Course Code	Course Name	Credits
MEDLO7032	**Renewable Energy Sources**	**03**

Objectives:

1. To study working principles of various renewable energy sources and their utilities.
2. To study design and installation criteria of various equipment's to convert the renewable energy into useful energy.
3. To study economics of harnessing energy from renewable energy sources.

Outcomes: Learner will be able to…

1. Describe the need for renewable energy and its potential for the development of a sustainable environment.
2. Analyze different solar collectors using geometrical parameters and photovoltaics for generation of solar energy.
3. Identify and analyze various wind turbine energy harnessment techniques.
4. Design biogas plant for harnessing energy from organic waste.
5. Describe significance of hydrogen energy to fulfill present and future energy needs.
6. Describe the operating principle of geothermal energy and ocean energy and their role in sustainable development.

Module	Contents	Hours
1	**1.1: Introduction to Renewable Energy Sources and Solar Radiation**: Global and National current energy scenarios, Prospects of renewable energy sources and renewable energies role in developing sustainable model. **1.2:** Solar radiation terms, solar geometry, earth sun angles, attenuation and measurement of solar radiation on horizontal and inclined surfaces, methods of solar radiation estimation.	**05**
2	**Solar Thermal Energy:** **2.1:** Introduction and working principle of flat plate collectors, thermal performance analysis of flat plate collectors, concentrating collectors, Installation and maintenance criteria of solar thermal systems.	**07**

	2.2: Solar thermal devices- Solar air heater and different types of solar air heaters, solar water heater and different types of solar water heaters, solar dryers, solar pond, solar distillation, solar still, solar cooker. **2.3:** Solar space heating & cooling, solar refrigerator, solar thermal energy storage systems. Case Study: Solar thermal power plant working operation.	
3	**Solar Photovoltaic Energy:** **3.1:** Introduction and working principle of a solar PV systems, types of solar PV cells, solar tracking systems, controls and measurement methods of solar PV systems. **3.2:** Methods to improve the efficiency of PV cells, parameters which affect the efficiency and life cycle of PV cells. Case Study: Installation of 1 kW of solar PV plant.	**07**
4	**Wind Energy**: **4.1:** Basic components and working principle of wind energy conversion systems, wind data and site selection considerations, various types of wind energy conversion systems, constructional features of horizontal and vertical axis wind machines, performance analysis of horizontal and vertical axis wind machines. **4.2:** Estimation of power output- betz limits, Environmental impacts of wind energy.	**06**
5	**5.1: Energy from Biomass**: Introduction of bioenergy, conversion technologies, types of biogas generation plants, design and construction details of biogas plant (KVIC), site selection, digester design consideration, filling a digester for starting, maintaining biogas production, utilization of biogas.	**07**

	5.2: Hydrogen Energy: Introduction and application, General introduction to infrastructure requirement for hydrogen production, storage, dispensing & utilization. Principles of fuel cells, types of fuel cells, power generation by fuel cells, applications of fuel cells.	
6	**6.1: Geothermal Energy**: Introduction to geothermal technologies and methods of extracting geothermal energy, prospects of geothermal energy in India. **6.2: Energy from the ocean**: Wave energy characteristics and wave energy conversion devices, tide energy conversion devices, Ocean Thermal Energy Conversion (OTEC) systems. **6.3: Energy management and economics:** Energy conservation, energy security, energy economics, energy audit- definition, need, types of energy audit, Energy management (audit) approach-understanding energy costs, Energy conservation in Buildings: Energy Conservation Building Codes (ECBC): Green Building, LEED rating.	**07**

Visit to wind farm/solar plant/biogas plant.

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum.**

3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Reference Books:

1. "Non-conventional Energy Sources", G.D. Rai, 6th Edition, Khanna Publishers, ISBN: 978-81-7409-073-7
2. "Renewable Energy: Power for a Sustainable Future", Edited by Godfrey Boyle, 3rd Edition 2012, Oxford University Press, ISBN: 978-0199681273
3. "Solar Energy: Principles of Thermal Collection and Storage", SP Sukhatme and J K Nayak, 4th Edition, Tata Mcgraw Hill Publishing Co. Ltd.
4. "Solar Energy: Fundamentals and Applications", H.P. Garg& Jai Prakash, First Revised Edition, Tata McGraw-Hill Education.
5. "Wind Power Technology", Joshua Earnest, 2nd Edition, PHI Learning, 2015.
6. "Solar Engineering of Thermal Processes", John A . Duffie and William A Bechman, 4th Edition, Wiley Publications.
7. "Renewable Energy Sources", J W Twidell& Anthony D. Weir, 3rd Edition 2015,ELBS Pub, ISBN: : 978-1-315-76641-6
8. "Energy Conversion Systems", Rakosh Das Begamudre, New Age International (P) Ltd., Publishers, New Delhi, 2007, ISBN: 9788122412666
9. "Solar Photovoltaics: Fundamentals, Technologies and Applications", C S Solanki, 3rd Edition, PHI Learning.
10. "Biomass Regenerable Energy", D. D. Hall and R. P. Overend, John Wiley, New York, ISBN:047190919X
11. "Wind and Solar Power Systems", Mukund R Patel, 2nd Revised Edition, CRC Press, ISBN: 9780429114960
12. "Wind Energy Explained: Theory, Design and Application", J F Manwell, J.C. McGowan, A.L.Rogers,2nd Edition 2009, John Wiley and Sons.

Links for online NPTEL/SWAYAM courses:

1. https://nptel.ac.in/courses/103103206
2. https://nptel.ac.in/courses/103107157
3. https://nptel.ac.in/courses/115105127