820740 - ESF - Solar Photovoltaics (DRAFT VERSION)

Coordinating unit: 820 - EUETIB - Barcelona College of Industrial Engineering

Teaching unit: 710 - EEL - Department of Electronic Engineering

Academic year: 2014

Degree: MASTER IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)
ERASMUS MUNDUS MASTER IN ENVIRONOMICAL PATHWAYS FOR SUSTAINABLE ENERGY SYSTEMS (Syllabus 2012). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: Spanish, English

Teaching staff

Coordinator: Rafael Martin Lamaison Urioste

Others: Santiago Silvestre Berges

Opening hours

Timetable: - To be published in the teaching intranet.

Prior skills

- Fundamentals of electrical engineering

Requirements

- No specific requirements.

Degree competences to which the subject contributes

Specific:

CEMT-1. Understand, describe and analyse, in a clear and comprehensive manner, the entire energy conversion chain, from its status as an energy source to its use as an energy service. They will also be able to identify, describe and analyse the situation and characteristics of the various energy resources and end uses of energy, in their economic, social and environmental dimensions, and to make value judgments.

CEMT-4. Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.

CEMT-6. Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.

CEMT-7. Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.

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Teaching methodology

Teaching methodology

The course teaching methodologies are as follows:

- Lectures and conferences: knowledge exposed by lecturers or guest speakers.
- Participatory sessions: collective resolution of exercises, debates and group dynamics, with the lecturer and other students in the classroom; classroom presentation of an activity individually or in small groups.
- Theoretical/practical supervised work: classroom activity, carried out individually or in small groups, with the advice and supervision of the teacher.
- Homework assignment of reduced extension: carry out homework of reduced extension, individually or in groups.
- Homework assignment of broad extension (PA): design, planning and implementation of a project or homework assignment of broad extension by a group of students, and writing a report that should include the approach, results and conclusions.

Training activities:
The course training activities are as follows:
Face to face activities
- Lectures and conferences: learning based on understanding and synthesizing the knowledge presented by the teacher or by invited speakers.
- Participatory sessions: learning based on participating in the collective resolution of exercises, as well as in discussions and group dynamics, with the lecturer and other students in the classroom.
- Presentations (PS): learning based on presenting in the classroom an activity individually or in small groups.
- Theoretical/practical supervised work (TD): learning based on performing an activity in the classroom, or a theoretical or practical exercise, individually or in small groups, with the advice of the teacher.

Study activities
- Homework assignment of reduced extension (PR): learning based on applying knowledge and presenting results.
- Homework assignment of broad extension (PA): learning based on applying and extending knowledge.
- Self-study (EA): learning based on studying or expanding the contents of the learning material, individually or in groups, understanding, assimilating, analysing and synthesizing knowledge.

Learning objectives of the subject

Objectives

The course focuses on technologies using the sun as energy resource. In this case, the technology uses the photovoltaic effect to transform the energy arriving from the sun into electricity.
In this area it is intended that students acquire the knowledge and skills necessary for describing and selecting equipment, as well as for calculating the performance of the different components of the system and aspects of analysis and design at a basic level.
It is intended to provide an overview of the technologies and methods that will enable the student to make judgments, and studies of alternatives in the context of engineering projects.

Learning Outcomes

At the end of the course, the student is able:

- to understand the role of solar energy in the context of regional and global energy system, its economic, social and environmental connotations, and the impact of technology on a local and global context.
- to understand the physical principles of the photovoltaic (PV) solar cell and what are its sources of losses.
- to understand and apply the basic concepts of solar radiation necessary for dimensioning (sizing) PV systems installations.

