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820744 - ESTM - Solar Thermal Energy

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering

Teaching unit: 724 - MMT - Department of Heat Engines

Academic year: 2019

Degree: MASTER'S DEGREE IN RENEWABLE ENERGIES (Syllabus 2011). (Teaching unit Optional)
ERASMUS MUNDUS MASTER'S DEGREE IN ENVIRONOMICAL PATHWAYS FOR SUSTAINABLE ENERGY SYSTEMS (Syllabus 2012). (Teaching unit Optional)
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)
ERASMUS MUNDUS MASTER'S DEGREE IN ENVIRONOMICAL PATHWAYS FOR SUSTAINABLE ENERGY SYSTEMS (Syllabus 2013). (Teaching unit Optional)
MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2013). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Ivette Rodríguez

Others: Ivette Rodríguez
Assensi Oliva
Jesús Castro

Opening hours

Timetable: Monday, Wednesday and Thusday 16-18

Prior skills

Fundamental aspects of thermodynamics, fluid mechanics and heat transfer required to understand the operation of solar thermal systems.

Requirements

Those equivalent to have passed the Master leveling course

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-5. Employ technical and economic criteria to select the most appropriate thermal equipment for a given application, dimension thermal equipment and facilities, and recognise and evaluate the newest technological applications in the production, transportation, distribution, storage and use of thermal 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

During the development of the course the following teaching methods will be used:

-Lecture or conferences (EXP): Lectures taught by the professors of the course as well as invited lectures.
-Interactive classes (parts): resolution of exercises, collective discussions with both the teacher and the students. Presentation by the students of exercises carried out individually or in small groups.
-Oriented theoretical-practical works (TD): completion of a classroom activity, theoretical or practical, carried out individually or in small groups with the teacher's guidance.
- Project, activity or work of reduced scope (PR): Self-learning based on accomplishing an activity of reduced scope, individually or in small groups, just applying the knowledge acquired.
- Project or work of broader scope (PA): Self-learning based on accomplishing an activity of broader scope, individually or in small groups, just applying the knowledge acquired.
- Assessment exam (EV).

Learning objectives of the subject

- know the different heat transfer phenomena (radiation, convection, conduction) that occur in equipment and solar thermal systems.
- Know the most common materials and their properties used in solar thermal applications such as selective treatments, phase change materials, transparent insulating surfaces, etc..
- Have a knowledge of the different methodologies that allow the design and calculation of solar thermal systems and equipment. Use of different calculation software both commercial and in-house codes developed at CentreTecnològic Heat Transfer, Technical University of Catalonia.
- Performing different practices for testing of solar thermal collectors and solar thermal systems.
- Know the different applications of solar energy such as absorption cooling systems, solar thermal energy as a primary source of energy systems for the production of electricity with solar thermal concentration (plants solar thermo-electric).

Study load

Total learning time: 125h	Hours medium group:	30h	24.00%
	Guided activities:	10h	8.00%
	Self study:	85h	68.00%

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Content

Introduction . Availability of solar energy

Learning time: 22h

Laboratory classes: 2h
Self study : 20h

Description:
Solar radiation basics and availability. Estimation of solar radiation available depending on the geographic location.

Related activities:
-Lectures or conferences
-Interactive classes
-Project, activity or work of reduced scope

Specific objectives:
-Acquire the appropriate knoledge about the solar energy resources, its availability and how to use it in an optimize manner.
-Being capable of evaluating the angular position of the Sun
-Being capable to estimate solar radiation on a tilted surface

Most common materials used in thermal solar energy and their properties

Learning time: 4h

Laboratory classes: 1h
Self study : 3h

Description:
Basic concepts of the radiant properties of materials and their evaluation.

