

1. Davis DW, Energy: Its Physical Impact on the Environment, John Wiley & Sons.
2. Monga P, Ravindranath NH, Rao KU, Natarajan B, Renewable Energy and Environment – A Policy Analysis for India, Tata McGraw Hill, 2000
3. Fowler JM, Energy and the Environment, 2nd Ed. ,McGraw Hill, New York, 1984

Centre for Energy Studies **Annexure: 3**

Course Name: **Climate Change & Sustainability**
Course Code: **EN-313**

Prerequisite: Nil	L	T	P	C
	3	0	0	3

Course Objectives :
CO1: To understand environmental aspects of sustainability.
CO2- To understand human impacts of the environment and biodiversity.
CO3- To understand the United Nations Sustainable Development Goals and their importance for a sustainable globe.

Course Content:
Environment: Abiotic and biotic factors, Biogeochemical Cycles, Ecosystems, Types of Ecosystems State of Environment and Unsustainability, Need for Sustainable Development, Traditional conservation systems in India, Need for an attitudinal change and ethics, Need for Environmental Education, Overview of International Treaties and Conventions, Overview of Legal and Regulatory Frameworks. Conservation of Biodiversity. People's action, Environment & Politics.

Impacts, causes, effects, control measures, international, legal and regulatory frameworks of: Climate Change, Ozone depletion, Air pollution, Water pollution, Noise pollution, Soil / land degradation / pollution, circular economy, industrial ecology, Specifically apply these concepts to: Water Resources, Energy Resources, Food Resources, Land & Forests, Waste management.

Environment Impact Assessment (EIA), Environment Management Plan (EMP), Green Business, Eco-Labelling, Problems and Solutions with Case Studies. Global and National State of Housing and Shelter, Urbanization, Effects of Unplanned Development Case Studies, Impacts of the building and road construction industry on the environment, Eco-homes / Green buildings, Sustainable Cities.

United Nations Sustainable Development Goals (SDGs), Basic Concepts, Strategies and Measurement, Consumption Patterns and Lifestyles, Poverty and Inequality, Instruments for Sustainable Development, Governance, Education and Science System,

Course Outcome:
Upon successful completion of the course, the students will be able to
CO1 Recognise how systems work by seeing the relationships between climate and other forms of environmental change.
CO2 Critically analyse policy-making processes in regard to sustainability issues
CO3 Apply analytical, critical thinking and problem-solving skills to specific governance and sustainable development problems

Text Books:

1. Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T. (Eds.), Handbook of Climate Change Communication: Vol. 1: Theory of Climate Change Communication, Vol. 2: Practice of Climate Change Communication, Springer, 2018.
2. Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K., Johnson, C.A. (Eds.), Climate Change 2001: The Scientific Basis, Cambridge University Press, 2001.
3. Masters, GM, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.

Reference Books:

1. Ruddell, B.L., Kumar, P., Muenich, R.L., and Hubacek, K. (Eds.), The Science and Practice of Landscape Stewardship, Cambridge University Press, 2017.
2. Berners-Lee, M., Clark, D., and York, H. (Eds.), The Burning Question: We Can't Burn Half the World's Oil, Coal, and Gas. So How Do We Quit?, Profile Books, 2013.
3. Flannery, T., Atmosphere of Hope: Searching for Solutions to the Climate Crisis, Penguin Books, 2016.

Centre for Energy Studies **Annexure: 4**

Course Name: **Energy Management & Policy**
Course Code: **EN-421**

Prerequisite: Nil	L	T	P	C
	3	0	0	3

Course Objectives :
CO1: To understand the concept of optimum energy procurement and utilisation.
CO2- To analyse the viability of energy conservation projects
CO3- To understand the business and policy environment regarding energy management

Course Content:
Energy resources, Energy Conversion Processes and Devices, Energy Conversion Plants, Energy Conservation Technologies Conventional - Thermal, Hydro, Nuclear, and Non – conventional – Solar, Wind. Biomass, Small Hydro, Fuel cells, Energy from Waste, Energy Plantation.

