Course title: Energy lab – II			
Course code: ENR 157	**No. of credits:** 3	**L-T-P:** 11-0-62	**Learning hours:** 73
Pre-requisite course code and title (if any): NA			
Department: Department of Energy and Environment			
Course coordinator: Dr. Atul Kumar	**Course instructor(s):** Dr. Priyanka Kaushal/ Dr. Naqui Anwer/ Dr. Jami Hossain/ Dr. Som Mondal/ Dr. Atul Kumar		
Contact details: atulk@teri.res.in			
Course type: Core	**Course offered in:** Semester 2		

Course description

In order to supplement various topics related to energy aspects in class-room lectures, some laboratory experiments are needed as a part of curriculum development of energy studies programme for better understanding of the subjects. The experiments based on science/engineering principles are so designed so as to provide students enough stimulation for further investigation.

Course objectives

The aim of Energy Laboratory II is to ground the analytical subject material in a practical problem, meaning that the skills and knowledge students learn throughout the programme will be applied in real renewable energy engineering work.

Module	Topic	L	T	P
1	**Solar radiation measurement** Measurement of total and diffuse solar radiation on a horizontal surface and comparison of computed values of total solar radiation on an inclined plane with experimental measured value	1	0	3
2	**Box type solar cooker** Thermal testing of a box type solar cooker: Determination of first and second figure of merit To determine the top heat loss factor of a box type solar cooker	1	0	6
3	**Paraboloid concentrator solar cooker** Cooling test on paraboloid concentrator solar cooker to determine its $F'U_L$ Heating test on paraboloid concentrator solar cooker to determine its $F'\eta 0$	1	0	6
4	**Solar thermal collector and storage** Determination of heat loss factor $F'U_L$ of linear solar absorber Estimation of energy storage by phase change material	1	0	6
5	**Solar PV module characterization** Dark and illuminated I-V characterization and spectral response of solar cells. I-V and P-V characteristics of PV modules under simulator and field radiation and temperature condition	1	0	5
6	**Power flow calculation for a stand-alone PV** Power flow calculation for a stand-alone PV system with DC load and a battery Power flow calculation of stand- alone PV system with AC load and a battery Power flow calculation of stand-alone PV system with DC & AC load battery	1	0	4
7	**Battery and Inverter performance analysis** Charging and discharging characteristics of a battery Performance analysis of inverter	1	0	4
8	**Biomass for energy (Combustion Lab)** Estimation of volatile matter and fixed carbon in biomass Estimation of calorific value of solid fuels	2	0	16

	Energy and environment performance testing of cook stove: Water Boiling Test (WBT) and Kitchen Performance Test (KTP)			
9	**Wind energy convertor** Determination of cut-in speed of wind turbine Determination of Tip Speed Ratio (TSR) at different wind speeds Determination of coefficient of performance of wind turbine Evaluation of power curves	1	0	6
10	**Performance evaluation of Solar PV Wind Hybrid System with DC/AC micro-grid** Study of system performance (a) with change in wind speed/pitch angle, and (b) with change in irradiance Study of integration of DC micro-grid to the main AC grid using 3-phase inverter Power flow control in DC micro-grid for various loading	1	0	6
	Total	**11**	**0**	**62**

Evaluation criteria

- Practical Records: 20%
- Viva voce: 30%
- Continuous evaluation: 50%

Learning outcomes

After completing this course, students would be able to:

- Measure solar radiations and test the performance of different solar thermal applications
- Characterize solar cells and analyse different parameters such as power flow, efficiency of different components such PV module, battery, inverter and PV system
- Characterize the properties of solid biofuels along with performance testing of cook stove
- Analyse the performance of wind energy converter and hybrid systems with DC and AC micro-grids.

Pedagogical approach

Students complete a procedure given in the laboratory manual to determine the behaviour of the equipments/prototypes/experimental set ups and produce the expected characteristics.

Materials

Garg, H. P., and Kandpal, T. C. (1999). *Laboratory manual on solar thermal experiments.* Narosa Publishing House, New Delhi. (self-study)
Doebelin, E.O. 2004. *Measurement Systems Application and Design*, 5th ed. McGraw-Hill, New York. (self-study)
D.P.Kothari and D.K.Sharma (2000), *Energy Engineering: Theory and Practice.* S. Chand Publisher, New Delhi. (self-study)
http://cleancookstoves.org/technology-and-fuels/testing/protocols.html

Additional information (if any): NA

Student responsibilities

Attendance, feedback, discipline: as per university rules.

Course Reviewers

1. Professor S. K. Samdarshi, Centre for Energy Engineering, Central University of Jharkhand, Ranchi
2. Dr. S. K. Tyagi, Centre for Energy Studies, Indian Institute of Technology Delhi