Lesson and Evaluation Plan - EN 517 (Spring 2024)

School: **Engineering**
Department: **Energy**
Course Code: **EN 517**
Course Name: **Advanced Solar Photovoltaic Energy**
Total credit: **3**
Instructor: **Dr Nabin Sarmah**

1. Abstract:

This course designed for a detail discussion on the fundamental working principle of solar photovoltaic technology to system design. The course comprises of six units to deal with the various aspect of photovoltaic technology, including the understanding of physical theories and phenomena of solar cell with inclusion of semiconductor physics. The discussions of different fabrication process for different solar cell technologies are included. The course discusses different aspects power electronics use is photovoltaic system and basics of grid integration.

2. Objective:

The course is designed with objectives to prepare students having capabilities of serving photovoltaic industry as well as to develop competency for research in photovoltaic system. At the end of the course the student is capable of:

i. Theoretical analysis of current and power generated by a solar cell.
ii. Analyze and optimize the performance of photovoltaic systems using modelling approach for specific location.
iii. Design off-grid and grid-connected solar photovoltaic system with given input of load demand and solar radiation.

Furthermore, the objective of the different units of the course has been given in the table below. At the end of the following units the student is capable of:

Unit	**Topic**	**Learning Objectives**
Unit 1:	Solar cell & Solar cell physics	Demonstrate and estimate the current generation process of the solar cell in different photovoltaic technologies
Unit 2:	Solar cell fabrication technology	Fabrication of solar cell if the facilities are provided.
Unit3:	Solar photovoltaic system	Design solar photovoltaic system for different applications and addressing the issues
Unit4:	Centralized and decentralized PV systems	Optimisation of PV system size and economics

3. Course Outcomes:

CO1: Discuss the properties of various energy materials used for solar cell fabrication
CO2: Analyse the parameter for improvement of solar cell efficiency
CO3: Design standalone and grid connected photovoltaic systems.
CO4: Assess and predict the performance of PV systems

4. Prerequisites of the course:

The prerequisite of the course is basic knowledge of solar radiation and fundamental understanding of photovoltaic principle and technology.

5. (a)**Time-Plan**

Tentative Lectures	Topic to be covered	No. of classes
1-10	**Solar Cell & Solar Cell Physics** 1. Intrinsic, extrinsic and compound semiconductor; energy levels; electrical conductivity; Fermi energy level 2. Probability of occupation of allowed states; Dynamics of energy density of allowed states; Density of electrons and holes; Carrier transport: Drift, diffusion, continuity equations 3. Absorption of light; Recombination process; Basic equations of semiconductor devices physics; new generation solar cell materials. 4. p-n junction: homo and hetero-junctions, Metal-semiconductor interface; Dark and illumination characteristics 5. Figure of merits of solar cell; Efficiency limits; Factors affecting the efficiency; Performance parameters and their measurements; Strategies to enhance the efficiency of solar cell	**12**
11-20	**Solar cell fabrication technology** 1. Preparation of metallurgical, electronic and solar grade Silicon 2. Production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method: Procedure of masking, photolithography and etching 3. Design of a complete silicon, GaAs, InP solar cell; High efficiency III-V, II-VI multijunction solar cell; a-Si-H based solar cells; Quantum well solar cell, Organic PV cells, Dye-sensitized solar cells; emerging solar cell technologies 4. Thermophotovoltaics	**8**
21-32	**Solar photovoltaic system** 1. PV system design and optimization 2. PV System installation, operation and maintenances; Balance of PV system (BOS) 3. Issues and Challenges of PV system operation and maintenance; Factor affecting the PV system performance 4. Performance measurements and characterization of PV power plant	**8**
33-36	**Centralized and decentralized PV systems** 1. Stand alone, hybrid and grid connected system; 2. Net and Feed-in Tariff mechanism, Energy generation analysis 3. Power control and management systems for grid integration 4. Issues and challenges of grid integrated PV system 5. PV market analysis and economics 6. National Solar Energy Mission.	**4**
Total		**32**

(b) **Evaluation plan**

Tests	Question Pattern	*Date	Marks	Time
Test 1	Descriptive/ Objective/ Quiz	As per the academic calendar and notification	25	45 min
Test 2 (Major I)	Descriptive/ Objective	As per the academic calendar and notification	40	2 hours
Test 3	Assignment/Seminar/Case study)	As per the academic calendar and notification	25	-
Test 4 (Major II)	Descriptive/ Objective	As per the academic calendar and notification	60	3 hour
	Total		**150**	

* As per the Tezpur University examination schedule

6. Pedagogy:

The primary teaching/learning methods of the course will be classroom teaching and learning followed by laboratory visits. The laboratory visit and getting familiar with the solar laboratory equipment and having a hand on experience will help in detail understanding of course material. The classroom teaching will include lectures; interactive sessions on the topics of the course; seminars on the chosen topics of current research on solar energy etc. Students will be required to submit one write-up on the chosen seminar topics. It is expected that this kind of teaching-learning activities will help in developing analytical and research oriented thinking of the students. In summary teaching learning method to be adopted for the course are:

- Lecture/Discussion using LCD projector and white board
- Flipped classroom
- Interactive sessions
- Seminar by the student
- Quiz

7. Text Books

1. Solanki C. S. (2009); Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall India
2. Reinders A., Verlinden P., Sark W., Freundlich A., (2017); Photovoltaic Solar Energy: From Fundamentals to Applications, Wiley.

8. References

1. Wenham S .R. Green M. A. Watt M. E. and Corkish R. (2007); Applied Photovoltaics, Second Edition, Earthscan.
2. Green M. A. (1992); Solar Cells - Operating Principles, Technology and System Application, University of NSW.
3. Antonio Luque, Steven Hegedus (2012), Handbook of Photovoltaic Science and Engineering, second Edition, Wiley-Blackwell.
4. http://pveducation.org/
5. Fahrenbruch A. L. and Bube R. H. (1983); Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press.

CO – PO Mapping and Assessment Criteria
EN517 Advance Solar Photovoltaics

CO1	Discuss the properties of various energy materials used for solar cell fabrication
CO2	Analyse the parameter for improvement of solar cell efficiency
CO3	Design standalone and grid connected photovoltaic systems.
CO4	Assess and predict the performance of PV systems

Course Outcomes, Mapping and Weightage with Programme Outcomes [Weightage (%)]				
PO1	CO1			
PO2		CO1, CO2, CO3, CO4		
PO3			CO2, CO3, CO4	
PO4				CO4

	Course Outcomes, Mapping and Weightage with Programme Outcomes [Weightage (%)]					
Course Outcomes	Weightage of Marks	Test-I	Test-II	Test-III	Test-IV	**Total**
CO1	27%	20	15		5	**40**
CO2	27%	5	20		15	**40**
CO3	27%		5	15	20	40
CO4	19%			10	20	30
Total	**100%**	**25**	**40**	**25**	**60**	**150**

Assessment Criteria						
Bloom Taxonomy	**Level**	**Marks Weightage (%)**	**Assessment - I**	**Assessment - II**	**Assessment - III**	**Assessment - IV**
Knowledge	Easy	10	5	5	0	5
Understanding	Average	13	10	5	0	5
Application	Average	24	10	15	0	10
Analysis	Difficult	20	0	10	0	20
Evaluation	Difficult	23	0	0	25	10
Application	Difficult	10	0	5	0	10
Total		100	25	40	25	60