Related activities:
lectures and conferences
Interactive classes

Specific objectives:
- To go over previous acquire knowledge about radiant properties of materials for both opaque and transparent surfaces.
- To deepen in the knowlege about most common used materials in solar thermal collectors and their properties.
- To evaluate the spectral properties of the materials.
- To evaluate the gains of a solar absorber

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Solar thermal collectors

Learning time: 29h

Laboratory classes: 6h
Guided activities: 3h
Self study : 20h

Description:
Solar thermal collectors for low, medium and high temperature (high temperature solar receivers) . Principles of operation. Study of the different heat transfer mechanisms . Defining the performance of a solar collector . Test of a low-temperature solar collector.

Related activities:
-Lectures or conferences
-Interactive classes
-Oriented theoretical-practical works
-Project, activity or work of reduced scope

Specific objectives:
-Acquire the knowledge about the different technologies used to harness solar energy dependending on the temperature of operation.
-Being able to assess from a thermal point of view the useful energy performance of a receiver regardless of the technology used.
-Know the standard for testing a solar collector.
-Perform a solar collector test.

Solar thermal storage

Learning time: 14h

Laboratory classes: 6h
Guided activities: 3h
Self study : 5h

Description:
Study of the most used technologies for thermal energy storage facilities of low, medium and high temperature. Study of thermal stratification and its influence on the performance of solar thermal systems .

Related activities:
-Lectures or conferences
-Interactive classes
-Project, activity or work of reduced scope

Specific objectives:
- Be aware of the different technologies used for the thermal energy storage
- Acquire the knowledge about the main properties of the different media used in thermal storage according to the type of technology
-Importance and evaluation of thermal stratification in a thermal storage system.
-Know the standards for testing a thermal energy storage system for low temperature applications

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Solar thermal systems	Learning time: 50h Laboratory classes: 12h Guided activities: 6h Self study : 32h

Description:
solar installations of low , medium and high temperature solar thermal plants. Evaluation , sizing and simulation of solar thermal systems: i) systems for domestic hot water and heating; ii) solar cooling (absorption) as domestic and industrial application; iii) solar thermal plants .

Related activities:
-Lectures or conferences
-Interactive classes
-Oriented theoretical-practical work
-Project, activity or work of reduced scope
-Project, activity or work of broader scope

Specific objectives:
- Acquire the knowledge about the different technologies used depending on the range of working temperatures.
- Be aware of the different aspects of environmental regulations and related installations of solar thermal as low and high temperature.
- Acquire the knowledge about the different methodologies and programs for the calculation of solar thermal installations
-Being able to perform the calculation and dimensioning of the different types of solar thermal installations such as facilities for sanitary water heating installations absorption, thermo-solar plants

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Planning of activities

lectures and theoretical classes

Hours: 25h
Self study: 10h
Laboratory classes: 15h

Description:
The content of the course is taught following an expository and participative model.

Support materials:
Notes available on the Atenea platform.
Main literature for the course

Descriptions of the assignments due and their relation to the assessment:
During some sessions face-to-face exercises will be exposed by the professor with the participation of the students.

Specific objectives:
Transfer the knowledge necessary for a correct interpretation of the contents in the large group sessions, resolving doubts in relation to the content of the course and development of generic skills.

participative classes

Hours: 30h
Laboratory classes: 15h
Self study: 15h

Description:
In these actitivities, problems and exercises will be worked out following a participative scheme.

Support materials:
Notes available on the Atenea platform.
Main literature for the course

Descriptions of the assignments due and their relation to the assessment:
The students will work out exercises, individually or in small groups, followed by the face-to-face presentation of the results.

Specific objectives:
Transfer the knowledge necessary for a correct interpretation of the contents in the large group sessions, resolving doubts in relation to the content of the course and development of generic skills.

Oriented theoretical-practical works

Hours: 20h
Self study: 5h
Laboratory classes: 15h

Description:
During these activities, laboratory activities for test equipment and systems studied in the course, as well as computer aided activities will be conducted.