- to know the electrical (current-voltage and power-voltage) characteristics of solar cell, panel or generator and how the environment parameters influence it
- to know the most important characteristics of the elements within a PV system and how they work: battery and charge controller, DC/DC converter, DC/AC converter (inverter) and loads.
- to present a software tools for PV system engineering.
- to list the relevant organizations, major projects at the international level, the main sources of information and regulations related to to solar photovoltaic technology.
- to know some practical applications that use solar photovoltaic systems and be able to do specify, analyze and design (sizing) of an autonomous photovoltaic system and energy produced by photovoltaic greed connected systems.
- to know and be able to analyze the behavior of a self-consumtion demand and the measurement of network management.
- to carry out a basic engineering project related to energy supply using solar photovoltaic technology.
- to know the main lines of research in the field of photovoltaic technology and solar energy.
- to bring innovative ideas in the field of solar photovoltaic energy.

Study load

Total learning time: 125h	Hours large group:	0h	0.00%
	Hours medium group:	0h	0.00%
	Hours small group:	30h	24.00%
	Guided activities:	15h	12.00%
	Self study:	80h	64.00%

Content

1. Introduction to Solar Photovoltaics

Learning time: 4h

Large group/Theory: 2h
Self study : 2h

Degree competences to which the content contributes:
CEMT-1 (Specific)

Description:
The module provides an introduction to Photovoltaic Solar Energy (PVSE) which discusses its importance, advantages, disadvantages, the components of a PV system and typical applications.

Related activities:
any activity related

Specific objectives:
In this module the student will understand the possibilities and applications of PV solar systems

2. Solar Radiation

Learning time: 4h

Large group/Theory: 2h
Self study : 2h

Degree competences to which the content contributes:
CEMT-1 (Specific)

Description:
The module provides an introduction to solar radiation and some important related concepts like blackbody, solar spectrum, irradiance, irradiation, air mass and peak sun hour. Also the student will also use PVGIS (Photovoltaic Geographical Information System), which is a tool that provides monthly and yearly averages of global irradiation at horizontal and inclined surfaces, as well as other climatic and PV-related data.The module provides an introduction to solar radiation and some important related concepts like blackbody, solar spectrum, irradiance, irradiation, air mass and peak sun hour. Also the student will also use PVGIS (Photovoltaic Geographical Information System), which is a tool that provides monthly and yearly averages of global irradiation at horizontal and inclined surfaces, as well as other climatic and PV-related data.

Related activities:
Any related activities

Specific objectives:
The student will acquire the knowledge of the most Important concepts of solar radiation used in photovoltaic systems and learn to use the PVGIS tool.

3. Photovoltaic systems	Learning time: 44h 20m Large group/Theory: 8h Small group/Laboratory: 4h Guided activities: 5h Self study : 27h 20m

Degree competences to which the content contributes:
CEMT-1 (Specific)
CEMT-4 (Specific)
CEMT-7 (Specific)

Description:
The first part of this module introduces the electrical behavior of a PV solar cell:
- Fundamentals of the physical principleof a PV cell: the photovoltaic effect and how a photovoltaic cell works.
- The electrical behavior of a diode and its curve.
- The Illuminated solar cell with its symbol, equivalent circuit, equations and I-V curve.
- Important parameters like short circuit current (Isc), open circuit voltage (Voc), voltage and current at the maximum operating power point, efficiency (?) and fill factor (FF).
- The P-V curve and the main factors affecting the performance of the solar cell.
- The effect of atmospheric factors and shadows on an array of PV modules and its effect on the I-V curve.
On the second part of this module we will see the Balance Of System (BOS) and the types of PV systems:
- Batteries.
- Regulators.
- DC/DC converters.
- Inverters (DC/AC converters).
- DC/DC converter as a Maximum Power Point Tracking (MPPT).
- Different configurations of stand-alone and grid-connected PV systems.

Related activities:
1. Photovoltaic system exercises.

Specific objectives:
The Students will acquire the knowledge and skills necessary for the description, selection, analysis and sizing the different components within a PV system and their different configurations.

4. Analysis, sizing and maintenance of plant using photovoltaic systems.	Learning time: 72h 40m Large group/Theory: 10h 20m Small group/Laboratory: 6h 20m Guided activities: 7h Self study : 49h

Degree competences to which the content contributes:
CEMT-1 (Specific)
CEMT-4 (Specific)
CEMT-6 (Specific)
CEMT-7 (Specific)

Description:
- Sizing a PV stand-alone system
  o Examples of design and calculation of PV systems for different types of applications (residential, water pumping systems, etc).
- Design and obtaining the energy produced from a Grid-Connected PV Systems (GCPVS).
- Simulation of stand-alone and grid-connected photovoltaic systems using the PVSOL software.
- Video-presentation of PV plants.

