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| **Course title:** Energy lab – II | | | |
| **Course code:** ENR 157 | **No. of credits:** 3 | **L-T-P:** 11-0-68 | **Learning hours:** 79 |
| **Pre-requisite course code and title (if any):** NA | | | |
| **Department:** Sustainable Engineering | | | |
| **Course coordinator:** Dr. Ramkishore Singh | **Course instructor(s):** Dr. Naqui Anwer<br>Dr. Ramkishore Singh | | |
| **Contact details:** ramkishore.singh@terisas.ac.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**<br>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, estimation of role of reflected component | 1 | 0 | 4 |
| 2 | **Box type solar cooker**<br>Thermal testing of a box type solar cooker: Determination of first and second figure of merit<br>To determine the top heat loss factor of a box type solar cooker | 1 | 0 | 6 |
| 3 | **Paraboloid concentrator solar cooker**<br>Cooling test on paraboloid concentrator solar cooker to determine its $F'U_L$<br>Heating test on paraboloid concentrator solar cooker to determine its $F'\eta 0$ | 1 | 0 | 6 |
| 4 | **Solar thermal collector and storage**<br>Determination of heat loss factor $F'U_L$ of linear solar absorber<br>Estimation of energy storage by phase change material | 1 | 0 | 6 |
| 5 | **Solar PV module characterization**<br>Dark and illuminated I-V characterization and spectral response of solar cells.<br>I-V and P-V characteristics of PV modules under simulator and field radiations & temperature condition, different shading conditions. | 1 | 0 | 6 |
| 6 | **Power flow calculation for a stand-alone PV**<br>Power flow calculation for a stand-alone PV system with DC load and a battery<br>Power flow calculation of stand- alone PV system with AC load and a battery<br>Power flow calculation of stand-alone PV system with DC & AC load with and without battery | 1 | 0 | 6 |
| 7 | **Battery and Inverter performance analysis**<br>Charging and discharging characteristics of a battery<br>Performance analysis of inverter, impact of weather conditions on performance. | 1 | 0 | 6 |
| 8 | **Biomass for energy (Combustion Lab)**<br>Estimation of volatile matter and fixed carbon in biomass<br>Estimation of calorific value of solid fuels<br>Energy and environment performance testing of cook stove: Water Boiling | 2 | 0 | 16 |

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| | Test (WBT) and Kitchen Performance Test (KTP) | | | |
| **9** | **Wind energy convertor**<br><br>Determination of cut-in speed of wind turbine<br>Determination of Tip Speed Ratio (TSR) at different wind speeds<br>Determination of coefficient of performance of wind turbine<br>Evaluation of power curves | 1 | 0 | 6 |
| **10** | **Performance evaluation of Solar PV Wind Hybrid System with DC/AC micro-grid**<br><br>Study of system performance (a) with change in wind speed/pitch angle, and (b) with change in irradiance<br>Study of integration of DC micro-grid to the main AC grid using 3-phase inverter<br>Power flow control in DC micro-grid for various loading | 1 | 0 | 6 |
| | **Total** | **11** | **0** | **68** |

**Evaluation criteria**

Test 1: Performance during experiments - 30%
Test 2: Viva-voce (at the end of the semester) - 30%
Test 3: Practical Exam (at the end of the semester) - 20%
Test 4: Practical Records (spread over the entire semester) - 20%

**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