Zarqa University

Faculty of Engineering Technology
Department: Energy Engineering
Course title:
Renewable Energy III (Photovoltaic Energy)

Prerequisite: Heat Transfer
Instructor: TBD
Lecture's time: TBD
Semester: TBD
Office Hours: TBD

Course description:

Fundamentals of Solar Radiation; sun energy, sun position, potential of solar radiation, Solar calculations of the global horizontal irradiation, determination of the solar angles, fundamentals of photovoltaic energy and its main components: (Semiconductor materials, pn-junction, pn junction solar cell under illumination, current voltage characteristics of solar cells, equivalent circuit of solar cells, electrical connection of PV modules (series, parallel), mismatch effect (mismatch losses), the effect of soft shading and hard shading on array performance, PV system components, Diodes in PV Systems, DC/AC inverter topologies, Maximum power point tracking, ON grid photovoltaic system connection, PV overcurrent protection, Module inter-row spacing.

Aims of the course:

1. **Define the solar radiation; sun energy and sun position. Understand the potential of solar radiation.**
2. **Calculation of the global horizontal irradiation, and determination of the solar angles.**
3. **Analyze the main components of photovoltaic cells and its principle of formulation.**
4. **Analyze the electrical equivalent circuit of solar cells.**
5. **Understand the effect of temperature, irradiation and shading on the performance of PV cells.**
6. **Understand the concept of maximum power point tracking.**
7. **Analyze the main components of the ON grid PV system.**

Intended Learning Outcomes (ILOs):

1. **Explain the fundamentals of solar radiation and the photovoltaic effect.**
2. **Calculate the solar angles.**
3. **Design and derive relations of the equivalent circuit of PV cells.**
4. **Explain the series and parallel connections of PV modules.**
5. **Explain the different phenomena regarding PV modules.**
6. **Explain the different components of the PV system.**
7. **Sizing overcurrent devices and calculation of the voltage drop within the cables.**
8. **Design an on grid PV system using PVsyst software.**

Course structures:

Week	C. Hrs	ILOs	Topics	Teaching Procedure	Assessment methods
1		1	**Fundamentals of solar radiation, electromagnetic spectrum, air mass, STCs and radiation types**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
2,3		1	**Identification and calculations of solar angles, isotropic sky model and radiation devices**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
4		1	**PV module layers, PV effect**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
5		2,3	**PV cell equivalent circuit, mathematical relations and design**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
6		4	**Series and parallel connections of PV modules**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
7,8		5	**Mismatch effect, soiling, hotspots and shading**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
9		5,6	**PV Diodes and solar module data sheet**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
10,11		7	**Temperature coefficient effect**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
12		6,7	**PV inverters**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**

13		2,6	**Solar radiation websites**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
14		8	**Design of on grid PV system**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
15		8	**Design of PV system electrical parts**	**Lectures using power point + home work assignment**	**1st + 2nd examination Final examination Assessment of home work**
16		2,3,8	**Online design of PV systems**	**Lectures using power point + home work assignment**	**Assessment of home work**
16		8	**Sun path diagram and row spacing**	**Lectures using power point + home work assignment**	**Assessment of home work**
			Exam		

Textbook:

"Principles of Solar Engineering", D.Yogi Goswami, CRC Press, 3rd Edition, 2015

References:

1. "Solar Energy Engineering and Processes and Systems", Soteris A. Kalogirou, 1st edition, 2009.
2. "Solar Energy: Renewable Energy and the Environment", Robert Foster, et al, 1st edition, 2010.
3. "Photovoltaics System Design and Practice", Heinrich Haberlin, 1st edition, 2012.
4. "Solar Energy: The Physics and Engineering of Photovoltaic Conversion Technologies and Systems", Arno Smets, et al, 1st edition, 2015.
5. "Fundamentals of Photovoltaic Modules and their Applications", G.N. Tiwari and Swapnil Dubey, et al, 1st edition, 2010.
6. "Photovoltaics: Fundamentals, Technology and Practice", Konrad Mertens, 2nd edition, 2014.

Lecturer hand outs

Assessment Methods:

Methods	Grade	Date
First examination	**20%**	**According to faculty time table**
Second examination	**20%**	
Final examination	**50%**	
Project assessment	**10%**	