Course title: Solar Photovoltaic Power Generation			
Course code: ENR 145	**No. of credits:** 3	**L-T-P:** 37-6-4	**Learning hours:** 47
Pre-requisite course code and title (if any):			
Department: Sustainable Engineering			
Course coordinator: Dr. Ramkishoare Singh		**Course instructor:** Dr. Ramkishoare Singh	
Contact details: ramkishore.singh@terisas.ac.in			
Course type: Elective		**Course offered in:** Semester 3	

Course description:

Solar Photovoltaic technology is used for direct conversion of sunlight to electricity with advantages of low gestation period, ease of installation, modular nature and minimum maintenance. The course is focused on techno-economics of power generation through solar PV technology. The course starts with the essence of solar PV power generation policies. It is followed by various aspects of system specification, design, project implementation and operation & maintenance. The course offers a blend of technical expertise required for design and operation of a solar PV power plant and the understanding of the management aspects required to implement and commission a PV power plant. It also covers the economic analysis of a PV project and its environmental benefits.

Course objectives:

The objective of the course is:

- To develop a comprehensive technological understanding in solar PV system components
- To provide in-depth understanding of design parameters to help design and simulate the performance of asolar PV power plant
- To pertain knowledge about planning, project implementation and operation of solar PV power generation.

Course contents

Module	Topic	L	T	P
1	**Introduction** Global solar PV deployment status, Solar policy in India – rooftop and ground mounted, Current Central and State schemes and targets Review of solar radiation components, radiation on tilted surface	4	0	0
2	**PV system** **PV module technology:** c-Si, Thin-film technology, response to weather parameters, commercial module ratings, standards, module reliability **Inverter technology:** Inverter technologies, types of inverters, inverter selection, voltage levels, performance, power quality **Balance of system/plant:** Module mounting structure, tracking system, Cabling and electrical design, single line diagrams, metering **Safety systems:** Hotspot, Blocking and bypass diodes, surge protection, PID and its protection, Lighting protection, anti-islanding	10	0	0

	Battery technologies: Introduction to battery, battery technologies, standalonesystem and utility scale storage **Types of PV systems:** Design considerations for standalone and grid-connected plants, rooftop and ground mounted, floating solar plant, BIPV			
3	**PV plant design** **Rooftop PV plant:** design consideration, types of mounting structures, standards **Ground mounted PV plant:** Array design and PV panel mounting, electrical layout, standards **Performance parameter:** Losses in solar PV power plant, Yield, Capacity Utilization Factor and Performance Ratio Design exercises using PVsyst for ground mounted and rooftop plants with shadow analysis	4	2	4
4	**PV project development** Preliminary site survey and feasibility study, statutory clearances and permits, Different modes of project development, PPA and evacuation planning, DPR Project schedule, procurement schedule, civil and electrical works, installation of module and inverter Grid-synchronization and power evacuation, Testing and acceptance Concept of Mega Solar Parks	6	0	0
5	**Operation and maintenance** Monitoring of PV plant, Best practices in operation, cleaning and maintenance, Generation data analysis and fault detection, Issues with long-term plant degradation/fault	5	2	0
6	**Case Studies based on module 1, 2, 3, 4 and 5**	4	0	0
7	**Estimation of energy payback and environmental benefits of SPV power plant:** Performance analysis and estimation of energy payback period for SPV power plant – rooftop, ground-mounted, stand alone and small-scale &large-scale power plant scenarios, assessment of carbon footprints and carbon credit calculation, estimating CO_2 mitigation potential	4	2	0
	Total	37	6	4

Evaluation criteria:

Test 1: Assignments (after completion of module 6) - 20%
Test 2: Written test (after completion of modules 1, 2 and 3)- 15%
Test 3: Written test (after completion of modules 4 and 5) - 15%
Test 4: Written test (at the end of the semester after completion of modules 7) - 50%

Learning outcomes:

After completing this course, a student will be able to:

- Develop understanding on the PV plant design and select suitable technologies (Test 2)
- Design and simulate a PV power plant using software tool (Test 1)
- Plan project implementation, operation and maintenance (Test 2, 3 and 4)
- Carry out techno-economic-environmental performance evaluation of a solar PV power plant(Test 3 and 4)

Pedagogical approach:
A combination of class-room interactions, expert lecture, assignment, tutorial, practical and case study

Reference books:
Handbook of photovoltaic science and engineering, ed. A. Luque and S. Hegedus (John Wiley and Sons,2010)
Solar Photovoltaics – Fundamentals, Technologies and Applications, C. S. Solanki, 2nd ed. (PHI Learning, 2011)
Renewable Energy Engineering and Technology – A Knowledge Compendium, ed. V.V.N. Kishore (TERI Press, 2008).
Photovoltaic system engineering, R. A. Messenger and A. Abtahi, 3rd ed. (CRC Press, 2010)
Grid connected PV systems design and installation, GSES (GSES India Sustainable Energy, 2013)

Additional information (if any):

Student responsibilities:
Adopt peer learning and knowledge sharing within the class Attendance, feedback,
discipline: as per university rules

Course reviewers:

1. Dr. B. D. Sharma, Chief Technical Officer and Vice President, JBM Solar, Gurgaon
2. Mr. Dwipen Boruah, Managing Director, GSES, New Delhi