Energy Economics - Time Value of Money Concept, Simple Payback Period, IRR, NPV, Life Cycle Costing, LCA, LCOE, Cost of Saved Energy, Cost of Energy Generated, Examples from Energy Generation and Conservation, Energy Chain

Energy Management – Definitions and Significance – Objectives –Characterising of Energy Usage – Energy Management Program – Energy Strategies and Energy Planning Energy Audit – Types and Procedure – Optimum Performance of Existing Facilities – Energy Management Control Systems – Computer Applications in Energy Management.

Energy Policies: Renewable Energy Policy, Incentives and Subsidies, Foreign Investment, Role of MNRE, IREDA, Bio Energy Policy, Solar Policy, National Solar Mission, Waste Management Practices and Policies, Renewable Purchase Obligations, Feed in Tariffs, Renewable Energy Certificates, Hydro Power Policy, Small/Large Scale Hydro Power Plants, National Policy on Hydropower in India, India EV Policy, Other Schemes – Saubhagya, UJALA, UDAY, RFMS, Smart Cities, etc.

Course Outcome:
Upon successful completion of the course, the students will be able to
CO1 Conceptual knowledge of the technology, economics and regulation related issues associated with energy management
CO2 Identify factors causing rising 'Peak' and 'Base' load electricity demand, and how renewable energy and energy management can reduce such demand.
CO3 Advocacy of strategic and policy recommendations on energy conservation and energy management.

Text Books:

1. Chakrabarti A, Energy Engineering and Management, Prentice Hall India, 2011.
2. Eastop TD, Croft DR, Energy Efficiency for Engineers & Technologists, Longman, 1990.
3. Rao S, and Parulekar BB, Energy Technology, Khanna Publishers, 2005.

Reference Books:

1. Albert Thumann PE, Younger WJ, Handbook of Energy Audits, Fairmont Press, 2008.
2. Doty S, Turner WC, Energy Management Hand book, 7/e, Fairmont Press, 2009.
3. Rai GD, Non-conventional Energy Sources, Khanna Publishers, 2011.

Centre for Energy Studies **Annexure: 5**

Course Name: **Hydrogen Energy Systems**
Course Code: **EN-422**

Prerequisite: Nil	L	T	P	C
	3	0	0	3

Course Objectives :
CO1: To understand the concept of hydrogen energy technologies.
CO2- To gain logical knowledge about hydrogen production, storage and utilization.
CO3- To familiarize the students with application areas of hydrogen technology

Course Content:

Introduction: Fundamentals, Terminology, History of Hydrogen Technology, General Overview: Advantages, Current Situation Of Technology and Challenges, National Hydrogen Mission.

Hydrogen Production: Properties of Hydrogen as Fuel, General Introduction to Infrastructure Requirement for Hydrogen Production, Thermal-Steam Reformation, Thermo-Chemical Water Splitting, Gasification-Pyrolysis, Storage, Dispensing and Utilization, Hydrogen Storage, Metal Hydrides, Chemical Hydrides, Carbon Nano-Tubes; Sea as The Source Of Deuterium, Methane Hydrate, etc.
Hydrogen Economy: Hydrogen as An Alternative Fuel in IC Engines; Suitability Of Hydrogen as a Fuel, and Techno-Economic Aspects of Fuel Cell as Energy Conversion Device; Hydrogen Fuel for Transport

Bio-Hydrogen: Production of Bio Hydrogen; Production of Hydrogen By Fermentative Bacteria, Hydrogen, Methane and Other Energy Fuels Energy From Algae: Algae Cultivation, Photobioreactors.