Related activities:
2. Project of stand-alone/grid-connected PV systems.

Specific objectives:
Students acquire the knowledge and skills necessary for a project of stand-alone and grid-connected systems, as well as knowing some different types of PV electrical installations with its protections.

Planning of activities

1. Photovoltaic systems exercises

Hours: 34h
Guided study: 6h
Self study: 22h
Laboratory classes: 6h

Degree competences to which the activity contributes:

CEMT-4 (Efficiently collect data on renewable energy resources and their statistical treatment and apply knowledge and endpoint criteria in the design and evaluation of technology solutions for using renewable energy resources, for both isolated systems and those connected to networks. They will also be able to recognise and evaluate the newest technological applications in the use of renewable energy resources.)

Description:

Resolution of exercises in class individually or in small groups with the advice of the lecturer and proposed exercises to resolve at home individually.

Support materials:

- Examples of solved problems.
- Statements of problems with answers (self-learning).
- Statement of solving problems (continuous assessment).

Descriptions of the assignments due and their relation to the assessment:

The resolution of proposed exercises to resolve at home individually or in small groups.

Specific objectives:

Deepen the theoretical knowledge and its application to solving problems related to PV systems.

2. Project of stand-alone and grid-connected PV systems

Hours: 55h
Laboratory classes: 8h
Self study: 37h
Guided study: 10h

Degree competences to which the activity contributes:

CEMT-6 (Employ technical and economic criteria to select the most appropriate electrical equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technology applications in the field of production, transport, distribution, storage and use of electric energy.)

CEMT-7 (Analyse the performance of equipment and facilities in operation to carry out a diagnostic assessment of the use system and establish measures to improve their energy efficiency.)

Description:

Learning based on the design and planning a project, working in groups to apply and extended knowledge and writing a report, which describes the approach, results and conclusions. The students have to design and sizing a stand-alone or grid connected PV system.

Support materials:

- Examples of stand-alone and grid-connected PV projects.
- PVSOL software.
- Video presentation showing some PV installations.

Descriptions of the assignments due and their relation to the assessment:

A project report will be submitted.

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Specific objectives:

The student will acquire skills for selecting and sizing the components and equipment most suitable for a solar photovoltaic project, as well as the steps required to carry it out.

Qualification system

Exam (PE): 60 %
Homework (TR): 40 %

Regulations for carrying out activities

For the exam, the student may have only one sheet of paper with formulas and a programmable calculator.
The specific rules of individual and group work will be published in the teaching intranet

Bibliography

Complementary:

Deutsche Gesellschaft für Sonnenenergie. Planning & Installing Photovoltaic Systems, A guide for installers, architects and engineers. 3 (7 de junio de 2013). Routledge, 2013. ISBN 978-1849713436.

Antonio Luque, Steven HegedusAntonio . Handbook of Photovoltaic Science and Engineering, Second EditionHandbook of Photovoltaic Science and Engineering, Second Edition. 1 MAR 2011. 2011. ISBN 9780470974704.

Luis Castaner, Santiago Silvestre. Modelling Photovoltaic Systems Using PSPICE. Edición: 1 (1 de diciembre de 2002). Ieee Computer Soc Pr, 2002. ISBN 978-0470845271.

Miguel Alonso Abella. Sistemas Fotovoltaicos: Introducción al diseño y dimensionado de instalaciones de energía solar fotovoltaica. AMV Ediciones, 2005. ISBN 84-86913-12-8.

Enrique Alcor Cabrerizo. Instalaciones solares fotovoltaicas. Tercera edición 2002. PROGENSA, 2002. ISBN 84-95693-00-3.

Universität Kassel. Photovoltaic Systems Technology . SS 2003. 2003.