**Course Syllabus for M.Sc. Engineering in Energy for Sustainable Social Development**

**Sustainable Energy Technology**

 (CORE COURSE 3)

Lecture: 3 hrs Year: I

Tutorial: 1 hr Part: A

Practical: 2 hrs Credit: 4

**Objective**:

 To provide the general understanding of the energy resources, energy conversion technologies, and the physics and sustainability of different types of energy conversion technologies, and economic evaluation of energy projects.

 To provide knowledge on active and passive solar systems photovoltaic systems, wind power systems, micro hydro systems, biomass systems, OTEC, wave/tidal systems and geothermal systems.

1. **Introduction: [8 hrs]**
* Sustainable energy and sustainable development, scientific and engineering foundations for defining energy, energy production and consumption, local and global effects of energy
* Mathematical representation of sustainability
1. **Biomass Systems: [8hrs]**
* Biomass energy resources, energy conversion technologies, and its applications.
* Solid biomass, liquid and gaseous biofuels.
1. **Solar Thermal Systems: [8hrs]**
* Solar radiation and its characteristics, basic principles of heat transfer, selective coatings, principles and performance of flat plate and solar concentrators, solar water heating, solar pond, solar swimming pool, solar stills, solar drying, solar cooling and solar cooking, conversion to mechanical energy, application of active and passive solar thermal system in buildings.
1. **Solar PV Systems: [8 hrs]**
* Fundamentals of solar cells, types of solar cells and their fabrication.
* Application of photovoltaic systems (modules and arrays), pumping systems, lighting systems, satellite solar power systems, solar home problems, PV cathodic protection, and other related problems, PV Tracking Systems
1. **Micro Hydro and Wind Power system: [8 hrs]**
* Theory on power generation and utilization, details of wind and micro hydro power system, site selection, transmission and installation
1. **OTEC, Wave, Tidal, Geothermal and other types of energy: [8 hrs]**
* OTEC: Temperature profile in temperate and tropical oceans, principles of OTEC systems, site selection, power cycles, selection of working fluid, pumps and turbines, heat exchangers
* Wave: Generation of waves, patterns, wave energy and power extraction devices
* Tidal: Origin and nature of tides, tidal heads and duration, principle of tidal energy conversion, tidal power generation
* Geothermal: Geophysics, available technology, harnessing geothermal resources
* Others: Hydrogen energy and fuel cells.
* Energy generation from waste
1. **Energy Conservation and Demand side Management: [5 hrs]**
* Thermodynamic of energy conservation, energy conservation through controls, energy auditing, process heat and steam management, waste heat recovery, electrical energy conservation in buildings and industries, economics of energy conservation
* Techniques for measuring energy use, approaches to optimizing and monitoring energy use, design principles to minimize energy use in buildings and devices, analysis of systems, satellite solar power system, PV cathodic protection, and other related relative costs of energy conservation and energy production in various appliances
1. **Environmental Effects of Energy [7 hrs]**
* Interaction of energy systems with environment
* Adverse environmental effects over local and regional length scales
* Global climate change
* Attribution of environmental damage to energy utilization
* Methods of environmental protection
* Implications for Sustainable Development
* Mitigation of Climate Change: UNFCCC, IPCC, Kyoto Protocol
* Internalization of environmental impacts costs
* Carbon finance in Renewable Energy Projects

**Experiments based on course content of RET:**

**Text Books, References and Journals**

1. Jefferson W. Tester, Elisabeth M. Darke, Michael W. Golay, Michael J. Driscoll, and William A. Peters, ***Sustainable Energy: Choosing Among Options***. Printice-Hall of India Pvt. Ltd., New Delhi, 2006.
2. Aldo Vieira da Rosa, ***Fundamentals of Renewable Energy Processes***. Elsevier Academic Press, California, USA( ISBN 13: 978-0-12-088510-7), 2005.
3. Frank Kreith and D. Yogi Goswami, ***Hand Book of Energy Efficiency and Renewable Energy***. CRC Press, Taylor & Francis Group, London, 2007.
4. John Twidell and Tony Weir, ***Renewable Energy Resources****,* 2nd Edition. Taylor & Francis, London, 2006.
5. Harish Gupta and Sukanta Roy, ***Geothermal Energy, An Alternative Resource for the 21st Century****,* 1st Edition, Elservier, Amsterdam, The Netherlands, 2007.
6. Y. Goswami, ***Principles of Solar Engineering***, Talor and Francis, 2000.
7. Thomas F. McGowan, Michael L. Brown, William S. Bulpitt, and James L. Walsh Jr., ***Biomass and Alternate Fuel Systems***. John Wiley & Sons, Inc., Hoboken, New Jersey, 2009.
8. Prabir Basu, ***Biomass Gasification and Pyrolysis Practical Design and Theory***. John Elsevier, 2010.
9. *Proceedings of International Conference on Role of Renewable Energy Technology for Rural Development, (RETRUD-98), IOE/AEPC/NESS, 1998.*
10. *Proceedings of Second International Conference on Renewable Energy Technology for Rural Development, (RETRUD-03), IOE, 2003.*
11. *Proceedings of First National Conference on Renewable Energy Technology for Rural Development, (RETRUD-06), 2006.*
12. *Proceedings of IOE Graduate Conference, Vol.1, ISSN 2350-8914, Nov 2013.*
13. *Proceedings of IOE Graduate Conference, Vol.2, ISSN 2350-8906, Oct 2014.*
14. **International Journal of Renewable Energy Technology**, Inderscience.
15. **Energy**, An International Journal, Elservier.
16. **Energy for Sustainable Development**, An International Journal, Elservier
17. **Mitigation and Adaptation Strategies for Global Change,** An International Journal, Springers.
18. **Renewable Energy**, An International Journal, Elservier.
19. **IPCC, *Fifth Assessment Report***, 2015