Support materials:
notes and material provided by the professor via atenea

Descriptions of the assignments due and their relation to the assessment:
Report on the results obtained

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Specific objectives:
Acquire the skills necessary for a proper assessment of equipment and systems.

name english	Hours: 30h Self study: 30h

Description:
The student will carry out exercises oriented to deepen into the subjects taught in classes. These works can be carried out individually or in small groups.

Support materials:
Notes available on the Atenea platform.
General Bibliography of the course
Exercises available on the Athena platform

Descriptions of the assignments due and their relation to the assessment:
Report on the results obtained

Specific objectives:
-Being able to apply the knowledge acquired both theoretical and practical to carry out the work.
- The student must be able to demonstrate and apply their knowledge on heat transfer to resolve the behaviour of solar thermal equipment.
- From the results, theoretical and practical solutions to improve the performance of solar thermal equipment should be proposed.

name english	Hours: 20h Self study: 20h

Description:
Broad scope work in which students will implement and integrate the acquired knowledge to the study the performance of a solar thermal system. This work can be done on any of the technologies studied in the course.

Support materials:
Recommended bibliography. Notes and transparencies. Journal articles related to the subject.

Descriptions of the assignments due and their relation to the assessment:
Report on the results and their analysis. Solutions to improve both the solar fraction and the performance of the solar installation should be provided.

Specific objectives:
-The student must be able to demonstrate and apply his/her knowledge through a system evaluation
-Understand the dependence of the different parameters on the solar fraction, system performance and in general, heat losses in the different equipment.
-Being able to provide solutions to improve the solar thermal installation.

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Qualification system

-Final exam (PE): 50%
-Assessment exercises (individually or in small groups) (TR): 40%
-Attendance and participation in classes and laboratories (AP): 5%
-Quality and performance of the work in groups (TG): 5%

Regulations for carrying out activities

- Final exam (PE): There will be a final exam for the course. Students must complete both theoretical questions and problems related to theoretical and practical content of the course. Reviews and / or complaints regarding exams will be conducted in accordance with the dates and times established in the academic calendar.

- Assessment exercises (TR): Students must follow the instructions explained in class and contained in the work file that will be proposed to the students. As a result of these activities, the student must submit a report (preferably in pdf format) to the teacher, within the deadline fixed for each activity. The assessment will involve both its realization as a possible defense.

-Attendance and participation in classes and laboratories (AP): Laboratory practices are assessed both during the development of the lab and by accomplishing a practical exercises proposed; The report resulting from the lab will be handed in to the professor following the instructions given in class. The assessment will involve both practical realization, as a possible defense.

- Quality and performance of group work (TG): Practices and class exercises will be assessed individually or in small groups by means of their oral defense if necessary.

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Bibliography

Basic:

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Duffie, John A; Beckman, William A. Solar engineering of thermal processes [on line]. 4th ed. Chichester: John Wiley & Sons, 2013 [Consultation: 11/10/2016]. Available on: <http://onlinelibrary.wiley.com/book/10.1002/9781118671603>. ISBN 9781118671603.

Tiwari, G. N. Solar energy : fundamentals, design, modelling and applications. Pangbourne, UK: Alpha Science International, cop. 2002. ISBN 9781842651063.

Vogel, Werner; Kalb, Henry. Large-scale solar thermal power : technologies, costs and development. Weinheim: Wiley-VCH, cop. 2010. ISBN 9783527405152.

Complementary:

Winter, C.-J; Sizmann, Rudolf L; Vant-Hull, Lorin L. Solar power plants : fundamentals, technology, systems, economics. Berlin [etc.]: Springer-Verlag, cop. 1991. ISBN 3540188975.

Beckman, William A; Klein, Sanford A; Duffie, John A. Solar heating design : by the f-chart method. New York [etc.]: John Wiley & Sons, cop. 1977. ISBN 0471034061.

Gordon, Jeffrey. Solar energy : the state of the art : ISES position papers. London: James & James, cop. 2001. ISBN 1902916239.

Others resources:

Audiovisual material

Transparències

Resource

Computer material

Apunts i articles

Resource