Hydrogen Storage, Utilization And Safety: Physical And Chemical Properties, General Storage Methods, Compressed Storage-Composite Cylinders, Glass Micro Sphere Storage, Zeolites, Metal Hydride Storage, Chemical Hydride Storage, Cryogenic Storage, Carbon Based Materials For Hydrogen Storage, Overview Of Hydrogen Utilization, Hydrogen Burners, Power Plant, Marine Applications, Hydrogen Dual Fuel Engines, Hydrogen Safety Aspects, Backfire, Pre-Ignition, Hydrogen Emission, Nox Control Techniques and Strategies, Hydrogen Powered Vehicles

Course Outcome:
Upon successful completion of the course, the students will be able to
CO1 Conceptual knowledge of the technology, economics and other issues associated with hydrogen energy
CO2 How hydrogen energy can be an option for future energy
CO3 Advocacy of strategic and policy recommendations based on national hydrogen mission

Text Books:

1. Barbir, Frano. PEM fuel cells: theory and practice. Academic press, 2012.
2. Larminie, James, and Andrew Dicks. Fuel Cell Systems Explained. John Wiley & Sons, Ltd., 2018.
3. Springer, Thomas E., et al. Fuel Cell Fundamentals. John Wiley & Sons, 2010.

Reference Books:

1. Zhang, Jiujun, ed. PEM fuel cell electrocatalysts and catalyst layers: fundamentals and applications. Springer Science & Business Media, 2008.
2. Gupta, R. B. Hydrogen Fuel: Production, Transport and Storage, CRC Press , 2008.
3. Lipman, Timothy E., and Adam Z. Weber, eds. Fuel cells and hydrogen production: A volume in the Encyclopedia of sustainability science and technology. Springer, 2019.

Centre for Energy Studies **Annexure: 6**

Course Name: **Circular Economy**
Course Code: **EN-423**

Prerequisite: Nil	L	T	P	C
	3	0	0	3

Course Objectives :
CO1: To understand the concept of circular economy
CO2- To acquire skills for developing circular techniques, models and resources for sustainable development.
CO3- To contrive skilled manpower and entrepreneurship in the field of Circular Economy

Course Content:
Introduction to Circular Economy: Linear Economy and its emergence, Economic and Ecological disadvantages of linear economy, Replacing Linear economy by Circular Economy, Development of Concept of Circular Economy, A differential - Linear Vs Circular Economy

Characteristics of Circular Economy: Material recovery, Waste Reduction, reducing negative externalities, Explaining Butterfly diagram, Concept of Loops

Circular design, innovation and Assessment: Zero waste: Waste Management in context of Circular Economy , Circular design, Research and innovation, LCA, Circular Business Models

Case Studies: Business models, Solid Waste Management / Wastewater, Plastics: A case study, EPR: polluters pay principle, Industrial symbiosis/ Eco-parks

Policy framework: Role of governments and networks, Sharing best practices, Universal circular economy policy goals, India and CE strategy, ESG

Course Outcome:
Upon successful completion of the course, the students will be able to
CO1 Acquire comprehensive knowledge and understanding the methodologies associated with Circular Economy. Apply knowledge to identify, formulate and analyse new circular business models
CO2 Use the principles of circularity for application to sustainable development
CO3 Advocacy of strategic and policy recommendations based on circular economy

Text Books:

1. Kirchherr J, Reike D, Hekkert M, Conceptualizing the circular economy: An analysis of 114 definitions, Resources, Conservation and Recycling, Volume 127, 2017.
2. Kirchherr J, Piscicelli L, Bour R, Kostense-Smit E, Muller J, Huibrechtse-Truijens A, Hekkert M, Barriers to the Circular Economy: Evidence From the European Union (EU), Ecological Economics, Volume 150, 2018.
3. Bocken NMP, Short SW, Rana P, Evans S, A literature and practice review to develop sustainable business model archetypes, Journal of Cleaner Production, Volume 65, 2014.

Reference Books:

1. Ellen MacArthur Foundation, Circularity: A Playbook for the Circular Economy, SunPine Press, 2021.
2. Stahel WR, The Circular Economy, Nature, Society and Thought, 2016.
3. Geissdoerfer M, Savaget P, Bocken NMP, Hultink EJ, The Circular Economy - A new sustainability paradigm?, Journal of Cleaner Production, Volume 143, 2017.